Tropentag 2015

International Research on Food Security, Natural Resource Management and Rural Development

Management of land use systems for enhanced food security: conflicts, controversies and resolutions

Book of abstracts

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Preface

The annual *Tropentag*, the largest European interdisciplinary conference on research in Tropical and Subtropical Agriculture and Natural Resource Management, rotates between the universities of Berlin, Bonn, Göttingen, Hohenheim, Kassel-Witzenhausen, Prague, Vienna and ZALF e.V. Müncheberg.

On-going organisational support for the event is provided by the Council for Tropical and Subtropical Research (ATSAF e.V.), the German Institute for Tropical and Subtropical Agriculture (DITSL) in Witzenhausen, and the GIZ Advisory Service on Agricultural Research for Development (BEAF) on behalf of the Federal Ministry for Economic Cooperation and Development BMZ. In 2015 the two ministries Federal Ministry of Education and Research BMBF in collaboration with the Project Management Jülich PTJ, and the National Aeronautics and Space Research Centre DLR as well as the Federal Ministry of Food and Agriculture BMEL in collaboration with the Federal Office for Agriculture and Food BLE organise additional supporting sessions.

The *Tropentag* has become the most important international conference on development-oriented research in the fields of food security, natural resource management and rural development in central Europe and provides a unique platform for scientific and personal exchange for students, junior and senior scientists, development experts and funding organisations from several countries together with their international partner institutions. Approximately 1200 participant registrations from 80 countries underline the importance of inter- and transdisciplinary scientific exchange to address the challenges ahead of us.

The *Tropentag* 2015 takes place on the campus of the Humboldt-Universität Berlin from September 16 - 18. It has been jointly organised by the Leibniz Centre for Agricultural Landscape Research ZALF e.V., Müncheberg, and the Humboldt-Universität zu Berlin.

The theme of 2015 is “Management of land use systems for enhanced food security – conflicts, controversies and resolutions”. Food security is still a vital worldwide concern and key policy issue. It will be increasingly challenging to feed a rapidly growing population on a declining area of arable and fertile land under unfavourable and unpredictable climatic conditions. Land has become a precious resource. A growing land

use competition for the production of food, fodder & forage, biofuels or forestry goods is creating tensions and conflicts. Especially the poorest nations in tropical regions have the highest prevalence of malnutrition - caused by inconsistent food availability, accessibility, utilisation and stability. The mainly rain-fed, subsistence-oriented smallholder farming systems are extremely vulnerable to environmental stressors and often lack access to inputs and resources, institutional support and, ultimately, adaptive capacity. The highly complex state of vulnerability needs to be addressed encompassing economic and socio-political factors which play a pivotal role in ameliorating food insecurity. Thus, effective adaptation and intervention strategies need to pursue a holistic approach and an array of objectives, including social and economic viability, gender empowerment, improvement of infrastructure and market access as well as soil health, minimum use of scarce water and fossil energy or conservation of natural resources and biodiversity. The issue is marked by a high degree of complexity, interests of stakeholders collide and strategic concepts diverge. Creating a sustainable road map for the future will be a challenging task for our global community. We invite you to discuss possible solutions in an effort to sustainably enhance food and nutritional security in the tropics.

The topics will be addressed by six internationally renowned keynote speakers, via 30 oral sessions presenting more than 160 talks and by about 450 poster presentations in 33 guided poster sessions. A special session featuring the International Institute of Tropical Agriculture IITA will underline the role of the CGIAR in the scope of improving crop quality and productivity through sustainable intensification as well as reducing producer and consumer risks.

We hope that the scientific contributions in this conference book will help you find answers to the research and development questions related to these topics and to the *Tropentag* 2015 theme.

Our special thanks go to our colleagues, who acted as reviewers and session chairs for the submitted abstracts and thus contributed substantially to maintaining the scientific standard of the conference. We like to express our gratitude to Eric Tielkes, DITSL Witzenhausen. Without his support the conference would not have been possible, and our thanks include all our donors whose financial contributions have made this conference possible and affordable especially for young scientists.

The Leibniz Centre for Agricultural Landscape Research in Müncheberg and the Humboldt-Universität zu Berlin welcome you as organisers to *Tropentag* 2015.

We wish you an enjoyable and rewarding conference.

The local organising committee of *Tropentag* 2015

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The Human Right to Adequate Food

THOMAS POGGE

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Inequality has risen through the colonial, post-colonial and globalisation periods; and the poorer half of humankind is now reduced to merely 4 percent of global household income. Still, the FAO tells us that chronic undernourishment is falling, declining from 1011 million in 1990–92 to 795 million in 2014–16. This is not an impressive result of a 25-year development effort. And there's much reason to believe that the truth is much worse. First, the asserted modest reduction is entirely due to the FAO's abrupt decision, in the 22nd year of the 25-year Millennium Development Goal exercise, to revise its method for estimating the undernourished, thereby transforming a steadily rising into a steadily falling trend line that is miraculously unperturbed by the near-doubling of world food prices toward twin peaks in 2008 and 2011. According to the earlier method, the number of chronically undernourished had RISEN from 843 million in 1990 to over a billion in 2009. Second, the FAO's statistics leave out 61 countries and territories for which it found insufficient reliable data, including Burundi, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Libya, Papua New Guinea, Somalia, Syria and Western Sahara. Third, the FAO works with an excessively narrow definition (SOFI 2012, p.50):

"'undernourishment' has been defined as an extreme form of food insecurity, arising when food energy availability is inadequate to cover even minimum needs for a sedentary lifestyle ... for over a year."

By focusing on food energy intake alone, the FAO ignores the human need for specific nutrients, as if Coca Cola's sugary soft drinks could fully dispel undernourishment. The FAO also ignores problems of food absorption, where parasites consume much of the ingested energy or disease prevents it from being absorbed through the small intestine. The FAO further ignores periods of undernourishment that are shorter than one year, such as severe seasonal hunger common in many rural areas. And the FAO lastly ignores people who absorb enough food energy for a sedentary lifestyle but not enough for the work they actually do to earn their living. There is every reason to believe that both the extent and the trend of chronic undernourishment are very much worse than the FAO is proclaiming. We urgently need a second opinion as well as finally a serious effort to eradicate undernourishment for good.

Keywords: Food security, human rights, undernourishment

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Building a Resilient Global Food System

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The world is facing a barrage of shocks that have become more frequent, intense, and increasingly evolving in unexpected ways. The adverse effects of climate change, conflict, and rising agriculture-related risks to health, among others, contribute to a vulnerable food system that threatens food security and nutrition of many. Building resilience to these challenges is critical especially to help the poor gain the ability to prevent, cope with, and fight off shocks, as well as prosper after shocks and crises. Resilience is more than just a buzzword‰it is about bridging the gap between short-term relief and long-term development goals at the global, national, community, and individual levels. It is also a systems way of thinking that can help to ensure nutritious foods for everyone at all times without damaging the planet. Efficient investments which target the weakest nodes and individuals are, however, critical to build a resilient global food system. This presentation will provide an overview of shocks that affect the global food system, highlight lessons learned from IFPRI's recent 2020 Resilience Conference, and outline recommendations for effective global food and agriculture governance.

Keywords: Resilience

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Empowering Rural Women: A Solution to End Hunger

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According to FAO's data, about 795 million people in the world today are undernourished and the majority of these live in developing countries where women constitute almost half (on average, 43 %) of the agricultural labour force (FAO 2011). Based on FAO report (2011) the agricultural sector is underperforming in these economies and among the reasons is that rural women do not have equal access to the resources they need to be more productive. Giving them the same access as men to agricultural resources and services, women could increase yields on their farms by 20–30 percent. Rural women are farmers, income earners, entrepreneurs, managers of natural resources and care takers for their households. Empowering them brings gains to society at large, not to mention increasing agricultural production, promoting food security and nutrition and boosting the economy.

FAO is working to foster an environment (global, national and community level) that promotes rural women's empowerment with a view to ensuring food security and nutrition. This presentation will show how FAO is providing such an environment at the global level through the implementation of Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (GVVTs). At national level, the presentation will show how FAO is collecting and analysing country level data on land. At the community level, it will show how FAO is working to empower rural women and men by offering platforms to access information and voice their needs.

Another growing area of work that promotes women's empowerment is on Social Protection Systems. The presentation will illustrate how FAO is unleashing rural women's opportunities through social protection systems, in order to enhance their access to decent work, control of income, ownership of productive assets, and participation in social networks. FAO's work demonstrates that social protection programmes – such as cash transfers, public works, asset transfers, and micro insurance schemes, if well implemented, have a great potential for fostering rural women's economic empowerment and provide a viable solution to end hunger, especially if they are complemented by other livelihood interventions.

Keywords: Country data, empowerment, food security

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IITA, the Lead Research Partner Facilitating Agricultural Solutions to Overcome Hunger and Poverty in Sub-Saharan Africa

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For IITA to thrive and meet the expectations of the wider agricultural community in sub-Sahara Africa it must: (i) continue to occupy the Research for Development (R4D) high ground and raise its profile among local and international partners; (ii) conduct rigorous, well-focused research and assure its delivery to end users; (iii) manage its human, physical and financial resources more effectively and (iv) expand its partnership with both the public and private sectors and more convincingly advocate for needed policy change at many levels across the continent. These are challenging goals, and closing the yield gaps of key commodities in a sustainable manner, as referred to in our Refreshed Strategy 2012–2020, requires doubling the current human and financial resources available to IITA over the next eight years. During the past four years. IITA has increased its funding from the $47 million in 2011 to $143 million today and the number of international staff from the 115 to 230. It is making progress with its partners to raise over 11 million Africans out of poverty and redirect over 7.5 million hectares of under-utilised, marginal and degraded lands to more productive and sustainable use, and guided by and contributing to the four System Level Outcomes (SLOs) as defined by the CGIAR: reducing rural poverty, increasing food security, correcting under-nutrition, and promoting more sustainable management of natural resources. IITA has prioritised formulation and delivery of its R4D products. As the Dalberg review commissioned by the CGIAR Consortium Board concludes, the CGIAR has fallen short of effectively translating its excellent science into impact on the rural poor. IITA has recently achieved several research breakthroughs from its core research projects that have the potential to greatly improve the lives and livelihood of these clients. Furthermore, IITA is fine-tuning its delivery systems as indicated through the early achievements of our Business Incubation Platform (BIP) and its Aflasafe, Nodumax and GoSeed product lines. IITA is refining its strategy to direct rural youth from diverse competencies toward agribusiness careers through the Youth in Agribusiness (IYA) program. We are engaging the private sector and strengthening our partnership with National Agricultural Research Institutions (NARIs) and regional organisations by establishing and coordinating major platforms such as the West Africa Biosciences platform; the Pan-African Platform for Soil Research for Development and a Regional Research and Training Centre to link climate change with biodiversity and biotic stresses.

Keywords: Research for development

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The Challenges of the Hub & Spoke Model. A Tanzania Case Study

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Kilombero Plantations Limited (KPL) is a greenfield 5,000 ha commercial farm that broke ground in 2008. The smallholder project started the following year and has now trained 7,403 neighbouring rice farmer families, transforming their yields and their yield potential. Both the commercial farm and smallholder project face large challenges. Both have suffered from a volatile market stemming from government policy decisions and bad governance. Both must cope with the absence of basic infrastructure and the underdevelopment of site-specific agronomic knowledge and inputs. Access to credit, a critical component in maintaining high productivity and rising out of poverty, is particular smallholder obstacle. KPL's short history illustrates successes and the long path of a work still in progress.

Keywords: Commercial farm, smallholders

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Agroecology: Enhancing Food Sovereignty and Resilience to Climate Change

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The realisation of the contribution of peasant agriculture to food security in the midst of scenarios of climate change, economic and energy crisis, led to the concepts of food sovereignty and agroecologically based production systems to gain much attention in the developing world in the last two decades. New approaches and technologies involving application of blended modern agricultural
science and indigenous knowledge systems and spearheaded by thousands of farmers, NGOs, and some government and academic institutions are proving to enhance food security while conserving agrobiodiversity soil and water resources conservation throughout hundreds of rural communities in the developing world. Case studies from Latin America are presented to demonstrate how the agroecological development paradigm based on the revitalisation of small farms which emphasises diversity, synergy, recycling and integration, and social processes that value community participation and empowerment, proves to be perhaps one of the only viable options to meet present and future food needs. Given the present and predicted near future climate, energy and economic scenarios, agroecology has emerged as one of the most robust pathways towards designing biodiverse, productive, and resilient agroecosystems available today.

Keywords: Agrobiodiversity, agroecology, climate change, paradigm

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Livestock and Water Linkages - Opportunities for Sustainable Intensification

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Large quantities of water are appropriated to produce the feed annually consumed in global livestock production. Rising concerns about increasing competition for water resources and projected increase in demand for livestock products make it imperative to look for strategies to sustainably increase livestock production, with water being one key natural resource to consider.

Using a combination of different datasets, a mechanistic livestock model, and a dynamic vegetation model, we estimate the annual consumptive water use (CWU) in the global livestock sector associated with crops and fodder cultivated on cropland and grazed biomass from pastures.

We go beyond earlier studies and explicitly account for the generally lower suitability of pasture CWU for crop production. Thus, from a water resource perspective, we can demonstrate that ruminant rearing can be a quite resource efficient alternative, in many cases even a better choice than to grow crops.

In the next step we use our analytic framework to quantify the effect of increasing the amount of crop-based feed to the diet of ruminants. For dairy cattle the results show an increase in protein production per m^3 of cropland CWU that lie in the upper range of protein water productivity for crops. For the less efficient beef cattle production, estimated increases correspond to the lower range for crops, but generally exceed protein water productivity of pigs and poultry.

For scenarios with constant global production of both the dairy and beef sectors, we find that the increase in productivity in some cases can result in an overall decreased pressure on water resources, despite the increase in cropland CWU needed to produce the additionally required crop-based feed. Whether a shift towards more cropland CWU can help to decrease pressure on water resources essentially depends on the amount and suitability of the saved pasture CWU for crop production.

Keywords: Consumptive water use, livestock, sustainable intensification, water productivity

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Reversing Natural Degradation into Resilience: The Afar Case

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In Afar region, pastoralists and agro-pastoralists, a semi-mobile population, belong mostly to hierarchically structured clans. They use traditional farming systems that were previously sustainable. More than half of the 1.4 million inhabitants (56 %) live below the poverty line. The main cause of the increasing degradation of natural resources is their excessive use, which is on the rise due to strong population growth, high livestock density and reduced access to land. The validity of former land-use arrangements is being weakened by conflicts among clans and competition between traditional ownership rights and the official land ownership claims of the government. Increasing degradation of vegetation and soils is accompanied by lower yields. Pasture land for herds is reduced; some areas are no longer available for production at all, and the growth of fodder plants decreases both in quantity and quality. Crust formation on the soil surface reduces water infiltration and most of the rain runs off. This surface water rapidly accumulates and causes deep erosion gullies through which the water quickly drains off the land. Groundwater levels drop, making less water available for people, animals and plants. Droughts and floods lead to crop failure and the loss of animals. Acute malnutrition is therefore widespread in the Afar Region, which especially effects women, infants and young children due to insuffient diets. Also conflicts are getting more.
Approach: GIZ implements a new approach to Ethiopia, using soil and water harvesting methods successfully tested in the Sahel. In the fertile but degraded valley areas, the effects of strong runoff of rain water and sporadic flash floods are reversed by a holistic approach based on water-spreading weirs. This leads to the rehabilitation of the valleys which can then be used for cultivation of animal feed and food and provide access to water for people and animal. River banks with their trees are protected and the groundwater level rises providing water for shallow wells. This approach combined with intensive training strengthens the resilience of the pastoralists and agro-pastoralists to the impacts of climate change offering economic options and reducing conflicts.

Keywords: Food security, gender, reduce conflicts, soil rehabilitation

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Agricultural Water Productivity Across Landscape Positions and Management Alternatives

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We examine the variation in water productivity across landscape positions as influenced by slope and prevailing crop management practices for the major crops grown in the Blue Nile Basin. Two watersheds were selected in the basin and each was divided into three landscape positions; summit, backslope and footslope. For each position, crops that together cover at least 70 % of that particular area were selected and monitored on five farmers' fields, in terms of variety selection and crop management practices. Soil and climate data for each landscape position were used to estimate crop water requirements of nine crops (maize (*Zea mays* L.), wheat (*Triticum aestivum* L), barley (*Hordeum vulgare*), potato (*Solanum tuberosum*), tef (*Eragrostis tef* Zucca), sorghum (*Sorghum bicolor*), finger millet (*Eleusine coracana*), niger seed (*Guizotia abyssinica*) and sesame (*Sesamun indicum*)). The effective rainfall during the growing period was estimated using FAO-CROPWAT model. The feed value of the crop residues was assessed under three livestock breeds and feeding scenarios. We found that water productivity was significantly affected by the landscape positions, crop type and management practices. Water productivity was the lowest in the backslope area, which is characterised by steep slopes and severe soil erosion. Irrespective of the landscape positions, improved crop varieties and livestock breeds and improved management practices substantially increased water productivity of the crop-livestock system. Widespread adoption of these improved options tailored for the landscape positions may significantly enhance income and livelihoods of the farming communities, provided their access to input and output markets is facilitated. This underpins the need for rigorous enforcement of the land use policy that favours the use of land according to its potentials and with suitable management practices.

Keywords: Backslope, blue Nile Basin, CROPWAT, Ethiopia, footslope, land use, summit

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Watershed Management: Efforts Beyond Plot/Farm Level in the Sudanian Zone of Mali: Review of Practices

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Most agronomic researches in support of development in Mali have emphasised on farm-level productivity issues with limited scope for managing interactions among components and actors beyond the level of the farm. While component integration at farm level addresses the interaction of components within a single farm, integration at watershed level addresses component interactions between farms and between farms and other landscape units (forests, springs, ground water sources, rivers etc.). Obtaining maximum benefits out of these component interactions requires the people of the watershed to collaborate with each other and often with outside parties providing services as well. The current paper discuses mechanisms of establishing a community managed watershed learning site in the Sudanian zone of Mali for research and capacity building. Review of the existing problems of rainfed agricultural practices at plot/farm level was conducted to define major constraints and methodologies to achieve a collective action through community participation. Biophysical characterisation was conducted using data collected from climate, soil, shallow wells, rivers and available intervention measures in the study area. New sets of hydro-meteorological monitoring stations that include weather station, ordinary rain gauges, soil moisture and ground water monitoring were established to generate new set of data. Remote sensing based study of land use / land cover (LULC), changes in LULC over time (1991, 2002, and 2013) was conducted using Landsat imagery to quantify changes over time and evaluate post intervention changes. Steady increase in cropland has been observed from 1991 to 2013 from 1618 ha to 2498 ha. This is due to increased availability of water from shallow wells and farm level constructed contour bunds which have increased over time. The role of NARS as a reliable partner was assessed to develop sustainable watershed programs. The paper concludes with a discussion on key implications of the methodology, policy frameworks and further actions for watershed development programme in Mali.

Keywords: Agricultural productivity, land use/land cover, Mali, watershed management

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Conflict Potential over Water Resources and Effects of the Water Management at the Bathi River

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Water is one of the most substantial resources for life. It is under threat by different effects, which include, but are not limited to: Anthropogenic pollution, deforestation, higher demand and climate change. Communities affected by changing water patterns are exposed to higher stresses, which may lead to increased conflict potential. The township of Kimende, south of the Aberdare Ranges in Kenya has high precipitation and is not yet prone to water scarcity. The Bathi River, which springs north of the township, supports many adjacent farmers and is a tributary feeding the Athi-Galana River.

The willingness of investment is restricted to water abstraction, like. e.g. pumps, but is not expanded to conservation, as e.g. by higher efficient irrigation techniques; this may lead to a situation where water scarcity becomes a hindering factor for economic growth. Illegal activities such as farming close to the stream and construction of dams without permits provide potential local conflicts between farmers. Forested areas between Kimende and Kagwe prevent from regional conflicts, since discharge increases significantly after the forest.

Local farmers report uniformly reduced discharge during the last years. Quality changes are mostly perceived as increased sediment load in the stream. The awareness of the connection between personal practises and environmental impacts increases with education.

Attempts to manage the water resources fail with the improper implementation and enforcement of laws and the poor acceptance of trainings and education by farmers. Key challenges lie in the communication between authorities and farmers to sensitize for individual impacts on the water resources.

Keywords: Bathi River, conflict, irrigation, Kenya, Kimende, management, water scarcity

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Application of Water Recovery Option for Agricultural Use in Developing Countries: Case Study of a Nigerian Community

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Africa's current population of 1 billion people is estimated to increase to 1.8 billion in 2050. This compliments the fastest growing population rate which stands at 2.4 %. Moreover, 40 % of Africa's land is arid while another 27 % is desert leaving a common conclusion that water is a crucial resource with tremendous implication on African development. The rapid urbanisation and growing population in African cities has resulted in new water management challenges. About 85 % of water in Africa is used on agriculture. Only 10 % and 5 % are used in households and industries, respectively. The objective of this study was to appraise the different methods available for water collection, treatment and reuse for agricultural purposes in sub-Saharan Africa. The study involved the assessment of available methods used by farmers for the promotion of agriculture. The study deployed the use of in-depth interviews, onsite investigation and group discussions in various areas in a typical semi-urban city in southwest Nigeria. The procedure combines descriptive data on the amount of water used per day on farms, sources of the water used, purpose of the water used and the size of the farm. Results of this study showed that a comparatively large volume of water being used for agricultural sustenance is withdrawn from natural aquifer storages. This poses a challenge and threatens global effort of achieving the United Nation's water-related Millennium Development Goals (MDG 7c) in developing countries aimed at making potable water available for millions of people. It was concluded that a sustainable, de-centralised wastewater treatment plant can be deployed for irrigation purposes in order to reduce pressure from agriculture on groundwater resources and, at the same time, encourage artificial recharge of wells. Also, adequate and efficient water management procedures which would help to overcome emerging water challenges were proposed.

Keywords: Agriculture, Nigeria, reuse, treatment, wastewater

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Streamflow and Lake Water Level Changes and their Attributed Causes in Eastern and Southern Africa

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Over the last century, changes in the water balance of river basins have been observed in many African countries, often resulting in water scarcity. Agricultural development hereby often has a direct impact on basin water resources. On the other hand, sufficient water availability is a pre-condition for sustained agricultural production and food security.

The presented review was conducted in frames of the BMBF funded Trans-SEC project (FKZ: 031A249A). It aims at compiling information on water resources development in Eastern and Southern Africa over the past century, and systematically analysing the obtained data base for patterns, trends and correlations between the nature and quantity of the described changes, as well as the attributed reasons.

The findings indicate that anthropogenic actions, foremost land use change and water abstractions for agriculture, are the primary drivers of change in drainage basin water balance and commonly associated with increased runoff and flooding as well as decreased dry season flow. The described pressures in Eastern and Southern Africa are mainly driven by population growth, whereby the vast majority of agricultural activities are conducted by small-scale subsistence farmers. Already, conflicts between the use of scarce land and water resources are evident, which are often further amplified by the expanse of irrigated cash crop and intensified food crop cultivation.

The regions with the reportedly most intense changes and highest number of water conflicts comprise the northern Rift Valley, and an area stretching from Lake Victoria and the Southern Rift Valley region towards the Indian Ocean coast in Tanzania. With respect to the sustainable enhancement of food security, colliding stakeholder interests here need to be gauged against the limits of available natural resources, underlining the need to diligently consider agricultural development strategies in regard to the available natural, and especially water, resources.

Keywords: Agricultural development, climate change, floods, land use change, water resources, water scarcity

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Role of Drainage in Managed Agrosystems Affected by Technical Changes: Case Study of Gharb's Irrigated Area, Morocco

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The drip irrigation technique is currently spreading at high speed around the world, including the Maghreb. This dynamic is observed among farmers outside irrigated areas as for those in the large irrigation schemes, with strong state's financial support for farmers to access these facilities (grants for collective or individual conversion). The irrigation drip, unlike the surface flow irrigation, brings a small and regular amount of water at the foot of the plant, and thus requires more drainage system to drain excess water. However, drainage as designed in large irrigation schemes, also played a role in the mastery of salinity on irrigated soils. Thus, the monthly monitoring of land (climate and water parameters) with the modelling of hydrosaline balance (SALTIR-SOIL) highlights the interest of the drainage in semi-arid areas for the control of salinity, and the interest to equip some drained plots with a measuring device.

Our study analyses the role of drainage on soil quality, agricultural production and the surrounding ecosystems in irrigated or remediated systems under constraints related to technical changes: the state of knowledge, practices and perceptions of farmers in the plain of Gharb in Morocco.

The research aims primarily a review of literature on traditional techniques on alternative drainage, to take advantages of alternative practices, and failures related to absence or unsuitable drainage design.

For the investigation open-ended interviews, surveys, PRA methods and natural science methods such as soil salinity detection were carried out between 20th April 2015 and 15 August 2015 in Gharb zone, Morocco.

The initial findings show that, in a food resource security context, the question of the re-engineering of former hydraulic schemes that control the ion and water balances in agro-hydrological systems seems major to ensure equitable sharing of natural resources, and the preservation of biodiversity.

Geographical information on the biophysical environment and irrigation practices may help to identify risk areas. The objective is to characterise salinity processes and to propose technical methods of land segmentation and water management according to the risk factors involved.

Keywords: Drainage, farmers perception, food security, Gharb irrigated area, irrigation practices, managed agrosystems, Morocco, salinity, technical changes

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Assessment of Irrigation Schemes in Turkey: Cropping Intensity, Irrigation Intensity and Water Use

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In Turkey, 1/3 of total agricultural areas have the potential to be economically irrigated. However, only half of this avaliable areas are open for irrigation and when irrigation intensity are taken into account, nearly 65% of the areas that are open for irrigation are actually irrigated. In our country, 70% percent of water consumption is based on agricultural purposes. In following years, water management will gain further importance to be able to answer to the increasing demand of water industry and tertiary sectors. In this study, variance between 2000 and 2013 were evaluated with regard to water usage, irrigation intensity, and cropping intensity indicators on irrigation areas which cover 2.847.382 ha of land in Turkey. In the evaluation of cropping intensity, the distrubition of crops in irrigated areas was identified as a percentage value. Most planted crops in irrigation schemes are corn, cotton, cereals, fodder crops and sugar beet, respectively. Cropping intensity was different from each other over all years. In specifying the field usage levels, irrigation intensity indicators and differences between irrigation intensity in the past 14 years in transferred and non-transferred irrigation schemes to a water-users' organisation were identified. The annual irrigation intensity was compared for 257 irrigation schemes (245 transferred and 12 non-transferred schemes) in Turkey. Irrigation intensity in the transferred schemes was higher than that of the non-transferred schemes. In order to evaluate the amount of water per unit area a use indicator was considered. This indicator increased every year. The amount of water supplied to the unit area also varied from 27.237 to 34.699 million m^3. Consequently, cropping intenstiy, water usage and irrigation intensity were changed in between 2000 and 2013 because of global climate changes, water scarcity and increasing water demand. In order to ensure the effective water usage in irrigated areas, efficient and rational irrigation management, information system for monitoring and evaluation which encompasses all stakeholders should be set up and irrigation scheduling and modernisation of the irrigation systems should be designed.

Keywords: Cropping intensity, irrigation intensity, irrigation management, irrigation scheme, water use

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Optimisation for Coastal Land by Applying Smart Combine Irrigation Systems for Eco-Friendly Agriculture in Yogyakarta, Indonesia

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Agricultural lands begins to shrink with population growth, while the need for food is increasing. Marginal land such as coastal land has a great potential to be developed as agricultural land. However, the use of coastal areas for agriculture impacts on the increase of water demand in that area. Besides its low water storage ability, salt content on the surface of leaves and soil caused by salt sea breeze also requires water for the salt washing process. Further, high evapotranspiration levels increase the need for irrigation.

Water in coastal areas is obtained by pumping groundwater. However, excessive and uncontrolled pumping will cause environmental damage such as sea water intrusion (intrusion of salt water from the sea into fresh groundwater), and impact the scarcity of clean water. Such conditions also contributed to the decline in agricultural production in coastal areas, since the amount of fresh water for irrigation is limited.

A solution is needed to overcome the danger of this sea water intrusion. Smart combine irrigation system technologies can be applied for an accurate and water-saving irrigation. Drip irrigation systems will save water consumption. Irrigation sprayer can be used to eliminate the salt levels on the surface of the plant. Both irrigation systems will be sensor controlled systems so that the provision of water will be more precise and will save groundwater in order to create eco-friendly agriculture

A smart combine irrigation system is an appropriate technology in the land management of coastal areas, and gives a positive contribution in solving the problems of agricultural development of coastal land. Therefore, besides contributing to food security, environmental conditions will also be maintained with eco-friendly agriculture.

Keywords: Coastal areas, combine smart irrigation systems, eco-friendly, intrusion, needs for food, water availability

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Biochar and Woodchips as Alternative Filter Materials for Pre-Treatment of Wastewater with Roughing Filter

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Wastewater reuse could help to reduce the pressure from global water scarcity, especially in arid and semi-arid regions. Efficient and cheap water treatment technologies need to be developed, particularly in low-income countries where wastewater treatment is often lacking. Slow sand filtration (SSF) is a proper, efficient and well known technology to reduce the amount of pathogens and turbidity. However, an efficient use of SSF requires low water turbidity to prevent rapid filter clogging, which could be achieved by an upstream roughing filter (RF).
The focus of this study was on the evaluation of biochar and woodchips as alternative and locally available filter materials in RF as pre-treatment for SSF and low cost production of safer irrigation water for urban agriculture in developing countries.
The experimental setup consisted of nine glass columns, which were filled in triplicates with biochar, woodchips and gravel (grain sizes: 5–16 mm). Filters were fed with raw wastewater from the municipal treatment plant Ölbachtal (Bochum, Germany). Samples of influent and effluent were taken once per week and analysed for the fecal indicator bacteria (FIB) *E. coli* and intestinal enterococci, using the Most Probable Number (MPN) method and physico-chemical parameters (e.g. turbidity, chemical oxygen demand, electrical conductivity, pH).
FIB concentration of raw wastewater was in the range of 10^6 to 5×10^7 MPN 100 mL^{-1}. Removal rates for enterococci and *E. coli* were in the range of 0.5 to 1.5 $\log_{10}$ units MPN 100 mL^{-1}, which is similar to other published results with respect to RF. Influent turbidity was in the range of 60 to 360 NTU. Beside FIB, turbidity (effluent turbidity below 35 NTU) and COD (reduction up to 89 %) could be significantly reduced and effluent of all filter types were expected to be suitable for further treatment with slow sand filtration. Over the entire observation, biochar filter showed slightly higher removal rates than other materials. Overall, roughing filter seems to be a proper pre-treatment step for wastewater treatment with SSF.

Keywords: Biochar, BMBF-GlobE, roughing filtration, UrbanFood^{Plus}, water reuse

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Analysing the Linkages of *ex-ante* and *ex-post* Coping Strategies to Flood Damages: Implications for Sustainable Flood Management in Rural Pakistan

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Pakistan is highly prone to flood hazard and faces a severe threat of this disaster under changing climate scenarios. Being an agrarian economy, rural households have been directly and indirectly affected by frequent flood events during the last two decades. Along with the presence of fragile flood protection infrastructure coupled with a flawed flood management system, rural households suffer heavily by these events and try to cope with varying degree of approaches and strategies. This study aims at exploring the range of coping responses and adaptation techniques of rural households and their linkage to flood damages in a previous flood event. For this purpose, a survey of flood-affected households in 5 districts of the country is carried out after the incidence of 2010 floods. Questionnaire-based field data is collected through multistage random sampling technique. Reported damage indicators are indexed and factor analysis is performed using polychoric correlation. Impact of various *ex-ante* coping strategies on indexed damage indicators is evaluated using multiple linear regression. Results indicate that weak to strong correlations exist among different damage indicators and *ex-ante* and *ex-post* coping responses. Moreover, overall flood damage for a farm household is found to be negatively and significantly affected by installing sand bags, seeking information about the flooding problem and leaving house before flooding. Elevating house, attending government meetings about flooding problem; and signing petitions and memos to resolve flooding problem are found to be positively affecting damage in a flood event. The study concludes with placing more emphasis on timely warnings, proper investigation of flooding problem and its likely impact on the community and strengthening of planning process through the involvement of community in order to reduce flooding risk in the study area.

Keywords: Adaptation, elevation, flood, household, mitigation, polychoric

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Enhancing Food Security through Soil Conservation and Other Land Management Options in Southwestern Nigeria

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It has been stressed that food security is one of the important conditions that must be achieved for an individual to be nutritionally secure and to maintain good health. In effect, household food security depends not only on the availability of an adequate and sustainable supply of food, but also on the strategies employed by households for its acquisition. Food insecurity for so many smallholders in the African continent has been reported to be due to the persistent problem of poor agricultural practices and technology used. Studies show that the adoption of improved agricultural practices and technologies may help stabilise production and lessen food insecurity. Among others, the factors that aid food production, its availability and its affordability are land use and tenure, soil management, crop breeding and selection, crop management, livestock breeding, and management. In this study, we used field survey data to estimate food insecurity incidences and to assess the impacts of the use of soil conservation and other land management (SC & LM) options among categories and groups of smallholders in two states (Oyo and Osun) of Southwestern Nigeria. The SC & LM options include soil and water management (mulching and irrigation); crop protection (herbicide and insecticide use) and crop management practices (thinning, inorganic fertiliser application, legume-cereal rotation). Results of data analysis of about 750 cross-sectional sample of smallholders obtained from the two states showed that food insecurity incidences are between 0.25 and 0.47 for smallholders separately practicing the SC & LM options. Food insecurity incidences are however noticed to be declining (improvement in food security) with increases in income as a result of consistent practices of the SC & LM options by the different groups of sampled smallholders. There are also improvements in food security with changes in some socio-economic, farm and institutional variables among the groups of respondents investigated. Generally, the use of the SC & LM options impact positively on food security, implying that efficient use of appropriate land management practices is consistent with increase in income and effect food security.

Keywords: Food security, smallholders, soil conservation and land management, Nigeria

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Accessing Newly Accreted Land by the Poor Farmers: Innovations Toward Food Security in Bangladesh

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Bangladesh has an estimated 1723 square kilometers of newly accreted lands, locally known as char land, emerging from water in the major river systems and the Bay of Bengal. Bulk of these lands is located throughout the banks of Brahmaputra / Teesta river system in the North and along the southern coastal districts of the country. While the char lands in the inland river systems are composed of coarse sands, those in the coastal regions are made up of silt and clay. By definition, these new marginal lands belong to the government, but in reality these are occupied, accessed or used by settlers in the vicinity of these chars for sandbar cropping and food crops. In a land scarce country like Bangladesh where average farmsize is hardly 0.5 hectare with one-fifth of rural households being functionally landless, the main importance of these lands is that the poor farmers, who are displaced settlers due to recurrent river erosion, produce food crops such as rice, maize, pumpkins, vegetables and fruits and raise livestock animals on these unfavourable lands. Access to these marginal lands does not only provide food security but also create livelihood opportunities for the extreme poor. This paper presents examples from two locations of Bangladesh, one from Rangpur chars in the North and the other from Noakhali chars in the South to illustrate the process of how the poor get access and retain their access to these lands, and how the conflicts over ownership or use rights to lands are resolved through the community participation facilitated by the local government authorities, land record department, agricultural extension services, local elites, land holders, settlers, national and international NGOs and private sectors. This will also reflect on improved management of land through changing cropping patterns, adoption of new technology, farmers' training, soil salinity in coastal chars, social forestry, and homestead gardening for household food security. Finally, this paper will highlight important policy options for char land management, research - extension - farmer linkages, technology dissemination, product supply chain development, and potential areas of collaborative research for best use of char lands.

Keywords: Accessing land, char land, community participation, land record, sandbar cropping

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Resource Management and Food Security of Small Scale Farming Systems in the Tien Shan Mountains of Kyrgyzstan

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The upland grasslands and meadows are one of the most important natural resources in Kyrgyzstan, covering up to 85 % of the designated agricultural areas. Most of the crop and livestock based small scale farms are located there, faced with degradation and loss of biodiversity due to overgrazing. Hence, proper pasture land management is one of the key issues to ensure long-term productivity for the farmers in the region. To increase proper management on pasture land, regulations to avoid overgrazing were enforced by the government, however, without much success until now. One of the main reasons for little success is the lack of knowledge about the prevailing small scale farming systems – their production systems, their resource management, their household economy and food security status and about the objectives and targets of the farm families. Agricultural research largely focuses, like during soviet time, on the economic development of large scale farming.

The present work focuses on developing the appropriate classification methodology to characterise and identify prevailing farming systems in the lower and middle elevation mountain pastures, in order to assess productive management methods of pasture land and other resources to ensure sustainable development pathways for the small family-based farms. The paper focuses on the characteristics and differences of the identified 'Postsowjet Jailoo Farming Systems' in terms of resource management, production system and household economy, and emphasises on the linkages to farm- and family income. Results further show distinctive characteristics in the length of pasturing, the size of cultivated land and the off-farm income. The authors indicate, how socio-economic parameters of these farming systems demand for different approaches for sustainable land management.

Keywords: Central Asia, mountain pastures, pasture management, upland farming systems

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Competing Land Use in the Area of the W Biosphere Reserve, Benin Republic

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The W Biosphere Reserve (WBR) is a nature reserve located in northern Benin and where nature, pastoralism and crop production compete for the use of land. The present study aims at assessing the extent of the competing land use inside the WBR and in its surrounding lands and to analyse the important drivers. To assess the competing land use, GIS data from 1994, 2004 and 2014 were analysed whereas to analyse the drivers, data were collected from regional statistics, community meeting and individuals interviews with pastoralists, crop farmers, members of village association for wildlife management and rangers. Food crop area and cotton cultivation area have expanded over time in the surrounding lands of the WBR while they have declined inside the WBR. It was found that the increase of cropland has been driven by population growth in combination with other factors such the increasing national and regional demand of food crop products, the institutional arrangement and infrastructures in the cotton sector and the use of animal traction in crop farming operations. So, the increase of food crop and cotton cultivation put pressure on prospective agricultural lands and grazing lands. As a result, traditional grazing lands and riverbanks are also converted to crop lands. As a consequence, pastoralists and some crop farmers moved illegally inside the park, either to sustain the feed of their animals, or to clear land for cropping. Because of the reinforcement of patrols by rangers inside the WBR, grazing lands largely diminished and the total number of livestock of pastoralists in the area has declined. Since livestock is still important for livelihood of smallholders and for sustainable food crop production, there is a need for innovative strategies to integrate crop production, livestock production and conservation.

Keywords: Benin Republic, competing land use, conservation, crop production, drivers, livestock, pastoralism, W Biosphere Reserve

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Climate Impacts on Global Agriculture and Land Use Change: Insights from the Agricultural Model Intercomparison and Improvement Projekt (AgMIP)

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In order to understand the impacts of climate change on agriculture and land use, research in AgMIP strives to integrate biophysical crop models with economic models on agricultural production, consumption, and trade. Climate change will, on average across the globe, lead to reduced yields, changes in production patterns and higher food prices. By comparing various models in the different domains, the uncertainty ranges in future projections can be better understood. Moreover, global model results provide valuable inputs for regional and local studies on climate change adaptation in agricultural resource use.

Keywords: Climate change, crop models

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Climate Change Adaptation, Local Level Institutions and Livelihood Dynamics in Rural Ethiopia

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Climate change is suspected to affect the livelihoods of rural households in Ethiopia, especially through increased likelihoods of extended droughts, and unpredictable rainfall variability. Specifically, its impact is much more exacerbated on those households who predominantly depend on rain-fed agriculture for their livelihoods. Projection of future climate also reports the increase in the mean annual temperature and increase in precipitation variability which make the livelihoods of rural households more vulnerable. These scenarios are most likely to further exacerbate the current underdevelopment, poverty and food insecurity in the country and in particular to the poor rural households. Adaptation is a vital part of a response to the challenge of climate change for local households in rural community. This research aimed to understand the role of local level institutions in the climate change adaptation process using two communities in the Northern Ethiopia; Harresaw community in Tigray region and Shumsheha in Amhara region.

The presentation offers empirical results from two communities in the northern part of Ethiopia. The analytical results of the two communities indicated that rural households in the two communities have different adaptation strategies to climate change. However the two communities have different forms of adaptation strategies. Especially the importance of these strategies differs significantly among the two communities and different household groups. These strategies are shaped and facilitated in the two communities by the local institutions differently. The study also found out that local institutions in two communities, differently, enhanced and at the same time undermined the adaptive capacity of the rural households.

Keywords: Climate change adaptation, institutions, livelihoods

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Organic Farming to Cope with Climate Change — Raising Awareness for the Management of Systemic Interfaces

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The aim of this project is to identify and implement climate change coping strategies in smallholder farms (including household and farm). The project is funded by KEF and BMLFUW, from Austria and BMU from Germany, within the framework of EU ERA ARD. The partners are the Division of Organic Farming / BOKU, Austria; University of Hohenheim, Germany; Bahar Dar University, Ethiopia; ARARI, Ethiopia; Egerton University, Kenya; and KARI, Kenya. The project commenced in January 2013 and will continue until 2016. The project consists of three components that are field trials, the development of farm specific innovation plans to cope with climate change and a collaborative learning community between farmers and researchers. We observe that many adaptations toward climate change are already well known in scientific literature, but neither communicated by advisory services, nor established at farm or household level.

Positive impact of organic methods in our field trials is already visible, while it is to keep in mind that the whole potential of implemented clover fodder legumes, farmyard manure and green manure from alley shrubs on yields will first only fully materialize after in minimum three years. Innovative ideas to increase organic matter and to add protein fodder, e.g. with tree lucerne, fail, when farmers finally cut all branches, let them dry and burn the whole material. Farmers are also not motivated to produce more milk with e.g. alfalfa or clover, if there is no processing unit and no access to markets.

Our preliminary conclusion is that farmers' adaptation of farms and households strategies to cope with climate change with organic farming methods is a long-term process. Instead of sector specific advice, the whole advisory strategy must change into a systemic approach that includes household and farm activities. The teaching system should orient itself toward site specific selection and implementing a broad range of climate change adaptation techniques. While this is already the case at some sub Saharan universities, we observe that education continues to predominantly follow a mainly top-down, disciplinary approach, with mainstream agriculture training, excluding organic and agroforestry methods.

Keywords: Awareness, climate change, organic farming, smallholder farmers

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Adopting Climate-Smart Strategies and their Implications for Food Security

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In order to provide food for a growing population in Tanzania, there is pressure to increase its agricultural production. In the light of climate change, small-scale farmers have started to adopt strategies to sustain their food production. The objective of this paper is to explore which strategies small-scale farmers adopt and which factors determine the adoption decision. Furthermore, it aims to analyse the implications of adopting climate-smart strategies for food security. The analyses are based on a household survey conducted in 2014 with 900 small-scale farmers in rural Tanzania. The randomly selected households were either located in a semi-arid or in a semi-humid regional setting. The results indicate that the main climate-smart strategies adopted by farmers, include fertiliser use, tree planting and adjusting the crop portfolio, i.e. increasing or decreasing the variety of planted crops. According to the farm households, these activities are considered as long-term adjustments to climate change. The adoption decisions have been found to depend on the number of income sources of the farm households. Thus, a household with more diverse income sources is less likely to adopt a climate-smart strategy. Further, an increasing distance to village centre has a negative influence on the adoption of the more capital intensive adjustments such as tree planting. Farmers with higher risk-taking attitudes are more likely to adjust their crop portfolio or increase their fertiliser use. Very important is also that farmers more easily adopt all these climate-smart strategies (except for decreasing the variety) if they have seen these from others. This finding suggests that on-farm trials with farmers' participation can be effective in promoting climate-smart strategies. The implications for the food security of the farm households have been proxied by the Food Consumption Score (FCS). The t-tests suggest that adopters of crop diversification have on average a higher FCS than non-adopters. Fertiliser users are on average less food secure with a lower average FCS but they also have on average a lower net income than non-adopters. This supports the assumption that the adoption strategy of fertiliser, including manure, is the first strategy chosen by relatively poorer farmers.

Keywords: Adaptation, climate change, food security, Tanzania

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Impact of Climate Change on Agricultural Production in North-West Cambodia

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In Cambodia, agriculture plays a main role to ensure food security and contribute to economic growth. Currently, this sector is strongly impacted by natural disasters (drought, flood and increasing insect pests and diseases) caused by climate change influencing farmer livelihoods. Therefore, this research was conducted to investigate farmer's agricultural practices, determine the impact of climate change on these practices, and to know how farmers adapt to climate change. 180 farmer households were selected to do individual interviews. Of 180 households, 90 households were defined as poor (ID poor) by Ministry of Planning and 90 households were common farmers. Semi-structured interviews were conducted with key main informants such as district governor, chief of commune, commune council and chief of village. The results demonstrated that both types of farmers mainly depend on rice cultivation in wet season. Most of the farmers use conventional practices and some farmers still use traditional agriculture equipments and animals (cow) in their rice production. Almost all the farmers use direct-seeding technique in growing rice. Because of the natural disasters, farmers don't want to invest money in agriculture production. The natural disasters (drought and flood) and insect pests destroyed rice production every year since 2010. To adapt to current climate change situation, half of the interviewed farmers have changed their rice varieties. Some farmers dig small ditches to mitigate the drought and flood and nearly half of interviewed farmers allow their family members to migrate to find a job in order to earn money for supporting daily livelihood and for starting up agriculture production again next year.

Keywords: Adaptation, agriculture production, climate change, poor farmer

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Determining Factors for the Application of Climate Change Adaptation Strategies Among Farmers in Magwe District, Dry Zone Region of Myanmar

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This study examined climate change adaptation strategies of farmers in the dry zone region of Myanmar. Farmers' adaptation strategies are influenced by many factors such as practical availability of the methods and socioeconomic conditions of farmers. They are moreover influenced by the perception of climate risk, and by farming difficulties. This research was carried out in Magwe district in the Dry Zone Region of Myanmar by randomly selecting 212 farmers in three Townships (Magwe, Yenanchaung and Chauk). A Multinomial Logistics Regression (MLR) was applied to assess the factor affecting to the choice for adaptation strategies by the farmers. The study found that in the past farmers used to apply traditional climate adaptation strategies. However, recently most farmers seem to shift to introduced adaptation strategies; while some farmers still use traditional adaptation strategies. The majority of farmers agreed that there is an impact of climate change on farming, and they strongly agreed on the impact on yield. In terms of adaptation strategies, the majority of farmers adjusted the planting and system method (56.1 %). Only 1.9 % of farmers did not employ any adaptation strategy. The study further identified perceptions about risk related to a changing climate such as water scarcity, growing indebtedness, and post-harvest losses. Farmers identified the small farm size, the lack of farm laborers, and low fertility of soil as important limitation to adopt introduced adaptation methods. The MLR model showed that livestock asset, liquidity asset, access to credit, income, public extensions, and farmer to farmer extension affect the choice of introduced adaptation strategies. The practical availability of the adaptation strategies, socioeconomic status of the farmers, and risk and difficulties of farming have significant impact and limit to the choice of adaptation strategies.

Keywords: Adaptation strategies, climate change, introduced methods, risk perception, traditional methods

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Potential of African Indigenous Vegetables to Contribute to Climate-Smart Food Systems

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Kenya has committed to reduce greenhouse gas (GHG) emissions from all sectors including agriculture being the major source accounting for about 34.6 % as outlined in the Kenya National Climate Change Action Plan of 2013–2017. This is in recognition to the serious threats posed by climate change on the country's efforts to alleviate poverty, achieve food security for all and enhance sustainable development. However, Kenya's growing population coupled with urbanisation have the potential to increase GHG emissions due to increasing demand for food and changing dietary patterns. Consequently, there is a need for the Kenyan government to promote high nutrition sensitive agricultural value chains in order to sustainably feed the growing population with low carbon food. African Indigenous Vegetables (AIVs) provide an opportunity to realise this climate-smart agricultural (CSA) development pathway. They are more profitable, adaptable to local climate variability, productive under low input systems and more popular among the growing number of urban dwellers in Kenya when compared to exotic vegetables. All arguments fit well to the three principles of CSA of sustainably increasing agricultural productivity and income, adapting and building resilience to climate change and GHG reduction. However, there is little data on GHG emissions and carbon footprints (CF) in AIVs smallholder production systems. Therefore, the first objective of this contribution is to fill this knowledge gap by showing results from existing literature on GHG emissions from African horticultural systems. Secondly, a comprehensive field research methodology on the measurement of on-farm N_2O fluxes using static chambers systems in smallholder AIV production systems will be presented. Lastly an estimation of CF per unit product of vitamin A, iron and protein per unit product of AIVs compared with exotic vegetables using Cool Farm Tool will be shown. This tool integrates several empirical models mainly derived from IPCC default values in a GHG calculator. The default values will be replaced by input parameters derived from activity data collected at farm level. The methods are essential for assessing current hotspots of GHG emissions in AIV smallholder practices and showing potentials for mitigation.

Keywords: African indigenous vegetables, carbon footprint, climate-smart agriculture, greenhouse gas emission

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Vulnerability to Climate Change of African Indigenous Vegetable Farmers in Selected Agro-Climatic Zones of Kenya

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Climate change and variability poses a major challenge to sustainable development in sub-Saharan Africa, slowing or even hindering the achievement of poverty reduction as demonstrated in the fifth IPCC report on impacts of climate change on ecosystems, food security, health, and water sectors. Given the adverse impacts of warming and changing rainfall patterns on food security on the one hand and the high importance of rain-fed farming for the smallholders' income and livelihoods, climate change particularly affects those economies largely depending on farming. In Kenya, 75 % of the population lives in rural areas and 68 % of the labour force depends on agriculture. About one third suffer from food and nutrition insecurity with national stunting rates of 35 % of children under 5 years. African Indigenous Vegetables (AIVs) are rich in micronutrients with the potential to close the large nutrient gap among poor and food insecure households, particularly for vitamin A, C, and iron, but also to balancing the diet by an improved protein-calorie ratio. Due to increased demand and general resilience of AIVs to local climate variability, AIVs are affected by but are part of the solution to adapting to climate change. According to the HORTINLEA panel survey (n=1234), 35 % of the AIV farmers experienced increased rainfall in the course of their lives and 19.4 % indicate hotter temperatures during the dry season. Water stress is observed in the sparsely populated arid and semi-arid lands (ASAL) (80 % of the Kenyan territory), while the humid and semi-humid agro-climatic zones experience irregular and heavier rainfalls. One third of AIV farmers do not know how to adapt to climate variability and less than 10 % invest in irrigation or money saving schemes, which suggests lower adaptive capacity. Finally, the case study methodology for measuring indicators for analysing adaptive capacities of smallholder AIV farmers in three agro-climatic zones (Kakamega, Nakuru and Kajiado counties) by multi stage purposive sampling procedure of 180 farmers is presented.

Keywords: Adaptation, African indigenous vegetables, agro-climatic zones, climate change impact, food security

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Yield Gap Analysis for Tanzania - The Impact of Climate and Management on Maize Yields

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For Tanzania, food security will be the biggest challenge in the next decades. One dimension of food security is the production of food. Because of limited extendable arable land, the yield (per hectare) must increase to achieve a higher food production. In Tanzania, maize (*Zea mays* L.) is the most important food crop, although the average yield is below 1.5 t ha^{-1}. Nevertheless, field trials show that Tanzania has a large potential to increase the maize yield and enhance food security. Therefore, regional-adapted agronomic practices are needed. The agronomic practices of the Trans-SEC upgrading strategies focus on the issue of both food security and environmental protection. To consider both issues under future climate conditions, crop models allow an impact assessment of agronomic practice and climate on actual (farm) yields (Ya). The Ya are limited by the water and nutrient supply and reduced by pests, diseases, and weeds. Without these limitations, potential (physiologically possible) yields (Yp) are achievable. The process-based model SWIM (Soil and Water Integrated Model) can compute the relevant impacts of agronomic practices on maize yields and thus shows projections to decrease the yield gap between Ya and Yp. However, not the entire yield variability of Ya and Yp can be explained by agronomic (fertiliser applications, crop varieties, sowing and harvest times) and climatic conditions. Additionally, the Ya are influenced by socio-economic and cultural impacts or unmodeled agronomic practices (e.g. plant protection). These impacts can be captured by the statistical crop model IRMA (Interregional Regression Model for Agriculture) by proxy variables or within collinear effects.

Keywords: Crop model, food security, maize, Tanzania, yield gap

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Yield and Biomass Gap Analysis of Maize in Ethiopia – A Case Study of Oromia Region

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Yields and biomass of crops must increase substantially over the coming decades to keep pace with food demand driven by increasing population and income growth. Agricultural productivity growth in sub-Saharan Africa over the past four decades averaged only 2.4 % compared with 4 % in the rest of the developing world. Ultimately global food production capacity will be limited by the amount of land and water resources available and suitable for crop production. Therefore future increases in production will mainly depend on closing the yield gaps or increasing the genetic potential of crops. Crop responses to changing temperature and incident radiation are visible in the potential yield, but even more in the simulated amount of potential aboveground biomass per crop. This variable expresses the result of biomass accumulation during the entire growing season, while the crop yield is accumulated during the second half of the growing season mainly. The biomass and yield gap was estimated for maize (*Zea mays* L) in three sites namely Jimma, Bako and Yayu in the Oromia region of Ethiopia which constitutes major maize production areas in Ethiopia. Potential and actual yields and biomass were estimated based on simulation runs with the SIMPLACE modelling framework and compared to yield statistics. The simulations were run at 38×38 km grid cells and yield was calculated for each simulation grid for the period of 11 years (2000–2011) and aggregated from the simulation grid to the district level for comparing them with the statistics. There were no spatial pattern in the average simulated yield and biomass gaps across the districts and there were no significant differences in the magnitude of these gaps. Yields gaps were mainly due to nutrient limitations because average farmer's N application rates to maize in this region are $<20\,\mathrm{kg\ N\ ha^{-1}\ yr^{-1}}$.

Keywords: Biomass gap, Ethiopia, food security, maize

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The Impact of Climate Modes and Precipitation on Tanzanian Maize Yield

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Previous research has shown the significant impact of the two climate modes El Niño/Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) on the interannual variability of Tanzanian rainfall. However, the relationship of these modes to crop yield in a country where agriculture is predominantly rain-fed has not yet been investigated. This study analysed in three steps the impact of ENSO and IOD, as well of the regional precipitation on maize yield in the East African country Tanzania. Correlation and multiple linear regression analysis were used to investigate the relationship between monthly climate indices and precipitation and annual maize yield data. IOD was shown to have positive and mostly statistically significant correlation with precipitation throughout almost entire Tanzania during October to February. ENSO has a comparably negligible, mostly non statistically significant impact on the Tanzanian rainfall. It was indicated, that the right timing of the precipitation is crucial for a good development of maize. From January to April, crops show increased susceptibility to drought. Too early precipitation (from August to December) can lead to crop failure. About half of the regions showed a month with statistically significant correlation of maize yield with precipitation. IOD is generally negatively correlated with the maize yield during September to November and positively during December to April. IOD has a stronger impact on maize yield than ENSO. Therefore, more attention should be paid on the Indian Ocean in future research. The available data was not sufficient to prove that climate modes affect the maize yield only via precipitation. A better understanding regarding climate modes effect on agriculture can contribute to a robust supply of food in a country, where food production comes mostly from rain-fed agriculture.

Keywords: ENSO, interannual variability, IOD, maize yield, rain-fed agriculture, rainfall

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Cost Benefit Analysis of Climate Change Adaptation Strategies on Soil and Water Conservation Methods in Northern Ghana

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Climate change, characterised by rising temperature and rainfall variability, is already having significant effect on crop yields and livelihoods of farm households in the agricultural production systems of Ghana. The trend in climate change is likely to continue and the effect is expected to become more pronounce, making farmers in particular vulnerable and putting agriculture in Ghana as a whole at a greater risk. Several technologies and indigenous adaptation strategies exist to mitigate the effect of climate change and to ensure adequate food production. Despite their importance in preventing nutrient loss, retaining soil moisture, increasing crop yield, and providing additional income for farm households, adaptation is an investment and requires that actors make the best decisions. Literature on climate change adaptation, particularly in sub-Saharan Africa, deal with impacts, vulnerability, and constraints to adaptation but only little is known about the micro-level costs and benefits of adaptation strategies. This study will identify soil and water conservation (SWC) methods as climate change adaptation strategies used by farmers, and conducts economic analysis of the identified strategies using data from 100 systematically selected farm households in northern Ghana. Preliminary results show that farmers adapt to change in climate by using SWC methods such as compost, vetiver grass, mulching, stone bonding, terracing, cover cropping, manure application. To access the economic benefits of these methods, financial indicators such as benefit-cost ratio (BCR), net present value (NPV), internal rate of return (IRR), and sensitivity analysis will be estimated. Adaptation strategies that have high BCR and NPV are efficient adaptation strategy. The adaptation strategy with the highest IRR is most economical. The sensitivity analysis will identify the most resilient adaptation strategy in terms of shocks such as policy change and severe climate incidence.

Keywords: Adaptation, climate change, economic benefits, economic cost, food security, Ghana

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Local Perceptions and Adaptation to Climate Change in North Kordofan State, Sudan

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Smallholder farmers in developing countries are the most vulnerable groups affected by the negative impacts of climate variability and climate change mainly associated with their low adaptive capacities. This study investigates farmers' perception on climate change and climate variability in North Kordofan State; identify local adaptation strategies and determinants of farmers' choice for adoption of adaptation strategies. Primary and secondary data was collected from relevant sources employing a combination of data collection tools. Household survey was the principal method followed for the collection of primary data from 140 randomly selected respondents in six villages. This was complemented with data generated from group discussions and key informant interviews. In addition, rainfall and temperature data were collected from the nearest metrological station. Data was analysed using descriptive statistics and binary logistic regression. Precipitation data over the last decades indicated high inter-annual and inter-seasonal variations with a general fluctuating trend. Consistent with this, farmers' also perceive fluctuation in the amount and distribution of rainfall, and a general trend of decreasing rainfall and increasing temperature over the last decades. However, the climate data did not show evidence for the temperature raise claimed by the local community. The common climate change adaptation strategies reported includes using improved seeds, increasing fallowing, rangeland management, tree planting, change in housing patterns, and alternative source of livelihoods. The logistic regression model revealed the significant socio-economic factors determining farmers' choice and adoption of adaptation strategies. Drawing from the empirical findings the integration of local knowledge and scientific knowledge is crucial in the development of effective adaptation strategies to cope with the impacts of climate change.

Keywords: Adaptation strategies, climate change, perception, precipitation, Sudan

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Climate Sensitive Diseases in the Mekong Region: Can We Predict Pests by Climate Factors?

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A warmer, wetter world is likely to be sicker. The Mekong is a hotspot for human, animal and plant diseases, and some of the most important are highly sensitive to climate and climate changes. These diseases can impose enormous burdens on human health and the agricultural sector and hinder broader development. Better response to climate sensitive disease requires better information and tools. The objective of the project we are presenting here is to develop tools to forecast climate-sensitive animal and plant diseases in Vietnam and Laos. Key work packages will include (among others) developing and disseminating maps of hotspots for selected climate-sensitive animal and zoonotic diseases, piloting a real-time prediction system, and exploring the potential for weather-based forecasting for aflatoxin mitigation (only Vietnam). As climatic-sensitive animal diseases and zoonoses leptospirosis and Japanese encephalitis have been identified in stakeholder consultations for Vietnam. Leptospirosis is caused by bacteria hosted by mammals, although the rodent-borne serovars are most often associated with serious human diseases which get infected through contact with contaminated water. Japanese encephalitis is a vector-borne viral disease transmitted by culicine mosquitoes from the amplifying hosts (e.g. pigs) to humans, where disease can be fatal. Aflatoxins, produced by *Aspergillus* spp in cereals, can cause acute or chronic aflatoxicosis in humans. The association of these diseases and meteorological conditions is evaluated and models will be built to predict future occurrence. If the models are successful in predicting disease, the aim is to provide policymakers and stakeholders with tools to aid in mitigating future disease and to make susceptible societies more resilient to future climate change. The ultimate outcome targets farming communities that are able to take practical action to reduce disease risk and/or benefit from risk-mitigating action provided by health providers. A framework which will guide through the various work packages will be presented and discussed. The project is funded by the CGIAR programme on Climate Change, Agriculture and Food Security (CCAFS).

Keywords: Animals, climate sensitive diseases, human, Laos, Vietnam

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Perception Shape Action: Will Smallholders in Colombia Adopt Climate Change Adaptation Practices Designed by Governments?

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Earth's climate is a complex system and involves many interactions between the natural and human system, causing delayed feedback loops, and uncertainties for decision making. During this century, climate change is a major challenge to achieving sustainable food security for a fast growing population while conserving earth' biodiversity for future generations. Smallholders in Colombia are exposed to many livelihood risks, including risks of inter-annual climate variability and progressive climate change. Actions and responses to threats are shaped by farmers' perceptions and priority settings of risks. Mental models provide an insight into perceptions and they have been used to understand how farmers' perception differs from the one of experts. We hypothesise that farmers adopt climate change adaptation strategies only when they rank climate risks higher in their mental models among other concerns, risks, barriers and motivations. We used a structured mental model approach to understand and compare risk perceptions. We carried out interviews with 13 national experts and 58 farmers from five rural districts in the municipality of Popayan, the capital of the Cauca department in Colombia. Results show, that there are differences in perceptions between experts and farmers. Experts perceive that poverty is the main worry for farmers', farmers' themselves ranked governance as their main worry. Asking experts about production risks, they say that insecurity is a main production risk, farmers felt overall safe in their region and ranked social vulnerability and the production process itself as a high risk. Experts further named lack of national policies as barriers for adaptation while farmers perceive that they lack practical knowledge about how to deal with climate risks and ranked the national policies lowest. However, experts and farmers agreed on what motivates farmers to adapt and also that the human capital is the most important livelihood capital for them, followed by the natural, financial and physical capital. One conclusion that may be drawn from our work is that adaptation strategies that are developed and promoted by governments and institutions might not be adopted by farmers if perceptions and risk ranking is different from that of experts.

Keywords: Adaptation action, climate change, livelihood risks, mental models, perceptions

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Climate Change Impact on Legume Species Used as Shade Trees in Coffee Agroforestry Systems in Mesoamerica

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Climate change (CC) is projected to reduce the suitability for coffee in Mesoamerica. Coffee's medium and high altitude ecological niche with mean annual temperatures from 18 to 24°C and annual rainfall between 1200 to 1500 mm will be shifted and often reduced by increasing temperatures and altered rainfall. Multi-strata agroforestry systems are being promoted both to reduce maximum temperatures up to 5°C, compared to full-sun coffee, and to accumulate carbon. Most coffee agroforestry tree species are Fabaceae with the ability to biologically fix nitrogen and a similar ecological niche to coffee. In this study, we use ecological niche models to estimate the potential current distribution of ten legume tree species (*Inga jinicuil, Inga densiflora, Inga oerstediana, Inga punctata, Inga vera, Inga laurina, Inga spectabilis, Erythrina berteroana*,*Gliricidia sepium* and *Inga edulis*) commonly found in coffee agroforestry systems and to evaluate the impact of climate change in the future suitability. We hypothesise that CC will reduce shade species suitability important for smallholder coffee resilience. Species presence data from herbarium records and studies on coffee agorforestry were used to model potential distribution with the Maximum Entropy algorithm using 19 environmental variables. Future distribution was mapped with climate change scenarios (RCP 2.6 and 8.5 for 2030 and 2050) and key environmental variables. *I. edulis* is the only species to show increased future suitability, while *I. laurina* presented the lowest reduction. Both species are concentrated at lower altitudes of current coffee distribution. The future distribution of the most common shade tree species, *I. oerstediana, I. punctacta* and *I. vera*, is reduced between 50 to 60 % of current potential suitability area. In Mesoamerica, CC will reduce the area suitable for all species by 5.2 %. The suitable area for 3 or more species will be reduced by 10 %. These results suggest that coffee growers will suffer a loss in the useful species from which they can choose for agroforestry-based adaptation to CC. The lowest reductions in suitability of all species were found in Costa Rica and Panama, while reduction in suitable area was much higher in Nicaragua, El Salvador and Guatemala.

Keywords: Climate change, coffee agroforestry, ecological niche models, *Inga*, legume tree species, shade trees

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Manure Management to Improve Soil Structure & Food Security and Mitigate Greenhouse Gas Emissions

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Manure is considered as a waste in some countries and is therefore poorly valued. However, if well managed, manure is a great asset, especially to smallholder farmers due to its richness of nutrients to potentially improve soil structure, crop yield and farmer livelihoods while also reducing detrimental environmental effects. This study is one of the initiatives of the climate and clean air coalition (CCAC), aiming at reducing emissions from short lived climate pollutants in the livestock sector.

In the first phase, the manure policy from 12 sub-Saharan African countries was summarised through a network of local researchers. The results indicate that most countries a) don't have a stand-alone manure management policy, b) have shared responsibility for manure management between different ministries which are often incoherent, leading to abnegation of these responsibilities c) take very limited action to promote good manure management practices.

Secondly, in depth interviews were conducted on livestock farmers from two of these countries (Ethiopia and Malawi) to assess current manure management systems and identify opportunities for improvement. It was found that Ethiopia and Malawi have similar challenges in manure management. All visited farms stored manure uncovered and without floors, exposing it to gaseous nitrogen losses and nutrient leaching.

The major cause for this poor management is lack of information by farmers; although non-coherence in policies between ministries additional drives poor management in Ethiopia. This led to the third phase, where we have partnered with the Governments of Ethiopia and Malawi in changing policies, disseminating information and encouraging practices that promote Integrated Manure Management (IMM). IMM involves the collection, treatment (e.g. to biogas or compost), storage and application of manure in ways that improve the value of the manure. Bio-slurry which is one of the end products in biogas production is a rich fertiliser with much higher concentrations of nitrogen, phosphorus and potassium compared with fresh manure.

Farmers using bio-slurry or well managed manure experienced improved crop yields confirming other findings which show that manure does not only provide nutrients to crops, but also improves soil quality, promotes carbon sequestration and can be used to restore eroded soils.

Keywords: Emissions, manure management, policies, soil structure, sub-Saharan Africa

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Effect of Rice Farming's Water Saving Managements on Greenhouse Gas Emissions and Micronutrient Availability in Philippine Paddy Soils

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The main challenge for global rice research and development for long-term sustainability as well as climate change adaptation is to find ways to reduce emission of greenhouse gases and limit micronutrient deficiency in soils using less water. This greenhouse pot study investigated the effects of water saving irrigation management (CF-continuous flooding, MSD-mid-season drainage and AWD-alternate wetting and drying) in rice farming on GHG emissions and micronutrient availability in three farmer's field in the Philippines (S1-Bay, Laguna, S2-Ubay, Bohol and S3-Sagbayan, Bohol). The impacts of water management among three soil types on different soil parameters were investigated, namely: soil Eh and pH, N_{min} (nitrogen mineralisation), DOC (dissolved organic carbon), soil temperature, VWC (volumetric water content). The impacts of water management among three Philippines soils in plant parameters were also investigated namely: plant height, no. of leaves, tiller count and fresh weight biomass.

The evolution of soil Eh, pH, N_{min} and DOC over one rice-growing season under different water managements in three soils followed expectable trends except Nmin. The soil Eh were significantly different among water managements but not in the three soils used. CF and MSD water treatments maintained negative soil Eh values throughout the season compared to positive soil Eh values in AWD treatments, which fluctuates as a respond to irrigation.

The soil parameters: soil Eh, pH, N_{min} and DOC, were all interrelated to each other. They were linked directly and indirectly to the GHG emissions from paddy soils that may had affected the biochemical processes in water and soil treatments. Methane emission increased when the soil was flooded (low Eh) and decreased when the soil Eh became positive. Nitrous oxide showed opposite findings compared to methane emissions. AWD emitted more nitrous oxide gas compared to CF as well as MSD. Based on the results of this study, water saving management affects the CH_4 and N_2O gas emission in three Philippine paddy soils. CH_4 emission rates were significantly higher in the CF for all three soils and AWD yielded the lowest emissions throughout the experiment, but not significantly different than that of MSD.

Keywords: Climate change, greenhouse gases, rice, soil micronutrients, water-saving

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GHG Mitigation through Implementation of Simple Fertilisation Strategies in Crop Production in Northern China

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Overuse of nitrogen (N) fertiliser constitutes the major issue of current crop production in China, exerting a substantial effect on global warming through massive emissions of greenhouse gases (GHG). Despite the ongoing efforts, which include the promotion of technologically sophisticated N management schemes, farmers' N rates maintain at excessive rates. Therefore the current study tests two simple and easily to apply N fertiliser recommendation strategies, which could be implemented on large scale through the existing agricultural advisory system of China, at comparatively low cost. Building on a detailed crop production dataset of 65 winter wheat (WW) and summer maize (SM) producing farm households of the North China Plain, scenario analysis is applied. The effects of the two N strategies under constant and changing yield levels on product carbon footprint (PCF) and gross margin (GM) are determined for the production conditions of every individual farm household. The N fixed rate strategy realised a higher improvement potential in PCF and GM in WW and SM. The analysis furthermore revealed that improved N management has a significant positive effect on PCF, but only a marginal and insignificant effect on GM. On the other side, a potential 10 % yield loss would have only a marginal effect on PCF, but a detrimental effect on farmers' income. With farmers currently applying excessive N rates as a "cheap insurance" against potential N limitations, the agricultural advisory system of China requires fundamental changes to successfully overcome the excessive fertiliser use and respective environmental pollution. The study concludes that the indirect subsidisation of N fertilisers needs to be stopped and a N tax should be introduced. Furthermore a cross compliance system should be implemented, which punishes non-compliance with maximum allowed N rates by cutting direct farm payments.

Keywords: Fertiliser, GHG mitigation, global warming, gross margin, nitrogen

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Rubber Cultivation Weakened the CH_4 Sink Function of Tropical Upland Soil, Comparing with Rainforest

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Rubber plantations have been expanded in past decades in the Mekong region where they were not traditionally grown. Investigation of gaseous carbon loss from soil is an important component of evaluating the impact of land use change on carbon dynamics and ecosystem functions. According to observed drop of soil respiration rates and high soil moisture in rubber plantation in rainy season when rainforest kept high rate, we hypothesised that rubber cultivation might change the tropical upland soil into CH_4 source periodically, which result to less net CH_4 oxidation by the soil comparing with rainforest. In order to find out how rubber cultivation affected the CH_4 processes in soil, we set 4 plots in transect that included rainforest and rubber plantations at age of 9, 17 and 30 years. We measured CH_4 flux with closed chamber method for half a year, and analysed CH_4 concentration profiles three times and $\delta^{13}C$ ratio of CH_4 once at soil depth of 5 cm, 10 cm, 30 cm and 70 cm. Monthly CH_4 flux measurements had large variation and there was no consistent difference between rainforest and rubber plantations in the early dry season. Comparing with older rubber plantation, more negative CH_4 flux was observed from rainforest and 9 years rubber plantation in the late dry season. The first gas profile sampling in dry season without rainfall events showed CH_4 concentration ranging from 0.43 ppm to 1.31 ppm, with lower values in deeper soil. The second profile sampling in dry season after heavy rain displayed different response, CH_4 concentration in rainforest and 9 years rubber plantation changed range to 0.17 ppm-1.61 ppm, while it changed to 0.46 ppm-22.36 ppm in 17 and 30 years rubber plantation with higher concentration in deeper soil. CH_4 concentration profiles indicated that with increasing of age, rubber plantation tended to change into CH_4 source in response to heavy rains. $\delta^{13}C$ ratio of CH_4 in soil varied from -49.73‰ to -38.05‰, with higher enrichments in deeper soil. The isotopic carbon signature in CH_4 confirmed weaker CH_4 oxidation in rubber plantations than rainforest, and decrease of oxidation rates caused by converting rainforest to rubber plantations might stabilise at certain age of cultivation.

Keywords: CH_4 oxidation, rainforest, rubber plantation, stable isotope carbon ratio, upland soil

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Meet the Balance of Carbon Emission and Land Use Productivity - Case Study from Naban National Nature Reserve, Xishuangbanna

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Land use planning for Low Emission Development Strategy (LUWES) is a crucial platform for sustainable land use management, which aims to decrease carbon emissions while maintains land use productivity/ economic growth in landscape. In Naban National Nature Reserve (NNNR), Rapid Carbon Stock Appraisal (RaCSA) approach was applied to evaluate time-averaged carbon stock of dominate land use types, namely upland forest, lowland forest, upland rubber plantation, lowland rubber plantation, bush and grassland, and agricultural crops. These values were used for upscaling and C stock estimate in landscape. Historical and current land use change patterns was assessed by creating transition matrix from 1989, 2007 and 2012 land use land cover maps. The top four land use changes were from bush and grassland to upland forest, from bush and grassland to agricultural crops, from agricultural crops to upland forest and from upland forest to upland rubber plantation, which had a percentage change of total area value of 39.45 %, 16.25 %, 8.38 % and 7.39 % respectively. From 1989 to 2012, the land use change induced 0.18 Mt carbon emissions and 0.73 Mt carbon sequestrations. The net carbon sequestration was 0.55 Mt with a sequestration rate of 20.62 Mg C ha^{-1}. In next step, the REDD Abacus (Reducing Emissions from Deforestation and Forest degradation Abatement Cost Curves and Simulator for Scenarios of Policies) software will be used to simulate business as usual scenarios and other emission-reduction scenarios within landscape. Opportunity cost will serve as a good indicator for providing reference benefit of various land use types within specific rotation life, it refers to the potential economic gains if certain types of land use change not happening. The analysis can provide a simple first approximation of potential avoidable emissions which driven from incentive mechanisms in the past. Results of this study can provide an entry point for the discussion on the feasibility of compensation-based mechanism of climate change mitigation actions, moreover, it can also serve as the foundation for more complicated process-based modelling for providing reference for local decision makers.

Keywords: Carbon emission, land use productivity, low emission land use planning strategy, RaCSA, REDD Abacus

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Improvement of Land Use Management to Reduce Livestock Greenhouse Gas Emissions in the Peruvian Andes

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Enteric fermentation is considered one of the main sources of greenhouse gas (GHG) emissions in the agricultural sector. This study was undertaken to assess the emissions of GHG released from dairy cows in the Peruvian Andes from 2015 to 2030 and analyse *ex ante* the potential mitigation of GHG emissions from reducing the number of animals after increasing milk productivity by improving rangelands lands or introducing rye-grass-clover pastures in the highlands. Calculations were done considering a hypothetical land intervention equal to 100,000 ha for each scenario. Emission factors and regression equations were derived from the methodology TIER-1 from the Guidelines of the Intergovernmental Panel on Climate Change (IPCC) – 1996. Results showed a GHG emission from dairy cows in the Peruvian Andes equal to 30.8 millions tons of CO_2-eq per period of evaluation. The accumulated CO_2-eq abatement in the "improving rangelands lands scenario" and in the "introducing rye-grass-clover pastures" scenario, compared with the reference scenario, were 3 and 15.5 million tons, respectively. The corresponding total incremental costs of both scenarios were 44 and 468 million dollars. It is concluded that there is great potential for CO_2 abatement in the Peruvian highlands with those interventions. Although the implementation of sustainable measures such as investing in improving rangelands and pastures or adjusting the stocking rate of the farms to the stocking rate capacity of the lands will result in CO_2 abatement, higher levels of abatement will demand more land intervened and increased incremental costs. It is suggested further research and significant data collection in the Peruvian Andes to apply more precise metodologies such as TIER 2 or TIER 3.

Keywords: Climate change, dairy, GHG, land management, mitigation

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Economic Costs of Implementation and Potential Carbon Sequestration of Agrosilvopastoral Systems in the Brazilian Cerrado

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Mato Grosso do Sul State in Brazil had a major agricultural expansion in the 70's, with sown pastures displacing local Savannah (Cerrado Biome) for cattle grazing and soybeans. Currently, pastures show severe signs of degradation, with expensive reclamation alternatives, sometimes reaching over 20 % of land price. This leaves farmers stagnated, leading to further degradation and environmental losses. Recent studies show increased demand for biofuels, wood and grains, displacing cattle ranching to more vulnerable areas, like the Pantanal wetlands and Amazon. Therefore, alternatives for improving farm profitability could help to prevent herd displacement, while improving environmental conditions. Agrosilvopastoral systems show to be a promising alternative for these fragile poor soils areas of the Cerrado and farmers have been showing interest on such systems. However, there is a lack on specific information, especially regarding economic and environmental aspects, for a safe decision-making, what evidently prevents farmers from adopting these technologies. Important aspects are the correlation between the scale of farms (small and large sector) and the labour costs in the different production systems, particularly regarding to agrosilvopastoral systems. A question is therefore raised, if agrosilvopastoral land use systems are feasible also for small farms with higher availability of labour. The proposed work, based on results from literature, running experiments and local farms, will compare different agrosilvopastoral systems in regards to costs of implementation, potential for beef production, profitability, greenhouse gases emissions and carbon sequestration on trees. Systems studied are based on eucalyptus trees, beef cattle and palisadegrass, with or without integrated grain crops. Scientific question is which combination of tree densities, which in their turn influence cattle stocking rates, allow the best economic results and the best additional carbon sequestration potential on trees per area. Preliminary results show that higher tree densities increase initial costs and reduce cattle stocking rates but increase the gross revenue in the total period, therefore purpose of wood production seem to have strong influence on final results.

Keywords: Agrosilvopastoral systems, decision-making, economics, environment

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GHG Emissions in Relation to Background Soil Carbon, Organic Amendments and Water Management from Rice Production Systems

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Elevated GHG emissions particularly methane (CH_4) from lowland rice production systems leads to high global warming potential (GWP). The strategies such as, altering water and residues (carbon) management practices are assumed to be essential to mitigate the GHG emissions from flooded rice system. We investigated the relative contribution of added organic amendments and native soil carbon on GHG emissions in flooded rice, and the potential of drainage on reducing either of the two fluxes. Rice plants were grown in pots under control conditions in growth chamber with $2\times2\times3$ factorial design. The treatments were: an arable soil with two different carbon levels (Check: 1.3 and 2.5 %); two water regimes (mid-season drainage and early plus mid-season drainage); three nutrient treatments (control, maize straw and maize compost). We hypothesised that i) methane emission would increase according to the amount of labile carbon in the amendments, ii) that early season drainage will as effective as mid-season drainage in reducing emissions from the amended materials and iii) that drainage will be ineffective in reducing soil-C derived methane. The highest accumulative methane was observed from labile C source (straw) under mid-season drainage from both high (198.6 g m^{-2}) and low (258 g m^{-2}) C-soils. Alternatively, highest accumulative nitrous oxide was observed under control treatment (mineral fertiliser) with early drainage from both high (10.2 g m^{-2}) and low (12.1 g m^{-2}) C-soils. Early drainage in combination with midseason drainage has a strong effect on CH_4 emissions reduction from flooded rice production. Background soil C has no effects on CH_4 and N_2O emissions in relation to drainage practices in short period. Similar field experiment is required for real and important implications for the choice of relevant and realistic mitigation practices (early vs. mid-season drainage) as well as short and long-term implications of use of organic amendments on GHG emissions from flooded rice production.

Keywords: Early drainage, GHG mitigation, organic amendments, soil organic carbon

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CO_2 Efflux in Vertisol under a Wheat Field and Tamaulipan Thornscrub Vegetation in Northeast Mexico

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Soil respiration is an important component of the terrestrial carbon budget and is considered the second-largest factor in the flux of carbon between the earth's ecosystems and the atmosphere. It has been pointed out that any increase in soil CO_2 emissions in response to environmental change have the potential to substantially increase atmospheric CO_2 levels and to provide a positive effect to global warming. Thus, determinations of CO_2 efflux, soil temperature and soil-water content were monitored, weekly during 2015. At each sampling date, two daily measurements (at 08:00 and 14:00 h local time, named as morning and afternoon, respectively) were carried out. A dynamic closed chamber with a portable system EGM employing a infrared gas analyzer (IRGA) and a soil chamber (SRC-1) was used to assess soil CO_2 efflux in four replications in vertisol under two land use in northeastern Mexico: a native undisturbed thornscrub and a *Triticum aestivum* field. Results have showed a significant relationship between morning and afternoon soil respiration rate and soil temperature, while a no significant relationship between soil water content and soil respiration for both land use was found. During the studied period, total average morning soil respiration rates for both land use ranged from 2.3 to 14.4 micromol CO_2 m^{-2} s^{-1}, while afternoon soil respiration rates ranged from 2.6 to 28.8 micromol CO_2 m^{-2} s^{-1}. Average morning and afternoon soil respiration rates were higher in thornscrub than *Triticum aestivum* plot; indicating that thornscrub vegetation showed the highest average morning and afternoon soil respiration rates; 9.9 and 14.6 micromol CO_2 m^{-2} s^{-1}, respectively. In contrast, crop field showed the lowest average morning (4.5) and afternoon (5.5 micromol CO_2 m^{-2} s^{-1}) soil respiration rates. In vertisol the soil CO_2 efflux varies with land use, is higher in the afternoon and it is related with soil temperature. Field observations have also illustrated the need of research efforts in vertisol under dry periods, especially when soil water content drops below 15 %, in order to explain the dynamics of the CO_2 balance of different land use.

Keywords: CO_2 efflux, Land use systems, soil respiration, Tamaulipan thornscrub, *Triticum aestivum*, Vertisol

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Intensification Options and Associated Greenhouse Gas (GHG) Emissions in Smallholder Crop-Livestock Systems in Kenya

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Population pressure on land has positioned food security and increasing production as top priorities for East African agriculture, over decreasing greenhouse gas (GHG) emissions. While some agricultural practices are faced with the trade-off of production versus climate change mitigation, others become a synergy by meeting the double win. In our study we reviewed intensification options for smallholder's mixed crop-livestock systems in Kenyan Central Province and their corresponding impact on the climate We analysed both farm production and GHG balance using agricultural activity data, IPCC equations and NUANCES-FARMSIM, the farm scale dynamic model which integrates the interactions between crop-soil, livestock and manure management. We combined data collected from 150 farms to develop different scenarios of intensification: Fertiliser rise (FERT); improved livestock feeding (FEED); improved manure handling (MAN); and combinations of them. The fertiliser rise scenario (FERT) increased maize production by 5-8 % on average, showing an increment of 16-30 % in total farm emissions from the baseline. Increments of dry matter intake by cattle increased emissions by 20-25 %, while improving the nutrient content in fodder and feed showed a 135-170 % increase in milk production per cow with lower GHG intensity. Better manure handling (MAN) reduced emissions in the manure management system but increased emissions in soils in proportion to the nitrogen cycled in the system and therefore the size of the N-pool. Yields significantly increased due to more manure available through better manure handling (MAN), with higher nutrient content coming to the system in the form of concentrates or enriched fodder (FEED) for the cattle. Emissions per unit of product were reduced as the production increased for the cases of improved feeding (FEED) and its combination with improved manure handling (FEED + MAN), but not for the fertiliser rise (FERT) or its combinations (FERT + FEED; FERT + MAN). Finally we discussed the inclusion of agroforestry practices to the farm balance, by analysing their potential to offset farm emissions while improving livelihoods.

Keywords: East Africa, greenhouse gas emissions, livelihoods, mixed crop-livestock systems, smallholders

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Variations in the Diurnal Flux of Greenhouse Gases from Oil Palm Plantation in Indonesia

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Climate change continues to be a topic of considerable scientific debate and public concern. The concentration of greenhouse gases including methane (CH_4) and nitrous oxide (N_2O) in the atmosphere has been increased due to human activities. Agricultural production plays an important role on atmospheric greenhouse gas concentration. Oil palm plantation has grown rapidly in Southeast Asia, with Indonesia and Malaysia currently meeting more than 85 % of global palm oil demand by using huge amount of fertilisers to increase the production. Under such conditions, N_2O and CH_4 gases tend to be emitted. For accurate emission measurement the diurnal variation need to be investigated. Gas samples were taken from different oil palm plantation fields from North Sumatra and Kalimantan in Indonesia. Diurnal variability in the rate of emission of N_2O and CH_4 were studied mineral fertiliser and organic residues. Specially made big closed static chambers were established for two hours in the weeded circle position to observe the mineral fertiliser (1.5 kg urea/palm) effect and in the inter-row position to observe the effect of the organic residues (Decanter Cake (DC), Empty Fruit Bunch (EFB)) with 3 replications for periods of 0 d (before fertiliser application), 1^{th}d, 3^{rd} d, 5^{th}d, 7^{th}d, 9^{th}d, 11^{th}d and 15^{th}d after fertiliser application. Samples were collected in the morning (8–10 am), afternoon (12–2 pm) and evening (4–6 pm) at 0, 20, 40, 60, 80, 100, and 120 min after the chambers were closed, and the concentrations of N_2O and CH_4 were determined using gas chromatography. Results indicated that the fluxes of N_2O and CH_4 from mineral fertilised plots showed significant difference in the afternoon than the morning. The flux was found to be increased as the day progesses and the flux was higher at noon and in the late noon than the morning 8 am. But in organic mulch position both in Kalimantan and Sumatra, the difference in flux during the different parts of the day was not very prominent. So there were no significant diurnal variations for organic mulch position. This finding indicated the importance of sampling time of the day for accurate emission measurement.

Keywords: Greenhouse gases, oil palm

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Introducing Carbon Stock Value in Public Forest Concessions: Drawing Alternative Approaches for Concession Agreements in Brazilian Amazon

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This study analyses the contribution of the Environmental Service Carbon Stock in the context of forest concession agreements in the Pará State, Brazilian Amazon, to understand how the valuation of Environmental Services may increase the estimated values attached to forests. In this context, the purpose of this study was to assess the economic value of the carbon stock in Amazon forests by using as study area a public forest under concession process, the Mamuru-Arapiuns region. The hypothesis is based on the assumption that the inclusion of carbon storage can be an alternative to the existing payments for logging in concession agreements. The study took an applied and quantitative approach, using documental research from selected technical reports, inventories, concession contracts and other documents related to Forest Management Unit I (FMU I), situated in Mamuru-Arapiuns. A map was produced to provide a greater precision regarding the dimensions of the forest and land use types. Two categories of vegetation were observed: lowland dense ombrophylous forest and lowland open ombrophylous forest, the predominant of the two. The map also identified logging and land use areas. The interpretation of natural vegetation was obtained through a digital processing of SPOT satellite images produced by the geoprocessing department of the State Secretary for the Environment (SEMA). Through satellite imagery it was possible to estimate vegetation and forest biomass at the FMU I (45,721.30 ha), where forest formations constitute about 94 % of the total area, that is 43,117.36 ha. According to the estimates, the carbon stored in this vegetation is about 8×10^6 t C. Under these conditions, the total value of carbon storage in the study area would be about US$ 95,000,000, an estimate derived from the value of the forests taking in consideration the carbon stock with an average price of US$ 3.24 per t.CO_2 for emerging voluntarily certifying emissions reductions market. The paper concludes with a discussion on the economic and environmental importance of considering the environmental services in the concession agreements and other forms of forest management.

Keywords: Environmental policy, forest management, public land, sustainable forestry

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Trade Liberalisation and Forest Protection Policies: Leakage Effects of Deforestation and CO_2 Emissions

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Forests contain large carbon stocks, storing 20 to 100 times more carbon per unit area than agricultural land. It is estimated that 247 Gt (GtC) carbons were stored in over 2.5 billion ha of forest in the early 2000s in Asia, Latin America and sub-Saharan Africa. Deforestation caused agricultural expansion renders the increase of greenhouse gas emissions. With implementation of bilateral trade in the global land-use model, MAgPIE ("Model of Agricultural Production and its Impact on the Environment"), we are able to present a comprehensive picture of trade effects on deforestation and the consequential CO_2 emissions. We analyse future trade liberalisation scenarios in terms of reduction of import tariffs over the period of 2005–2050 with 5-years interval. It turns out that trade liberalisation could slow the pace of deforestation and CO_2 emissions, but the distribution of deforestation is unequal between regions. China, sub-Saharan African, and Latin America that have comparative advantage in food production will face sever deforestation. If a region such as Latin America implements forest protection policies, it will reduce the deforestation in region, but leaks the deforestation through trade of crop products to other regions which have relative comparative advantages but a lack of forest protection policies. Thus liberalisation could not address the shifts of deforestation, although the total deforestation area is reduced. In addition to the trade liberalisation and forest protection policies, we add scenarios of food demand by assuming different food demand pathways. We find that due to the reduction of consumption of livestock products, the leakage effects of trade liberalisation on deforestation will reduce.

Keywords: CO_2 emissions, deforestation, food demand, leakage effects, trade liberalisation

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Biodiversity and ecosystem services

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Farmers' Perspective on Incentives for Ecosystem Services – Insights from Kenya and Tanzania

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Farmers often link ecosystem service (ES) provision to food production. They rely on ecosystems for crop cultivation and animal husbandry, but may at the same time provide ES for the larger society. Despite this dependency ecosystems are under threat in an environment ever more competitive for land, market access and cheap food provision. Producers often resort to unsustainable land use. Incentives for Ecosystem Services (IES) is one approach to deal with this challenge by looking for common ground among different agro-ecosystem actors. It requires a coordinated effort by the public and private sector, civil society and rural population. Farmer commitment to sustainable practices is particularly crucial for the viability of such IES schemes.

Our study analyses farmers' perspectives on IES within the framework of an ongoing FAO project. Knowing their extrinsic and intrinsic motivations in relation to various adoption barriers for sustainable agricultural practices allows for designing viable and effective incentive packages for ES provision.

The reasoning of the analysis is based on relevant literature and a review of case studies from different developing and industrialised countries. In early 2015, the resulting hypotheses and models for best practice are debated and further elaborated in semi-structured interviews and focus group discussions in four different IES environments in Tanzania and Kenya. Farmers – including youth and women – are asked about their reasons to (not) commit to sustainable agro-ecosystems. Different motivations and their relative importance in the overall short- and long-term decisions will be visualised.

First insights suggest that monetary and in-kind incentives are perceived as a jump start or reward by many farmer communities. Beside access to knowledge and related increase in yield, indirect incentives such as market access, recognition of agricultural efforts and improved contacts to institutions are equally important.

Our analysis seeks to stimulate the ongoing debate on how to improve framework conditions for viable IES schemes contributing to food security. Hereby selected policy dialogue events will contribute to the dissemination of the findings, ultimately leading to increased consideration of farmers' perspectives and their involvement in the negotiation, implementation and monitoring of IES schemes.

Keywords: East Africa, incentives for ecosystem services, policy dialogue, small-scale farming

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Assessing Ecosystem Services for the Integrated Management of Sakabansi Dam in Northern Benin

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Agro!pastoral dams in Benin provide various provisioning, cultural and regulating ecosystem services to local communities. In water scarce localities such as Sakabansi village in northern Benin, the local dam contributes significantly to communities' livelihood and plays a key role in the preservation of species diversity including the red listed African Crocodile. However, its management has been increasingly challenged over the last decade by a tremendous increase of farmlands over natural ecosystems and a huge pressure put on the dam buffer zone.

Framed by the ecosystem services cascade model, this paper attempted to assess, quantify and value the total economic value (TEV) of ecosystem services provided by such complex system (dam and buffer zone) and the contribution of such small buffer zone to local communities' livelihood. The quantification approach was based mainly on specific indicators and potential of the buffer zone to provide a given service. Valuation techniques including market pricing, income factor and avoided damage cost were used to express the importance of ecosystem services in monetary terms.

Overall, five ecosystem services (food, fresh water, raw materials, maintaining soil fertility and erosion prevention) have been quantified and valued based on nine benefits local communities derived from these services. Based on this valuation, the total economic value (TEV) of the dam and surrounding buffer zone has been computed to 149,380 € among which 37,389 € from Sakabansi dam and 111,991 € from the buffer zone.

Opportunities for implementing a payment for ecosystem services (PES) scheme to sustain the integrated management of the dam shows a willingness to pay (WTP) ranged from 0.31€ to 7.69 € with more than 53 % of respondents agreeing on 1.54 € per year. However, respondents were against the compensation of riparian farmers due to the local land ownership system and were in favour to pay for a bundle of services considered as a minimum well-being packageänd which include fresh water, pasture and forage, and tree shed. This constitutes an opportunity for the integrated and participatory management of the agro-pastoral dam-buffer zone system.

Keywords: Agro-pastoral dam, buffer zone, ecosystem services, ecosystem services cascade model, PES, TEV, WTP

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The Influence of Payments for Ecosystem Services on Land-Use Decisions in the Nicaraguan Agricultural Frontier

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Between 1990 and 2010, Nicaragua has experienced a loss of 70,000 hectares of forest per year, which corresponds to a net decrease of 2.11 % of its forest area. The main cause is the conversion of forest areas for agricultural use.
The selected study area is situated in the new agricultural frontier in the limit of the Biosphere Reserve Indio-Maíz, municipality El Castillo, department Rio San Juan, where the Danish NGO 'Forests of the World' pays farmers for the preservation of a defined area of forest within their property for 5 years. This research aims to identify the influence of these payments on the land use decisions of the farmers. The methodology of the agricultural diagnosis is used to identify and understand both agricultural and historical dynamics as well as agricultural practices of farmers. This, in turn, serves to explain their motivations in relation to changing (or not) the use of their land.
Two dynamics enhancing deforestation in the area were identified. Firstly, migration from the poorest stratum to the agricultural frontier in search of land. This is due to the unequal distribution of land in Nicaragua, given that only 6.8 % of farmers occupy 56.67 % of the agricultural land. Secondly, the evolution of farms based on mixed cropping towards livestock production as the main cause of forest conversion to pasture.
Payments for ecosystem services have been unable to stop this evolution towards livestock production for three reasons. First, the amount of $ 28.5 / hectare does not cover the opportunity costs of other land uses. Second, farmers receiving payments only commit to the conservation of forest which they are not planning to use during the five years of their contract. Thirdly, converting the remaining areas of forest to grassland provides the possibility of significantly increasing agricultural income per active worker in the family.
To reduce deforestation in the farms, the combination of two strategies is recommended. On the one hand, providing greater value to forest areas through sustainable timber harvesting. On the other hand, increasing sustainability of the production systems through the establishment of silvopastoral and agroforestry systems.

Keywords: Agricultural frontier, deforestation, extensive livestock production, payments for ecosystem services

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Payments for Ecosystem Services Using Product Bundles to Prevent Deforestation in Tropical Montane Cloud Forests

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Tropical mountain cloud forests (TMCFs) represent endangered ecosystems found worldwide in the tropical regions. Although TMCFs account only for 1.4 % of the world tropical forest area, they harbor 50 % of the known neotropical higher plant species and high levels of endemism. Besides, they deliver to societies outstanding ecosystem services (ES) such as: increased water retention and quality, soil carbon sequestration, and biodiversity richness. Many authors agree that deforestation due to land use change is the main threat to TMCFs, and it has been reported in the 1990s that their deforestation rate was higher than any of the other tropical forest biomes. Smallholder farmers, led by uncertainty in crop yield, food insecurity, tenure conflicts and climate impacts, have, among others, extensively contributed to deforestation. Costa Rica has been a pioneer nation on the enforcement of payments for ecosystem services (PES), aiming at the decrease in deforestation rates and conservation efforts. In spite of the large areas successfully reforested and preserved in the recent years, PES leave behind a number of smallholder farmers who are excluded to establish market relations because clear land rights are essential to participate in the trade of ES. Moreover, whilst many studies have dealt with ES separately, this research intends to evaluate their effect in bundles. The environmental value that TCMFs represent in terms of natural resources and biodiversity as well as the rural communities that they support, makes necessary to re-evaluate PES design if we aptly want to preserve both biodiversity and rural livelihoods. This research includes both biophysical and social sciences approaches aiming at:

The Development of an evaluation model and its application to the ES that can be provided by TCMFs with special interest in water, soil carbon, and biodiversity. Geographic information system (GIS) models will be employed to evaluate and combine the ES in bundles, this will provide a better understanding of ES interactions and will help in the decision-making process. The understanding of stakeholders' perceptions and interests in designing PES. These will combine scientific and local knowledge and a development strategy aligned with local interests instead of rigid environmental policies or socioeconomic external factors.

Keywords: Biodiversity, bundles, GIS, land tenure, payments for ecosystem services, soil carbon, tropical montane cloud forests, water regulation

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Action-Based versus Outcome-Based Payments for Environmental Services: An Experimental Auction for Tree Planting Contracts in Kenya

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Theory predicts that outcome-based payments, relative to action-based payments offer more flexibility in the choice of relevant conservation actions, enhance the development and use of innovative approaches, and can improve landholders´ intrinsic motivation for the actual conservation outcome. On the other hand, they are also associated with risk, which might prompt landholders to ask for higher payments. We assessed the various effects of the two payment types in a field experiment in rural Kenya, allocating tree planting contracts via a tender mechanism in two separate auctions for the action and outcome-based contracts. Conservation payments helped to overcome economic constraints of tree planting and did represent a direct incentive for better care taking. However, our results do not reveal significant differences between the two contract types in submitted bids, tree survival rates and the overall cost-effectiveness. Our data indicates strategic bidding behaviour to avoid translation of contract differences in risk and flexibility into detectible differences in bidding and to adversely affect the cost-effectiveness. Participatory approach of the study lead to very strong intrinsic motivation of all participants, which explains high tree survival rates independent of the contract type. This was further confirmed under the aspect of continuity. Strategic bidding behaviour resulting from information spillover within small communities is challenging and difficult to tackle by means of auction design. The largely positive effect of participatory approach on the intrinsic motivation has great implications for conservation efforts in general. Overall, the field experiment revealed the complexity of the payments for environmental services scheme going beyond the contract type or auction design.

Keywords: Action-based, conservation auction, cost-effectiveness, intrinsic motivation, outcome-based, participatory approach, payments for environmental services, strategic bidding

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Effect of Social Capital on Land Allocation in Payment for Environmental Services Schemes under Individual and Collective Incentives

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The expansion of oil palm plantations has been identified as one of the main drivers of deforestation in Indonesia. Conversion of forests and complex agroforestry systems, such as rubber agroforest, into pure oil palm stands has been associated with significant reductions in ecological functions. In order to slow down rapid transformation processes and reconcile some of the ecological functions, payments for environmental services (PES) have been suggested as a tool to incentivize the cultivation of rubber agroforest. In this study, we explore the effects of an external reward system on land use decisions using framed field experiments that we implemented in Jambi province in Indonesia. The scheme was framed as payments for environmental services that aim to foster environmentally friendly behavior associated with the cultivation of rubber agroforestry. In this framework, we compare two alternative PES schemes: an individual incentive scheme, where participants are offered a flat rate payment for each experimental land unit conserved, and a collective incentive scheme, where individuals only receive payments, if in the aggregate a pre-determined conservation threshold is passed. Under both treatments, participants were asked to allocate their experimental land units under three different scenarios: no incentives, low incentive payments and high incentive payments. Farmers where randomly matched into heterogeneous groups of three participants to account for heterogeneity in land endowments. After the experimental session, participants were asked to fill out a post-experimental questionnaire that included a social network module. This data allows us to explore the role of social networks in participants' responses to different types of incentives. Our results reveal that at the group level the allocation of experimental land units to rubber agroforest significantly increases in response to the introduction of incentives. At high incentive levels, this holds similarly for individual and collective incentives. At low incentive levels, however, the increase in agroforest is significant under the collective incentive scheme, but not under the individual incentive scheme. In addition, the magnitude of the marginal effect of introducing low payments under the collective incentive scheme is similar to the marginal effect of high payments under the individual incentive scheme. These results suggest that more sustainable land use options can more cost-effectively be introduced when relying on collective action dynamics within communities. When including social network characteristics, it was possible to identify the significant effect of the network size and the level of education of the share of land allocated to agroforestry. The education of the network has a positive effect on land allocation to jungle rubber.

Keywords: Framed field experiment, jungle rubber, payment for environmental services

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Land Use Change Effects on Ecosystem Services and Opportunities to Enhance Food Security in Central Highlands of Ethiopia

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In Ethiopia, land resources scarcity coupled with high population growth influences land use decisions that cause conflicts with neighbouring nature conservation areas. For small holder farmers, what to eat and use from the ecosystem determines the pattern of land use changes. However, this practice failed to satisfy the food self-sufficiency and impedes sustainable land management.
This research investigated land use change effects on ecosystem service (carbon stock) and biodiversity. In addition it assessed viable options to enhance food security while maintaining ecological integrity. Carbon stock and woody plant species diversity were compared across five land use types (natural forest, plantation forest, moderately cultivated land, intensively cultivated land and grassland) in the Menagesha Suba forest area. Nested plot design of 50m $\times$ 50 m for trees with diameter at breast height (DBH) >50 cm, 25m $\times$ 25 m for trees with DBH between 5 and 50 cm and 1 m $\times$ 1 m for seedlings and saplings were used. Likewise 0.5 m $\times$ 0.5 m plots were used in four corners of 1 m^2 subplots for litter and soil samples collection.
The preliminary results show higher woody plant diversity for both natural forest and moderately cultivated land compared to the plantation forest and the other agricultural lands, clearly showing woody plant species diversity was highly influenced by land management. Above ground biomass carbon stock also varied across land uses. It is higher for the forests and lower for the agricultural lands. Similarly, soil carbon content significantly declined on agricultural lands compared with the forest lands. The result indicates that clearing land for agricultural purposes negatively influenced the important supporting ecosystem services of biodiversity and carbon stock, which both play a pivotal role in function of ecosystems. This shows that forest clearing for intensive agriculture misses the opportunity to contribute to sustainable food security integrated with the maintenance of ecosystem services. In this regard, mosaic agriculture landscapes incorporating agroforestry and carbon financing have recently received much interest as a cost effective alternative to enhance food security and sustainable land management. The practice of agroforestry is already in place in the study area and profitable although it needs further up scaling.

Keywords: Agroforestry, biodiversity, carbon financing, carbon stock, food security, land use change

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Valueing the Impact of Rubber Agroforestry: An Integrative Ecosystem Service Assessment Framework

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With today´s need of a project to meet inter-, multi- and trans-disciplinary standards as well as integrating stakeholder based decision making processes into a research framework, project management staff and project proposal writers face quite difficult tasks. Not only do the scientists need to meet their own disciplinary standards, but also it is expected that from the fruitful interdisciplinary interaction something bigger is born.
Within the SURUMER project we have established a working framework that allows for an integrative Ecosystem Service Assessment (ESA) aiming at bringing together both the needs of disciplinary data acquisition and high quality research with interdisciplinary modelling approaches under the umbrella of a stakeholder based steering mechanism.
A continuous stakeholder process focusing on three different groups of decision-makers (village heads and innovative farmers, regional planners as well as politics) in our project region develops key questions related to ESS to be addressed by the project scientists. Based on these questions, scenarios are designed in an iterative process during the stakeholder process. One of the major aspects of these scenarios is the integration of different management methods for various agroforestry-based intercropping approaches. These scenarios are analysed by multiple disciplinary and interdisciplinary modelling and assessment approaches, leading first to a bio-physical assessment of the scenario. This assessment is, in a second step, supplemented with socio-economic appraisals on expected changes in household income and economic welfare. Finally, these assessments are combined and adapted to be returned into the continuous stakeholder process for information exchange and possible adaption of key scenario questions.
For this Tropentag, the authors present the established framework as well as first results of the ESA. In addition, we want to share our experiences from the stakeholder integration processes and discuss possible adaptation strategies for other agroforestry systems and other (inter-) national settings.

Keywords: Ecosystem services, Greater Mekong Subregion, rubber

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Empirical Analysis of the Cost Effectiveness of Smallholder Ecosystem Services in Kenya

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Smallholder farmers in parts of sub-Saharan Africa engage in sustainable (conservation) farm management practices and participate in agri-environmental schemes that generate additional on-farm revenues through payment for ecosystem services (PES). However, smallholder farmers that are inadequately compensated for the forgone income for providing marginal ecosystem services pay a higher price compared to those farmers that are over-compensated especially if the joint agricultural output is complementary, supplementary or competitive. Therefore stakeholders are confronted with the challenge of evaluating all possible interaction between agricultural production and ecosystem services when making strategic decisions.

A possible solution for decision makers is to access the marginal cost of ecosystem services and effectiveness of agri-environmental schemes based on farm level bioeconomic interaction. Theoretical classification of marketed agriculture output and non-marketed ecosystem services into complementary, supplementary or competitive relationships, depending on the minimum farm-level non-marketed ecosystem services, is proposed in this study. These joint production classifications are associated with diverse opportunity cost which is central to this study. A flexible transformation function and cross sectional data on 120 smallholder farmers with agroforestry certification in parts of rural Mount Kenya is use to empirically test the theoretical model.

The results seem to suggest that the joint production (agricultural output and ecosystem services) of a substantial number of smallholder farms in Kenya may not have a complementary relationship. Furthermore, the biophysical linkage between non-market ecosystem services and marketed outputs strongly influence the marginal cost of ecosystem services. Agri-environmental schemes could be designed in a more efficient manner if they target certain smallholder farms based on aforementioned classification and offer a range of contracts to encourage competitive bidding.

Keywords: Agroforestry, agri-environmental scheme, efficiency, payment for ecosystem services

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Incidence of Deforestation in Permanent Preservation Areas in Settlement of Agrarian Reform in Brazilian Amazon: A Case Study at the Pacajazinho Community

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As the activities developed in the Brazilian Amazon settlements have potential to produce forest degradation and deforestation in the region, the public policies remain with the dilemma of either meeting the social demand ensuring access to land for small farmers, or keeping areas with natural forest, source of numerous services and ecosystem functions. Within the settlements, the Permanent Preservation Areas (PPAs) are recognised for their ecological importance and therefore should be protected. In this context, this study aimed to determine the incidence of deforestation in PPAs of the rural settlement Pacajazinho in the municipality of Novo Repartimento, Para State, which has 32 settled farmers. Here we used an exploratory research based on the data set of the Rural Environmental Registry (CAR) provided by the State Environmental Agency, in order to identify variables to enhance such territories given its ecological potential and provision of environmental goods and services to the society. The study found that many areas that were considered PPAs were cleared and declared to be subject to future recovery of natural vegetation. The areas of PPA cleared corresponded on average 4.06 ha per property, ranging from 0.26 ha to 12.08 ha. In addition, from the PPA initially planned, only 21.29 % remain unchanged. The exploratory research findings of this study draw attention to the importance and the benefits provided by PPAs, coupled with the fact that the settled farmers, generally do not have the resources to rebuild those areas already cleared. In fact, the benefits derived from PPAs reverberate throughout society and require the correct valuation, supporting thus the establishment of environmental protection and recovery policies. Therefore, we proposed the insertion of Payment for Environmental Services (PES) schemes for the PPA remnants as economic incentive to recover the degraded areas and thus restore the ecosystem functions and services lost due to forest removal, especially in rural settlements located in agricultural and livestock frontier areas, such as the community case study.

Keywords: Payments for ecosystem services, public policy, sustainable development

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Management, Biodiversity and Plant Phenology Are the Most Important Predictors of Forage Provision and Erosion Regulation in West African Grasslands

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The ability of grasslands to provide vital ecosystem services (ES) depends on ecosystem functioning, which is interactively driven by abiotic and biotic factors. The relative importance of these factors for ES supply in West African grasslands is still poorly understood, hampering the design of appropriate land management strategies. Taking a macroecological perspective, we aimed at detecting broad and consistent patterns in ES drivers and supply, focusing on the provisioning ES 'forage' (proxies: aboveground herbaceous biomass – AGB; metabolisable energy – ME; metabolisable energy yield – MEY) and on the regulating ES 'erosion control' (proxy: cover of perennial plants in grass layer – PC). This study which is part of an interdisciplinary project addressing climate change adaptation and mitigation in West Africa (www.wascal.org), covered almost the entire climatic gradient of West Africa's Sudanian savannahs, and reached from northern Ghana to central Burkina Faso. We used linear mixed-effect models and model selection procedures to test effects of eighteen biotic and abiotic drivers on ES proxies, and bootstrapped final models to quantify bias. We found that biotic factors (related to management, biodiversity and plant phenology) were generally more important than abiotic factors (related to climatic aridity, topography and soil characteristics). Grazing pressure and litter cover were the most important management-related factors while species richness and the relative abundance of three functional groups (e.g. tall perennial grasses) were the most important biodiversity-related factors. Increasing grazing pressure (quasi-) linearly reduced forage AGB and MEY while increasing forage quality (ME). The effect of grazing on AGB and MEY was modulated by phenology. Our study established the first predictive models of vital ES in West Africa's Sudanian savannahs. The finding that management and biodiversity related drivers are more important for ES supply than climate implies that ecosystem-based adaptation strategies could mitigate potential negative effects of climate change. This is of great value for land management planning in the region.

Keywords: Abiotic, biotic, ecosystem services, forage, grasslands

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The Genetic and Morphological Diversity of Nance (*Byrsonima crassifolia*) in Yucatán, Mexico

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To assure future food security, the conservation of agrobiodiversity is a key aspect. It is important to preserve the interspecific diversity as well as the intraspecific diversity. In many areas worldwide plant agrobiodiversity is conserved in home gardens. A great variety of neglected and underutilised species can be found there. The promotion of these species matters as they can contribute to food security, improved nutrition, improved income of rural poor, and agroecosystem stability.
Here, the diversity of the tropical fruit tree Nance (*Byrsonima crassifolia*) was investigated in Yucatán, Mexico. Nance is a typical representative of an underutilised and neglected species. The multipurpose tree occurs in Central and South America. Although broadly distributed and still frequently found in Mexican home gardens, it is only relevant for local markets.
Being a plant with future potential and so far not intensively investigated, it is interesting to evaluate the morphological and genetic diversity of Nance in detail. In total 213 trees were investigated, of which 16 could be assigned to be wild.
This study is divided into three parts: A questionnaire about the local use of Nance, morphological observations based on leaf characteristics and genetic diversity descriptions, analysed with microsatellite markers. With the developed questionnaire the knowledge and management about Nance of the locals was captured. Results indicated knowledge erosions about the utilisation of the multipurpose plant.
Nance showed a great leaf morphological diversity. The observed and expected heterozygosis for the genetic diversity was calculated with H_o= 0.3380 and H_e=0.4319. Comparative results of cultivated Nance individuals and wild savannah stands, did not show clear signs of clustering, but indicate a process of Nance towards domestication. Comparing genetics, morphology and vegetation, evidence points out two subgroups of Nance, divided by a vegetation change and differences in leaf size.

Keywords: Agrobiodiversity, *Byrsonima crassifolia*, interspecific diversity, intraspecific diversity, morphological diversity, neglected and underutilised species

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How Does Biodiversity Work in Tropical Agroecosystems? - Physiological Responses of Cacao Plants to Neighbouring Plants

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While reactions of plants to their abiotic environmental conditions as well as to herbivore attacks are well understood, research on plant-plant interactions such as allelopathy and facilitation is still at the very beginning. The latter may be the clue for understanding the impacts of biodiversity in agroecosystems. It is common knowledge that plants communicate unspecifically via volatile compounds, e.g. jasmonic acid, emitted after a herbivore attack and react by the upregulation of the synthesis of secondary compounds, e.g. polyphenols. Additionally, more specific reactions to such stressful events can take place on the enzymatic level. Stress-related enzymes, such as chitinases or polyphenoloxidases (PPOs), or rather their activity patterns can be considered as a possible physiological marker for such reactions. However, the question whether plants respond to the presence of other plants in their vicinity remains unanswered. A further point to be clarified is whether plants react differently to plants of their own species surrounding them than to plants of other species. Do they recognise their neighbour? The physiological response to allelochemicals emitted by neighbouring plants in partiular has scarcely been assessed. To answer these questions, we cultivated cacao seedlings with leaf extracts of banana and/or papaya and analysed the isoenzyme patterns of PPOs using native PAGE. The results indicate that cacao seedlings show changes in the PPO activity pattern when being treated with different leaf extracts. These results are in accordance with greenhouse and field trials. Our data highlight the relevance of plant-plant interactions in diverse cropping systems such as agroecosystems and may contribute to better exploiting the potentials of plant facilitation in agricultural production.

Keywords: Allelopathy, facilitation, isoenzyme patterns, polyphenoloxidases

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The Impact of Landscape Characteristics on Biodiversity of Spider Assemblages in Okra Fields in West Africa

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The objectives of this study were to investigate how ground dwelling spider abundance and family richness of okra agroecosystems change along an urbanisation gradient and also to investigate how changes in ground dwelling spider abundance and richness are affected by landscape elements. To achieve these objectives, 36 okra fields in and around Ouagadougou, Burkina Faso and Tamale, Ghana were selected, with 12 fields equally distributed in four areas (three fields per area) of the rural, peri-urban and urban zone. These fields were sampled for ground dwelling spiders using pitfall traps for two weeks. At the end of the study, the results show that spider assemblages in Ouagadougou and Tamale are unique and are also affected by climate. Ground dwelling spider abundance in the drier Ouagadougou was higher than in the wetter Tamale but Tamale is richer in ground dwelling spider families. Also, even though not significant, trends in Ouagadougou show that there is the increase of ground dwelling spider abundance from rural to urban zones while the opposite trend exists in Tamale. In both cities, the Gnaphosids decrease from rural to urban while the Lycosids increase from rural to urban. Ouagadougou ground dwelling spider assemblages are characterised by the dominance of the Gnaphosidae, the Lycosidae, the Salticidae and the Linyphiidae, while the ground dwelling spider assemblages in Tamale are characterised by the dominance of the Gnaphosidae, the Lycosidae, the Zodariidae, and the Thomisiidae. Future multi-seasonal studies should include multiple methods of sampling rather than only relying on pitfall trapping and on spider species determination.

Keywords: Aranae, biodiversity, urbanisation, West Africa

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Local Forest Management Institutions and their Role in Conserving Woody Species Biodiversity: A Case Study in Tigray, Northern Ethiopia

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Traditional forest management institutions have a long history in Tigray, northern Ethiopia. However, little evidence exists regarding the nature of the local-level institutions and their role in conserving biodiversity. This study was undertaken to analyse the nature of local forest management institutions and their effectiveness in conserving woody plants biodiversity using a case study in the northern Ethiopian region of Tigray. The communal forest management institutions incorporate clear forest boundaries; defined users and use rules; monitoring procedures and sanctions; and conflict-resolution mechanisms. This study evaluates both the subjective perceptions of the people who manage and use communal forests and the objective conditions of communal and open access forests, and finds positive results for communal management based on both types of evidence. Three communal forests managed by communities under local forest management institutions and three adjacent free access grazing lands were selected to compare the vegetation composition. The communal forests and the adjacent grazing lands had similar vegetation cover in the past. In addition, they have similar geological parent material, altitude, rainfall and drainage conditions. Investigation of vegetation parameters was undertaken from 84 plots. Data from group discussions and a 120 household survey were also collected in order to analyse institutional arrangements and the perceptions of users. Results show greater forest health under indigenous communal institutions than under open access. For instance, a total of 30 indigenous woody species of trees were recorded in the three communal forests, while only six species were recorded in the three grazing lands. The diversity of woody species of trees in the communal forests was significantly different ($p < 0.01$) from the free grazing lands. About 95 % of the respondents reported their preference for the local communal forest institutions to continue. In conclusion, the local forest management institution appears to be much more effective than the free access to grazing lands in conserving woody tree species diversity. The results imply that local forest management institutions can help in biodiversity conservation. The experiences of the three communal forests can shed light on the scaling up of such management arrangements.

Keywords: Biodiversity, conflict resolution, Ethiopia, local forest management institutions, open access

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Biodiversity of Beetles (Coleoptera) in Areas under Participatory Forest Management in Kafa Biosphere Reserve, Ethiopia

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The UNESCO Kafa biosphere reserve is located in western Ethiopia in the Southern Nations Nationalities and People's Region. Kafa is one of the last mountain cloud forest regions in Ethiopia. The Kafa biosphere reserve is around 760,000 hectares and is largely covered by mountain cloud forests where wild coffee *Coffea arabica* grows. However, creeping deforestation and the spreading of agriculture are threatening the reserve. Areas under participatory forest management (PFM) are mostly used to grow coffee as understorey tree in the montane rainforest. Other ecosystems include bamboo forest, the bamboo is used for construction, and wetlands partly used for grazing cattle. Projects are underway for protecting, reforesting and sustainably using the wild coffee forests and their biological diversity. Intense field work was conducted in December 2014 in order to conduct for the first time a comprehensive assessment of the biodiversity of beetles (Coleoptera) in the Biosphere reserve. A wide range of habitats and altitudinal gradients were covered. Various sampling and trapping methods used proved to be effective, including sifter, sweeping net, aerial insect car net, Barber pitfall traps, light trap and flight intercept trap. 400 beetle species belonging to 79 families / subfamilies were recorded, almost all major beetle families occurred in the sampled sites. Within 10 sampling days and despite collecting during unfavourable season, 164 Staphylinidae species were recorded, out of ca. 530 known for Ethiopia (30 %). In the bamboo forests, phytotelmata were discovered, hidden freshwater habitats yet unknown for Ethiopia. Species diversity in PFM forest sites was found to benefit when moisture in the ground layer is kept by the presence of large trees, or microstructures like climbing plants, tree holes, or diversity in shrubs and herbs.

Keywords: Biodiversity, *Coffea arabica*, Coleoptera, mountain cloud forest

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Population Structure and Genetic Diversity of Sudanese Pearl Millet Landraces, and Relationship Between Genetic and Agro-Morphological Diversity

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Understanding the genetic structure and identification of distinct clusters with complementary traits is an important goal for a sustained and successful pearl millet breeding program. In this study a genotypic analysis of 214 pearl millet accessions collected from different geographical regions of Sudan, and 10 accessions from West and Central Africa, were conducted with 30 simple sequence repeat markers (SSRs) covering the pearl millet genome. A high degree of molecular diversity among the studied material was observed, with an average of 13.3 alleles per locus was detected. The average polymorphic information content (PIC), gene diversity and observed heterozygosity of the 30 SSRs were 0.77, 0.82 and 0.72 respectively. A total of seven phylogenic groups with variable sizes were identified. Low correlation between the agro-morphological matrix and the genetic matrix was observed (r = 0.20). The average PIC values obtained across the seven linkage groups varied significantly. Neighbour-jointing tree, principal components analyses and STRUCTURE showed that there were no clear differentiations among the geographical regions. This result indicated that there were high levels of admixture among the regions. Analysis of molecular variance (AMOVA) revealed that the variation of pearl millet accessions within the regions was much higher than among the regions. The large divergence observed among the landraces of this study would be promising for developing new varieties as well as for development of heterotic groups which can be used to develop population and hybrid varieties with higher degrees of heterozygosity and therefore hybrid vigour and stability, as well as to intensify yield production in the harsh production environments of Sudan.

Keywords: Genetic diversity, geographic regions, pearl millet, simple sequence repeats (SSRs), Sudan

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Monitoring Wetland Vegetation Regeneration in an Inland Valley in Uganda

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With rapid population growth and degradation of upland fields, East African wetlands are increasingly converted into cropland. While fertile soils and seasonal or permanent water availability make wetlands highly suitable for crop production, such land use changes adversely affect biodiversity and functions of these ecosystem. Such effects may be counteracted by a recovery of natural vegetation during fallow periods.
We studied the dynamics of vegetation recovery within an agriculturally used inland valley in Central Uganda. The sampling plots were at three hydrological positions. Over two seasons we assessed biomass, vegetation structure and species composition and abundances at regular intervals.
Regeneration models are used to predict the biomass recovery after abandonment of cropland. The regular monitoring of seasonal and successional stage related changes in species composition will help to estimate the importance of fallow periods for biodiversity conservation and for restoring ecological functions as well as for the provision of Ecosystem Services that may depend on the successional stage. These include medical plants used by the local population, valuable forages and also flowers to support pollinators and hence pollination.
After six months, biomass regrowth was on average 1087 ± 136 gm^{-2}, ranging from 764 ± 47 gm^{-2} at the outer fringe to 1420 ± 175 gm^{-2} in the centre of the studied wetland. The biomass recovery is significantly affected by the type of uses prevailing previous to fallow ($p < 0.05$). In early recovery stages, the vegetation was dominated by sedges, especially the annual *Cyperus difformis* in the wetter and the perennial *C. distans* in the dryer positions. During the dry season, these were gradually replaced by grasses such as *Setaria homonyma* and *Paspalum scrobiculatum*. Species abundant throughout the observed period were *Leersia hexandra* in the moister locations and *Ageratum conyzoides* towards the dryer fringes of the wetland.
The average number of species per plot was gradually increasing during the rainy season from 8.7 after two months up 15.8 after four months and then decreasing during the dry season. In conclusion the vegetation recovery and hence the resilience to anthropogenic disturbances is depending on hydrologic conditions and past uses with faster recovery in the moist centre of the wetland.

Keywords: Biodiversity, biomass regeneration, East Africa, fallow, growth models, inland valley, vegetation ecology, wetlands

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Food and Timber Plants from Mexico, their Response to Spatio-Temporal Variations and Implications for Rural Development

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Tamaulipan thornscrub is the native vegetation of northeast Mexico. Most of its plant species are used by the rural community for different purposes including fodder, timber, traditional medicine and food. Tamaulipan thornscrub is severely fragmented due to land use change to give way to agriculture and induced buffel grasslands for cattle grazing. The remaining fragments vary in size from a few hundred hectares to those under one hectare, with the most common not larger than ten hectares each. Isolated trees of useful species remain inside induced grasslands and sometimes even inside agricultural lands. Thus, for a given individual tree, conditions vary from growing inside native vegetation to growing isolated in a human made landscape with varying competition, pollinators assemblages and seed dispersers that may influence individual reproductive fitness. In addition to spatial variation, there is little information on the influence of temporal variations such as climatic events on growth and reproduction of thornscrub plants. In here we studied three of the more economically important species from thornscrub: *Prosopis laevigata* (mesquite), *Ebenospis ebano* (Texas ebony) and *Capsicum annum* (wild chili) that provide good quality timber, fodder (mesquite and Texas ebony), charcoal (mesquite), and edible fruits (wild chili) and pods (mesquite and Texas ebony). We determined that (i) wild chili does not establish seedlings above its current elevation range as was predicted by climate change; (ii) variations in rainfall and temperature over the past 15 years did not affect flowering and fruiting of mesquite but affected flowering events of Texas ebony; and (iii) isolated mesquite trees produced many times more fruits and seeds than those inside native vegetation, although the number of seedlings was similar under both conditions perhaps as a result of differential seed harvesting. The implications for management and rural development are discussed.

Keywords: Elevation, fragmentation, rural development, weather variations

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The Role of Herbivores as Dung Seed Dispersing Agent for Encroaching Woody Species in Nech Sar National Park, Ethiopia

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The Plains of Nech Sar National Park are a semi-arid savannah, and have been used for cattle grazing since 1960s. This has led to changes in the vegetation, which have been associated with overgrazing and is affecting biodiversity conservation and ecotourism development. To determine if endozoochory could be one explanation for changing vegetation, we investigated the seed dispersing role of herbivores in this ecosystem. We collected a total of 27.5 kg dry weight dung of cattle, goat, sheep, zebra, greater kudu, lesser kudu and Grant's gazelle from the savannah plains; extracted seeds of *Dichrostachys cinerea*, *Acacia nilotica* and *Solanum incanum* and carried out seedling emergence tests between 2012 and 2014. We found 15926 seeds of which 95.4 % were undamaged. *S. incanum* accounted for 53.4 % of the undamaged seeds, followed by *D. cinerea* (25.7 %) and *A. nilotica* (20.9 %) with seed density of 339.6, 163.8 and 133.1 kg^{-1} dung, respectively. We found large number of seeds in the dung of greater kudu (42.2 %), Grant's gazelle (24.9 %) and lesser kudu (20.3 %), whereas small quantity from dung of cattle (1.4 %), zebra (5.3 %) and goat (6 %). However, seeds from dung of lesser kudu showed the highest germination success (14 %) followed by seeds from dung of cattle (11.1 %) and greater kudu (10 %). The germination success of seeds of *D. cinerea* from dung of lesser kudu, cattle and goat was 28.7 %, 19.7 % and 16 %, respectively. The overall germination success for seeds from the dung samples was 9.2 %, being 17.1 %, 6.5 % and 4 % for *D. cinerea*, *A. nilotica* and S. incanum, respectively whereas it was 6.4 % for seeds from control groups. Our results show that lesser kudu, cattle, greater kudu, Grant's gazelle and goat facilitated the dispersal of *D. cinerea* and *A. nilotica* but not *S. incanum*. This, leading to change in vegetation structure, may have negative impact on biodiversity conservation and ecotourism development in the region. Hence close monitoring to control expansion of the bush encroachment because of zoochory should be supported by large scale researches.

Keywords: Encroaching species, endozoochory, herbivore, Savannah plains of Nech Sar National Park, seed dispersal

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Response of Cowpea Genotypes to Low Soil Phosphorus Conditions in Africa

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Soils in tropical regions have inadequate levels of phosphorus and this apparently leads to reduced cowpea yield in Africa. Identifying P-efficient cultivars has the potential to reduce the demand for P fertiliser and increase the productivity of cowpea. Therefore, this study was conducted to identify cowpea genotypes that maintain high yields, high P use-efficiency and uptake under low soil P condition.

A green-house experiment was conducted at the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria. Fifteen (15) cowpea genotypes were used with two sources of phosphorus fertilisers: rock phosphate (RP) (60, 90 and 120 mg P kg^{-1} soil) and mono potassium phosphate (MP) (30, 60 and 90 mg P kg^{-1} soil) and compared to the control. The experiment was laid out in a strip plot arrangement, using completely randomised block design with three replications.

The findings suggest that enough variability and genetic heritability exist among the tested cowpea genotypes. Out of the 15 cowpea genotypes, IT90K-59 was identified as best P responder genotype for biomass production and IT90K-76 for grain yield at a rate of 60 mg P kg^{-1} soil as MP, whereas Danilla and IT89KD-288 were good performers for grain production under no or minimal external P application. Five genotypes were identified as good responders to rock phosphate based on their grain yield production. The best response by cowpea genotypes was at P-fertiliser treatment level 60mg P kg^{-1} soil of MP. A significant correlation was found between grain yield and total P-uptake (R^2 = 0.3629*), but there was a very weak correlation between of grain yield and total N-uptake (R^2 = 0.0203) in cowpea genotypes. Fertiliser recovery rate of cowpea genotypes was between 14.03 % - 4.63 % with the cowpea genotype IT90K-59 having the best recovery rate.

The differential response to low P-efficient implies that these traits warrant effective selection for further improvement. Hence, identifying genotypes that can grow well in low phosphorus condition has the potential to reduce the quantity of fertilisers used on agricultural lands. Genotypes with high biomass production are of immense importance in soil fertility management since cowpea has unique potentials to fix atmospheric nitrogen.

Keywords: Cowpea genotypes, mono potassium phosphate, nitrogen fixation potentials, nutrient uptake, rock phosphate

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Tied-Ridging: Great Concept, But Rare Implementation – A Review of Knowledge and Risk Reduction Options

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Water deficit is the main factor limiting crop production in rainfed farming systems under arid and semi-arid environments. In these environments uni- and bimodal rainfall regimes prevail, while annual total precipitation is low, erratic and highly variable between years. In addition, high intensity rainfall events lead to significant run-off water and soil losses from sloping fields. To avoid these losses tied-ridging has been developed as a soil and water conservation technique. The technique consists of establishing contour furrows with cross-ties, creating mini-basins. Water collected in the basins overflow the cross-ties when rainfall is heavy and follow the furrows that are built at a slight angle to the contour.

Tied-ridging has been shown capable of reducing run-off by more than 75 %, soil loss up to 95 % and to improving greatly soil water availability and consequently increasing yields up to over 50 %. Reduced surface run-off and higher infiltration has been proved not only to increase plant available soil water, but also to significantly contribute to groundwater recharge. The effects of tied-ridging on soil water, yield and groundwater recharge are, however, highly variable in space and time. This variability in combination with the fixed additional investment for ridging might be the principal reason for the limited implementation so far.

Results from over 100 articles published on tied-ridging research are structured and examined to assess whether it is possible to tailor multi-factorial threshold values, for precipitation, slope, soil type, crop, tied-ridge dimensions, that are required to allow a significant positive impact of tied-ridging. Furthermore, the published data are analysed for their suitability to describe functions that can be integrated into current water and crop growth models. Integration of tied-ridging as an management option into these models could serve farmers, extension workers and researchers to predict the impact of tied-riding. This could eventually reduce the risk of investment loss, promote implementation and ultimately improve food security. Remaining knowledge gaps identified are translated into into specific research questions.

Keywords: Furrow diking, run-off, soil conservation, tied-riding, water conservation

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Soybean Growth Affected by the Application of Biodigestates from Sugar Cane Vinasse

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The biodigestion of vinasse, a byproduct of sugar cane ethanol industry, is a technology that results in the formation of two products: biogas and the biodigestate of vinasse. Besides the production of biogas that can be used as energy source (for electricity generation or heating), the resulting biodigestate presents a remarkable reduction in its biochemical oxygen demand (BOD), which in turn decreases the pollutant impact of the vinasse. Moreover, the fertiliser value of vinasse will not be reduced, keeping the same potassium levels and allowing the use of vinasse in irrigation systems. Sugar-cane is a semi-perennial crop, requiring replanting every five to seven years. In the Central region of Brazil, soybean is one of the best alternatives as crop rotation between two sugar cane production cycles because of the short production season and the contribution to the soil nitrogen pool. This work aimed to study the effect of application of different vinasse biodigestate amounts on the development of soybean plants.

The test was conduced in the Faculty of Agronomy of the Federal University of Goiás (Brazil). Pots were filled with a Rhodic Ferralsol and planted with soybean seeds. The treatments consisted of different amounts of biodigestate (equivalent to 0, 0.5, 1, 2 and 3 times the recommended amount, which is 300 m^3/ha). Vinasse was also applied at the recommended rate (300 m^3/ha). Plants height and diameter were measured after seven weeks of planting.

Except for the 150 m^3/ha treatment, all other treatments presented lower plant height and diameter when compared to the control treatment (no application of vinasse). One of the possible reasons is that the high content of K present in the biodigestate and the vinasse had a phytotoxic effect on the soybean plants. Further studies are being conduced to better understand the processes and impacts of application of sugar cane byproducts and avoid negative impacts.

Keywords: Bioenergy, *Glycine max*, natural resources management, probiogas, residues

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Biological Nitrification Inhibition (BNI) in Tropical Pasture and its Influence on the Recovery of Applied Nitrogen Fertiliser by Subsequent Maize Crop in the Llanos of Colombia

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Biological Nitrification Inhibition (BNI) by the tropical pasture grass *Brachiaria humidicola* (Bh) suppresses the microbial conversion of relatively immobile ammonium (NH_4^+) to very mobile nitrate (NO_3) in soils. BNI is expected to reduce nitrogen (N) losses by NO_3 leaching and nitrous oxide (N_2O) emission. Smallholder farmers could benefit from BNI of improved Bh pastures by obtaining higher yields of a subsequent crop. CIAT researchers had demonstrated that within 3 years, Bh pastures had suppressed soil nitrification. It was hypothesised by us that the residual BNI effect of Bh enhances the N use efficiency of a subsequent maize crop since tissue turnover of Bh biomass could lead to passive release of BNI compounds and consequently preserve N in the form of NH_4^+. A field trial was established in Colombia to determine the effects of BNI from a long-term Bh pasture after its conversion to maize cropping in terms of grain yield and N uptake of maize. Maize was also grown in an area of degraded Bh pasture (low BNI) and also in a long-term maize mono cropping field (non-BNI control). Four N fertiliser levels were used to study the influence on N losses and its influence on maize grain yield. ^{15}N traced N fertiliser in microplots was used for determination of the N recovery. Dicyandiamide application served as synthetic nitrification inhibition control. Soil incubation method was used to test differences in rate of nitrification among the three field sites. Results showed superior yields in the preceding Bh field sites. Reduced nitrification rate observed in soil indicated that the BNI effect was present even after conversion of Bh pasture to maize cropping. Fertiliser N recovery by maize on BNI soil from pasture sites was only higher under low rate of N fertiliser application but not under higher rate of N application. It can be concluded that Bh has a huge potential to reduce N fertiliser amounts and N losses due to BNI and boost yields of subsequent crops in low input pasture-crop rotations by enhancing plant N supply. New research tools are necessary to measure BNI in plants and soil.

Keywords: Biological nitrification inhibition, *Brachiaria humidicola*, forage grasses, maize yield, nitrogen use efficiency, residual effect

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Analysing Nutrient Flows in Mixed Crop-Livestock Systems to Identify Efficient Practices in Western Kenya

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Depleted soils and low resource efficiency are a risk for smallholders' food and financial security in East Africa. Soil fertility is affected by management decisions which depend on biophysical and socio-economic factors. Aiming at finding options to increasing farmers' efficiency in nutrient use, this study analyses the nutrient management and flows within mixed crop-livestock systems. Carried out within the Mau-Mara-Serengeti (MaMaSe) Sustainable Water Initiative, which aims at improving water safety and security in the Mara River Basin, we focused on the upper Mara River basin in Western Kenya. We used the MonQI Toolbox, which together with its predecessor has been thoroughly tested in Africa, designed to monitor and evaluate the performance of smallholder farms. A typology was constructed to take into account the diversity of farming systems in the area. All details about farm management, inputs and outputs were quantified for three farm types: 1) dairy production strategy in a mixed system 2) cash crop strategy through coffee or tea production 3) staple crops in semi-arid conditions. Our findings showed that big losses occur within farm nutrient flows. Due to a lack of water, plants couldn't uptake applied nutrients efficiently and yields remained low. Farmers who adopted agroforestry practices, a diversified intercropping system and soil and water conservation measures showed better performance. We discussed that implementation of these practices have an advantage regarding nutrient balance, yields and income. Looking at the high frequency of droughts and intensity of rainfall, implementation of soil and water conservation measures is a first necessity for the future of this area.

Keywords: Food security, Mara River Basin, mixed crop-livestock systems, monQI, nutrient flows, soil and water conservation, soil fertility, western Kenya

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Field Experiment on a Tropical Andosol in Karagwe, Tanzania Using Organic Wastes from Bioenergy Provision and Ecological Sanitation

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Because of high phosphorus (P) fixation, Andosols regularly require P amendments to guarantee high crop production and sustainable land use. Further they tend to accumulate organic carbon (C) and thus they can act as CO_2 sinks for C-sequestration. Ecological sanitation and bioenergy production, such as anaerobic digestion and pyrolysis or microgasification, can contribute to local nutrient and carbon recycling. Soils can be amended with compost, urine, biogas slurry or CaSa-compost (containing biochar and sanitised human excreta) to replenish nutrients and to guarantee sustainable crop production. A practice-oriented field experiment was conducted to assess five amendments' short term effects on crop productivity, plant nutrition and soil properties on tropical Andosol in Karagwe, Tanzania. Seven intercropped local plant species were planted on 9 m^2 plots with five repetitions arranged in a latin rectangle. Differences in biomass production were related to the availability of water and nutrients in the soil. The amendments did not change the plant-available water in the soil significantly. Therefore, differences in crop yield and plant nutrition could be related to nutrient availabilities from the soil alone. Biogas slurry, compost and CaSa-compost increased the aboveground biomass of *Zea mays* by about 140, 154 and 211 % respectively as compared to the unfertilised control treatment. Plots amended with biogas slurry, compost and CaSa-compost yielded about 2,630, 3,180 and 4,400 kg ha^{-1} air-dry maize grains respectively compared to 1,100 kg ha^{-1} on the control plots. Nutrient balancing revealed that 20 % of the applied P was taken up by plants. Only the amendment of CaSa-compost significantly increased plant-available P concentrations (from 0.5 to 4.4 mg kg^{-1}) in the top-soil compared to the untreated control. We conclude that the used amendments are applicable and effective to sustain fertility and productivity of the local Andosol. Especially CaSa-compost contributes to mitigating P-scarcity and acidification.

Keywords: Biogas slurry, composted biochar, crop nutrition, ecological sanitation, field experiment, hydraulic properties, soil chemistry, soil improvement, Terra Preta practice, waste as resource

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Smallholder Management Practices and their Effects on the Carbon and Nutrient Status of Peat Soils under Oil Palm Cultivation in Sebauh Sub-District, Sarawak, Malaysia

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Recently the development of industrial plantations and cultivation of oil palm on peat lands has created numerous discussions due to its future potential but also because of its adverse social and environmental effects. On tropical peat land in Malaysia, in particular in Sarawak with its big peat swamp areas, oil palm production is increasing. Due to high market prices, governmental support and the convencience of the peat land, more smallholders are getting involved in cultivating oil palm on peat soils, even though initial cost and labour for drainage might be required and land ownerships issues are creating conflicts. Industrial estate plantations on peat soils have been studied in terms of carbon emissions and management practices, but there is currently no information available when it comes to smallholder management practices and their future possibilities for more sustainable practices in a sensible environment like peat lands. Due to the lack of information, extension officers, and resources, most of the smallholders tend to copy their management strategies from the neighbours and only rely on chemical fertiliser without being aware of alternative strategies. Therefore this study aimed to investigate soil management practices that are applied by small scale oil palm producers cultivating on peat soils in Sebauh Sub-District, Sarawak Malaysia, and the effects of these management practices on soil nutrient characteristics. Furthermore, it is intended to evaluate the potential for more sustainable management practices. To characterize the variety of practices, influencing factors, and to measure soil nutrients, interdisciplinary methods are being carried out in the field and in the lab. The qualitative mehods used, are a variety of PRA's, interviews and a questionnaire survey. Additionally quantitative methods in terms of soil sampling in selected sites were incorporated to relate applied soil management practices to the state of the soil nutrients.

Keywords: Oil palm, peat, smallholders, soil management, sustainable management

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Comparison of Determinants of Fertiliser Use Between Wheat and Maize in Hebei Province of China

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Hebei province is one of the most productive agricultural regions and one of the key areas for national food security in China. Since the 1980s, an intensive use of chemical fertilisers has been applied to the regional typical wheat-maize rotation system. This resulted in an increase in productivity of the two crops; however it led to a growing threat to the sustainability of local agricultural systems and ecosystems. In order to control and reduce excessive fertiliser usage, much research on optimal fertiliser application and determinants of fertiliser application has been conducted. However, there are few studies comparing the determinants of fertiliser use across different crops. The aim of this study is to answer the question of whether the determinants of fertiliser use intensity are identical or different between wheat and maize in Hebei province. Using a panel data covering the rural households in Hebei province over five years, the factors influencing fertiliser application to wheat and maize are analysed respectively. Under the wheat-maize rotation system, each household grows both wheat and maize in the same field every year. This makes the fertiliser use on the two crops comparable and leads to less bias in the results. The explanatory variables include age, education, off-farm job, agricultural assets, agricultural insurance, formal and informal loans, farm size, hired labour, manure use, irrigation, crop yields, crop sales and government purchase and are analysed in a fixed effects model. The findings of this study are expected to identify the different determinants of fertiliser use intensity between wheat and maize production in Hebei province. These findings will be the empirical evidence that can guide existing as well as future fertiliser use policies, which take crop differences into consideration.

Keywords: China, crop comparison, fertiliser use, Hebei province, wheat-maize rotation

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Innovation of Biofertilisers-Organic Based Nutrients Management and Water Saving Technology to Secure Rice Productivity

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Indonesian's food security is hazardous due to rapidly growing population, soil health degradation and water scarcity problem. Since 2007 different nutrient management techniques have been developed (1) biofertilisers inoculant (consortia of *Azotobacter* sp, *Azosprillum* sp, *Pseudomonas* sp and *Bacillus* sp), (2) decomposer inoculant (consortia of *Streptomyces* sp, *Cytophaga* sp, *Bacillus* sp, and *Trichoderma* sp) for composting rice straw, (3) organic ameliorant (75–90 % of straw compost + 10–25 % of rice husk biochar). These techniques were introduced as an integrated organic-biofertilisers based nutrients management and water saving technology, known as SOBARI (system of organic based aerobic rice intensification). This technology should remediate the soil health, reduce the inorganic fertilisers uses, increase the efficiency of water irrigation use and to increase the rice production in sustainable ways. The SOBARI uses efficient water condition from muddy to –5 to –10 cm as indicated at the water gauge of the water level indicator, it uses young seedlings (12–15 days), a widely planting space (30 cm × 30 cm or 30 cm × 35 cm), two single seedlings are planted at each planting cross section with a distance of 5 cm, and it further uses 2–5 ton ha^{-1} organic ameliorant and 500 – 1000 g ha^{-1} of biofertilisers inoculant. The field experiments and demo plots results from 2007–2015 at different locations (provinces) in Indonesia revealed that (1) the SOBARI as integrated water saving technology increased the efficiency of water irrigation uses by 35 %, (2) twin seedling planting technique of SOBARI increased the rice grain yield by 20–30 % as compared to conventional methods, (3) application of 2–5 ton $ha^{-1}$of organic ameliorant and biofertilisers reduced the application of inorganic fertilisers by 25–50 %, improved soil health (soil organic carbon, nutrients status in soils) significantly, and increased the rice productivity by 50—200 %. Therefore, SOBARI has a great prospect to increase the rice productivity from 5–6 ton ha^{-1} to 6–8 ton ha^{-1} of grain yield relatively easy nationalwide for securing the food resilience in Indonesia.

Keywords: Biofertilisers, food security, organic fertilisers, SOBARI, straw compost

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Effects of Biodynamic Preparation 500 (P500) Cow Horn Manure on Early Growth of Barley, Pea, Quinoa, and Tomato under Saline Stress Conditions

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Large areas of salt-affected soils are found in tropics, especially in Africa, South America and the Middle East. While soil salinity might lead to food insecurity in those regions and affect farmers who are most vulnerable to environmental stress, however, little is known how the abiotic stress can be managed with locally available resources without involving high cost. Decades of practical evidence have demonstrated the benefits of the farm input, called biodynamic preparation 500 (P500) cow horn manure, such as improving crop performance and providing resilience against various stress conditions. Organic agriculture is already seen as an important issue in sustainable crop production in the tropics, but also biodynamic philosophy and agricultural practices are discovering tropical countries. Biodynamic preparations in tropical crop production are already in use, while there is a lack of research concerning their performance. This study was conducted to quantitatively determine the effects of P500 on the early growth of different crops under saline condition. A randomised block design with six replicates in a green house chamber pot trial consisting of two factors, viz., SALT (stressed and control) and PREP (P500 and blank) was run with four crop species that have importance in temperate and tropical countries, viz., barley, pea, quinoa and tomato. Plants were harvested 38 days after sowing and aerial biomass dry matter (DM g) was measured. Results suggest that the application of P500 significantly enhanced the initial biomass production of all tested crops, even under saline conditions (except for tomato). In all crops the biomass yield was significantly improved, average 18.5 % and 16.7 % for non-saline and saline treatments, respectively. Findings suggest that P500 may be a measure to mitigate the stress from adverse environmental conditions for crop plants. Thus, future research with more genotypes, varieties, and crop species, in field conditions where the soils suffer from extreme abiotic stress, should be followed.

Keywords: Biodynamic, biomass, salinity, stress

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Effects of Nitrogen Deposition Rates and Frequencies on the Abundance of Soil Nitrogen Related Functional Genes

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Microbial nitrogen (N) cycling are interesting topics under increasing N deposition. N-related nitrogen functional genes (NFG) abundances are most responsive to N deposition and commonly used to be indicator for N transformation rates. However, conventional simulated N deposition has been exclusively processed through large and infrequent N fertilisation, which may have caused contrasting effects on NFGs. Therefore, experiments with small and frequent N additions which are close to natural N deposition are necessary.

Independently manipulated N addition rates and two frequencies (twice per year addition as conventional large and infrequent N fertilisation (2N), and monthly addition as small and frequent N deposition (12N)) were conducted in a field experiment of semiarid grassland in China. Quantified analysis using RT-PCR were carried out for NFGs, including *nifH* for N fixaation, *chiA* for N mineralisation, archaeal (AOA) and bacterial (AOB) *amoA* for nitrification, and *narG, nirS, nirK*, and *nosZ* for denitrification.

NFG abundances showed distinct sensitivities to N addition rates. The *nifH, AOA-amoA, nirS* and *nosZ* gene abundances increased due to increased available N at low N rates; but constrained by salt toxicity and low soil pH at high N rates. Abundances of *chiA* and AOB-*amoA* gene showed their great sensitivities to the N enrichment. The abundance of AOB-*amoA* was more sensitive to N addition than AOA-*amoA*, although AOA-*amoA* dominated in absolute numbers, and they may predominate the ammonia-oxidation process in different conditions. The N frequencies caused significant different gene abundances of *nifH, nirS* and *nosZ* under the 2N frequency due to acidification and salt toxicity; and resulted in significant higher AOB-*amoA* gene abundances because of higher N availability under the 2N frequency.

The NFGs abundances responded to N addition rates differently, highlighting the N addition rates changed the N cycling processes. The different effects of two N frequencies on NFG abundances indicated small and frequent N addition should be used to project the effects of N deposition on N-related microbial groups as well as on N cycling, as the empirical large and infrequent N fertilisation cannot represent the natural N deposition.

Keywords: Functional gene, nitrogen addition frequency, nitrogen addition rate, nitrogen deposition, nitrogen transformation, temperate grassland

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Fluxes of Plant-Mineral Nutrients in Subsistence Agriculture of the Indigenous Community of Sarayaku

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Terra Preta and knowledge about the nutrient cycle of indigenous agriculture may be crucial for the survival of indigenous villages and the protection of the Amazon rain forest. Thus, there is a growing scientific interest in Terra Preta resulting in numerous publications on its relevance and its manufacturing. However, there is little evidence on the opportunities Terra Preta offers for sustainable indigenous way of life. Extraction of natural resources, growing communities and the attractions of capitalist luxury are a threat to many indigenous villages and their traditional lifestyle. Only a sustainable and producitve agriculture puts the indigenous villages in a position to maintain their lifestyle and counteract against exploitation of natural resources and deforestation. In line with this, recent studies showed that Terra Preta can often be found next to precolonial large villages in the interior of the rainforest.

The present study aims to analyse the nutrient cycles of one local family and thereby create ideas how to manufacture Terra Preta. It was conducted in Sarayaku, an indigenous village famous for its resistance against extraction of oil. Therefore were taken samples among others of residues of food, the traditional beverage "Chicha", ash, sawdust, sand and clay of a river crossing the village and analysed to obtain an almost total balance of the macronutrients.

With regard to the soil quality, a proposal for reusing these nutrients by producing Terra Preta is made. The soil-degrading practice of slash-and-burn cultivation, which is especially problematic in growing communities, may thereby be replaced by creating fertile gardens.

First results show that the combination of residues of the food, sawdust and ash among other of the family's residues seem to be a good basis with probably all important nutrients needed for agriculture. Also, obtaining the necessary coal to produce Terra Preta turned out to be no problem. The role of incorporating faeces and clay of a nearby river, which carries nutrients from the Andes, will also be elucidated.

Keywords: Ecuadorian Amazon, nutrient cycles, river sediments, Terra Preta, traditional agriculture

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Assessing, Understanding and Targeting of Non-Responsiveness to Inorganic Fertilisers Across Heterogeneous Smallholder Farming Landscapes in Sub-Saharan Africa for Improved Maize and Soybean Production

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Using improved varieties and inorganic fertilisers by smallholder farmers in sub-Saharan Africa has led to doubling, even tripling of crop productivity in many cases. Yet some reports show failure to reach effective increases of crop production by use of inorganic fertilisers, referred to as 'non-responsiveness'. Little research has investigated occurrence and causes of non-responsiveness to fertilisers. This study assessed the frequency of non-responsiveness, underlying biogeochemical causes, and management interventions to improve fertiliser efficiency in smallholder farming landscapes of DR Congo, Kenya, Tanzania and Nigeria.

Responses of maize and soybean to inorganic fertilisers varied greatly between the farming landscapes, irrespective of growing season. Inputs of NPK to maize crops failed to increase grain yield by 1 ton ha^{-1} from non-fertilised controls in 24 % of studied farmlands in Kenya, 46 % of farms in Tanzania, a staggering 74 % of farmlands in DR Congo and 79 % of farms in Nigeria. For soybean inoculated with Rhizobia, inputs of P and K failed to increase yield by 300 kg ha^{-1} from non-fertilised controls in 54 % of the studied farms in Kenya, 61 % in Tanzania, 30 % in DRCongo and a staggering 91 % of farms in Nigeria. Crop non-responsiveness across all farming landscapes tended to be greater in seasons with low or erratic rainfall, and increase with time after land conversions. Improved management with broadcasting agricultural lime at 3 tons ha^{-1} decreased the frequency of non-responsiveness for both test crops by 15 to 20 % in the Kenya site, whereas in the DR Congo site only a 5 % reduction in non-responsiveness was reached. Inputs of secondary and micro nutrients decreased non-responsiveness in maize with 20 % in the Tanzania site. At the Nigeria site, spot application of manure at 2 ton ha^{-1} and deep tillage brought down the frequency of non-responsiveness in maize by 45 % and by 27 % in soybean. Exhaustive laboratory and field kit analyses were carried out on soil texture, mineralogy, extractable nutrients, P sorption, exchangeable Al, CEC, fungal-bacterial community composition, root mycorrhizal colonisation, pest and disease scores, and plant nutrient deficiencies to understand their individual contributions to crop productivity and (non-)responsiveness to fertiliser inputs.

Keywords: Fertiliser efficiency, integrated soil fertility management, smallholder grain and legume cropping, soil and plant health

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Using CERES-Maize Model to Determine Nitrogen Fertilisation Requirements of Early Maize in Nigerian Sudan Savannah

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Optimising fertiliser management for targeted yields of maize can be achieved by the use of crop models. CERES-Maize model of DSSAT version 4.6 was used to determine nitrogen fertiliser requirements of early maturing maize varieties in the Sudan Savannah of Nigeria. Data were collected from 2013 (model calibration) and 2014 (model validation) field experiments conducted in Bayero University Kano Nigeria (11°59'N 8°25'E). The experiments consisted of 3 nitrogen fertiliser levels (0, 60, and 120 kg N ha^{-1}) and 2 early maize varieties (EVDT and 2009 TZEEW). Sensitivity analysis was performed to evaluate the responses of the two maize varieties to varying N fertiliser rates. Further sensitivity analyses were carried out for economic and strategy responses. The model predicted grain yield and harvest index reasonably well for EVDT and 2009TZEEW (RMSE= 71.1, D-index = 0.99 and RMSE= 34, D-index = 0.95, respectively). Increasing N application from 0 to 30 kg N ha^{-1} resulted in grain yield increase of 105 %, when increased to 60, grain yield increased by 226 % and when increased to 90, 120, and 150 kg ha^{-1} grain yield increased by 364 %, 451 % and 461 %, respectively. Increasing N application from 30 to 60, 90 and 120 kg ha^{-1}, increased grain yield by 82 %, 135 % and 171 %, respectively. Sensitivity analysis showed no significant yield increase when N fertiliser application was increased from 90 kg ha^{-1} to 120 and 150 kg ha^{-1} for both varieties. Economic and strategic analysis revealed that application of 90 kg N ha^{-1} gave higher monetary return per hectare and was also the most strategically efficient rate for production of early maturing maize in the Sudan Savannah.

Keywords: Biophysical analysis, CERES-maize model, nitrogen, strategy analysis

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Morpho-Physiological and Yield Response of Okra to Fertiliser Application and Weed Control Treatments

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Okra (*Abelmoschus esculentus*) is one of the most important vegetables in Nigeria and many other tropical counties. It responds to fertiliser application but is highly sensitive to weed competition, thus weed control which is usually manually done should aim at reducing drudgery and maximising fertiliser use in the crop.

Two experiments were carried out at Ido, Nigeria to evaluate the effects of fertiliser application and weed control treatments on performance of okra. The trials consisted of main plot fertiliser application of 0 and 60 kg N ha^{-1} (NPK 20:10:10) while the sub-plots were five weed control treatments: (1) Pre-emergence herbicide (acetochlor plus prometryne) application at the rate of 1.2 kg active ingredient (a.i.) per ha and supplementary hoe-weeding, (2) hoe-weeded initially for 6 weeks, (3) weed infested initially for the first 6 weeks, (4) weed free and (5) weedy check (controls). The treatments were in split-plot arranged in randomised complete block design.

Fertiliser application and weed control treatments significantly influenced morphological and growth parameters, the chlorophyll content of the leaves and fruit yields. Uncontrolled weed growth for up to 6 weeks and weed infestation throughout the crop's lifecycle significantly ($p = 0.05$) reduced okra plant height, stem diameter and crop vigour in the two trials. Okra fresh weight reduction as a result of weed infestation for 6 weeks after sowing (WAS), pre-emergence herbicide and weed infestation throughout the crop's lifecycle treatments were 24, 31, and 77 % respectively in the first trial. In the second trial, weed infestation for 6 WAS and maximum weed interference caused 50 and 79 % reduction in fresh weight of the okra. Pre-emergence herbicide application with a supplementary hoe-weeding produced okra fresh weight of 67 % 9.57 t ha^{-1} and comparable to 14.22 t ha^{-1} from weed free for 6 WAS treatment.

Therefore, for effective weed control in okra production, pre-emergence application of acetochlor plus prometryn at the rate of 1.2 kg a.i. per ha with single supplementary hoe-weeding is recommended as an alternative to two hoe weeding at 3 and 6 WAS for the production of okra under similar fertility conditions.

Keywords: Fertiliser application, okra, pre-emergence herbicide, single hoe-weeding, weed control

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The Influence of Nitrogen Nutrition on Root Exudates of Rice (*Oryza sativa*)

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Plant root exudates play an important role for plant nutrition. They consist of a complex mixture of organic acids, amino acids, phytosiderophores, sugars, carbohydrates, root border cells and other low molecular weight compounds that create interactions between the root and the microorganisms and other plants present in the rhizosphere. They play a role in the solubilisation of unavailable nutrients and to overcome toxicity. Nitrogen nutrition is known to greatly influence the carbon allocation in plant metabolism. We thus hypothesise that changes in nitrogen nutrition will affect the composition of the root exudates. Rice plants (*Oryza sativa*, cultivar IRRI-154) were pre-cultivated in hydroponic systems until the stage of maximum tillering, with 20 replicates per treatment. Three different levels of nitrogen as NH_4NO_3 (control: 2.86 mM N, high: 4.0 mM and low 0.4 mM N) were used. To collect the root exudates, rice plants were individually immersed in a sterile solution containing 10 % of the micronutrients for 2 hours during daylight. Next, the samples were lyophilized and rediluted in a solution of 80 % methanol. GC-MS analyses were performed after derivatisation with MeOX and MSTFA, using ribitol as internal standard. Principal Components Analysis revealed a clear separation in the root exudates composition between the different nitrogen levels, with a decrease for the plants with high level of N fertilisation, especially for ribose, glucose, myo-inositol, glycine, GABA and organic acids. On the contrary, plants under low level of N did not experience bigger changes in comparison with the control, except for shikimic and quinic acid, which were slightly higher. Plant growth and photosynthesis were severely affected by the long term nitrogen deprivation, so the relative surplus of reduced carbon may thus have induced a shift towards formation of more C-rich compounds. The results suggest that the release of root exudates is influenced by nitrogen nutrition. Surprising is the influence of an increased N supply. Tackling this question needs further research.

Keywords: Nitrogen nutrition, organic acids, root exudates, sugars, rice

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Nutrient Management Strategies for Rice Production in the Kilombero Flood Plain of Tanzania

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Tanzania is an important rice producer with about 16% of the total rice production area of East Africa. Some 75% of the rice is grown by smallholder farmers under Rainfed conditions in floodplain wetlands. Grain yields and returns to investments are modest with declining soil fertility being the main production constraint. Within the research project 'Wetlands in East Africa- Reconciling future food production with environmental protection', we investigate integrated nutrient management options for lowland rice in comparison to farmer's traditional production methods. Long-term field trials have been established in 2015 at Ifakara in the Kilombero District of Morogoro Region, Tanzania in three hydrological zones within the floodplain (fringe, middle, and center positions). Treatments in 2015 included inorganic fertiliser (urea), farm yard manure and green manure (*Lablab purpureus*). urea was applied at 60 and 120 kg N ha^{-1}. Both, farm yard manure and green manure have been applied at rates equivalent to 60 kg N ha^{-1}. Green manure has been incorporated into the soil after 40 days of growth and two weeks prior to rice transplanting. Grain yield and yield parameters, data on crop phenology, and nutrient uptake and use efficiency by rice have been determined. Environmental and economic impacts of the different management strategies are also being assessed for future integration into a decision support tool. First results indicate a strong response of rice on mineral N application and only a moderate response to organic N sources after one season. These responses differ in their extent by the hydrological conditions and tended to be least in the center and most pronounced in the fringe positions. Thus, the effectiveness of fertiliser strategies varies with the hydrological regime and technology targeting must be site-specifically differentiated for a sustainable future uses of floodplain wetlands.

Keywords: Flood plain, GlobE, nitrogen source, rice, small holders, sustainable

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Changes in Soil Fertility in 25 Years of Sugar Cane Monoculture in Comparison to Natural Ecosystems

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There are growing concerns about the soil fertility when changing natural land into agricultural land. With the objective to determine the long term effects of sugar cane cultivation on the soil fertility, a 25 years investigation was carried out on Vertic Haplustept soils (0–20; 20–40; 40–60 cm depth) comparing one sugar cane field (conventional agriculture), with natural forest, natural grassland and a field with annual crops. Every year soil samples of the respective plots were analysed regarding organic matter, available P and K content (extraction with H_2SO_4 0.1 N), pH (H_2O), exchangeable cations (extraction with ammonium acetate 1.0 N), bulk density, total porosity, and macro fauna. The sugar cane cultivation resulted in a decrease of the organic matter content (from 2.7 to 2.2 %, 0–20 cm) after the 25 years, while the forest showed high and stable values of about 4 % during the experimental time. The organic matter content of the grassland was relatively low at the beginning of the study, but increased with time from 2.3 to 2.9 %. The pH value increased in the sugar cane plots until undesirable high values of about 8.0, which is related to erosion and the following reduction of the upper soil layer. This brought the CaCO3 rich layer near to the soil surface. This effect was even more pronounced for annual crop cultivation. The nutrient status of the soil was higher for the field with sugar cane and annual crops because these fields received chemical fertilisers. The sugar cane field showed a lower total porosity (46 % in 40–60 cm depth) than the forest (61 %) and the grassland (58 %). The diversity of the macro fauna (number of taxons and individuals) in the sugar cane field was smaller than in the forest and the grassland but higher than in the field with annual crops which is probably related to the amount of organic residues remaining after the harvest at the fields. This study confirmes that land use changes from natural vegetation to sugar cane cultivation can have negative effects on soil fertility.

Keywords: Biodiversity, grassland, land use, monoculture, soil fertility, tropical forest

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Digested Sugar Cane Wastes Can Improve the Early Growth of Brazilian Leguminous Trees and Soil Chemical Parameters

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Agroforestry systems in the Brazilian Cerrado region can mitigate negative environmental effects of agriculture in this area. Digestates as remaining by-product of the biogas process were proofed to have a good fertiliser value. However, application of digestates to tropical trees is not evaluated yet. A greenhouse experiment was conducted at Forschungszentrum Jülich, Germany, from August to December 2014. The leguminous tree species Enterolobium contortisiliquum (Tamboril) was cultivated in 5 l pots with two different Oxisols brought from the Cerrado region, whereas one soil was taken from an agroforestry field the other soil was taken from field used for maize and livestock. Soils were amended with digestates based on a blend with filter cake (70 % w/w) and bagasse in five replications in three doses (192 ml per pot; corresponding to 33 m^{-3} ha) in the 7^{th}, 9^{th} and 11^{th} week of tree cultivation. A control was established without any supply of the digestates. We used the protocol of chemical soil analysis from EMBRAPA (Brazil) to analyse pH, organic C and the available P and K contents in the soil at the end of the experiment. The trees (stem+leave and roots) were weighted and the plant tissue was analysed for the concentration of nutrients. When the digestate was applied the length of Tamboril plants increased (28 %), more shoot biomass (17 %) and less root biomass (12 %) were produced in comparison to the control (average of all soils). The N and P concentration in plant biomass did not show significant differences but tended to increase for the digestate treatments. Furthermore, with the digestate application the soil organic C (1.97 %) and the bioavailable P content (87.6 mg kg^{-1}) were higher than in the control. The soil pH was not affected by the treatments. Higher tree biomasses were always found for the agroforestry soil. The results showed that the application of digestates can have advantages for the early development of tropical trees. However, further studies under natural conditions in the Cerrado region are necessary.

Keywords: Agroforestry, organic residues, soil fertility

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Agronomic Biofortification of *Brachiaria brizantha* Stapf. cv. Marandu with Selenium in Urea Coating

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The fertilisation of forages with Selenium (Se) coated urea allows a homogeneous application with low environmental risks. Such an application has benefits for the forage grazing animals in quality and digestibility of these plants with consequent reduction of greenhouse gases. The goal was to evaluate production and quality, besides degradability and gas production of *Brachiaria brizantha* cv Marandu grown in greenhouse with Se application of 0, 10, 20, 40, 80 and 160 g ha^{-1} as sodium selenate through coating of urea with mixing boric acid and copper sulfate in N application of 100 kg ha^{-1} under two cuts. This study was conducted at Laboratory of Animal Nutrition, CENA/USP, in Piracicaba, São Paulo, Brazil. Experimental design was a randomised block with four replicates in greenhouse. The forage plant showed no visual influence or dry matter production of shoots and roots, for Se application. The crude protein (CP) resulted in quadratic adjustment for interaction Se levels $\times$ cuts. There was reduction of CP in the larger levels of Se for the first cut, and opposite effects in the second cut. The fibrous fraction as ADF, NDF, cellulose and hemicellulose were not influence by Se levels, exception of lignin, that it was larger than control with 40 g ha^{-1} of Se. The organic matter degradability (OMD) was adjusted in a quadratic curve with peak in 59.5 g ha^{-1} of Se. Gas production/ DM decreased linearly with Se levels. The gas production/ OMD presented effects for interaction Se levels $\times$ cuts, and it was lower with increasing Se levels in the second cut to 60 days. The methane production, gas production/ NDF and NDF degradation had no influence of treatments. The ammonia-N content was adjusted in a quadratic curve with lower values in highest Se levels, however positive effects were observed with Se levels up to 40 g ha^{-1}. Se levels up to 40 g ha^{-1} were favourable for production and quality of forage considering to parameters quantitative and qualitative for animal feed.

Keywords: Animal nutrition, fertilisation, grazing, sodium selenate

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Root Yield Response of Contrasting Cassava Genotypes to Fertiliser Application and Leaf Harvest in Nigeria

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Cassava is usually grown for the starch-rich storage roots, yet in many countries of West, Central and East Africa cassava leaves are a highly appreciated vegetable and source of protein, vitamins and minerals. Root yield responses to leaf harvest are rare, limited to DR Congo and did not investigate the effects of fertiliser on the ability of cassava to compensate the loss of foliage and root yield losses. This study investigated the response of 9 varieties to 2 levels of fertiliser application on leaf and root yield. Leaves were harvested from all shoots of all plants at 3, 5, 7 and 9 months after planting (MAP). Fertiliser was NPK 15:15:15 at 300 and 600 kg ha^{-1} in 2 dressings. Root harvest was at 11 MAP. Cumulative leaf yields were not different between varieties, ranging from 300 to 480kg ha^{-1} DM. Fertiliser had no effect on leaf yields. Variety did not interact with fertiliser. Cassava root yield revealed 3 fertiliser per leaf harvest response types: non-responders to fertiliser with drastic yield loss due to leaf harvest; responders with a yield loss due to leaf harvest yet with fertiliser compensating for losses caused by leaf harvest and responders with a large loss due to leaf harvest and unable to compensate for yield losses when fertiliser was applied. Highest root yields were 9.87 Mg ha^{-1} in control and 8.06 Mg ha^{-1} when leaves were harvested. Maximum root yield loss was 4.26 Mg ha^{-1} equivalent to 43 %. Above ground biomass loss, determined at final harvest) and root yield loss were weakly correlated (r^2=0.184). Cassava root yield loss due to leaf harvest was positively correlated with root yield in control (r^2=0.522), indicating that cassava varieties with a higher productivity suffer larger losses when leaves are harvested. However, the actual amount of dry matter removed in all leaf harvests was neither correlated with the root yield loss nor with the above ground biomass loss caused by leaf harvest. Varieties responding to fertiliser and able to compensate root yield losses caused by leaf harvest through application of fertiliser (here 300 kg ha^{-1} NPK 15:15:15) appear suitable candidates for dual purpose cassava production systems.

Keywords: Fertiliser, leaf harvest, Nigeria, root yield loss

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Farmer's Perception on Soil Fertility Status and Soil Fertility Management in Semi-Arid Areas of Central Tanzania

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Declining soil fertility is among an influential factors contributing to insecure household food security among other in Central semi-arid regions of Tanzania. A comprehensive study was undertaken at Idifu and Ilolo villages in Dodoma Region to investigate farmers' perceptions on current soil fertility status, indicators of soil degradation and exiting farmers' initiatives on soil fertility management. Semi-structured interviews were conducted in 206 households and analysed by descriptive statistics and inferential statistics using Chi-square test at $p < 0.05$. Results showed that (67.6 %) of the households interviewed perceived that soil fertility has declined. Key indicators of low soil fertility across study villages include occurrence of noxious weed i.e. *Striga* infestation/ Alectra vogelii (67. 6 %) and stunted plant growth (43 %). Perceived reason for continued nutrient mining overtime include soil erosion (77 %) occurring at landscape; extensive grazing system widely practised in the area (72 %); burning of crop residues during land preparation (78 %) locally called "kuberega". In addition, there is misconception that uses of chemical fertiliser destroy soils (33 %). Findings clearly noted that about 47 % per cent of household interviewed lack knowledge on soil fertility management. The most common practice employed by farmers to reverse low soil fertility problems in the study villages encompasses fallowing (7 %), use of ridges (4 %) and crop rotation (11 %), intercropping (38.4 %) and only 2 % of farmers own livestock applying farmyard manure. In view of these, during 2014/2015 cropping season Trans-SEC Project has initiated participatory action research on integrated soil water and fertility management across locations as sound strategies for improving household food security using mother and baby approach.

Keywords: Central Tanzania, farmers perception, farmers practice, semi-arid areas, soil fertility

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Parametrisation of a Simulation Model for Tropical Soils for the Development of Sustainable Nutrient Management Strategies

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Simulation models are a key instrument for the development of sustainable agricultural management strategies. However, the majority of the existing crop models were designed and parameterised for soils of temperate regions. Consequently the soil simulation routines, embedded in the crop models, are not able to correctly mimic the processes that occur in tropical agroecosystems. In order to obtain a high accuracy of the simulations, the models require a precise parameterisation of the particular conditions. Therefore, an observation of field data is essential.
In the course of the German-Brazilian joint project PURESBio (BMBF, start 09/2014) the agroecosystem model MONICA will be parameterised for tropical soils of the Cerrado region in Central Brazil. To obtain the required data for parameterisation (coefficients for decomposition, mineralisation and nitrification), a micro-lisimeter field experiment is established in Goiânia, Goiás, Brazil. Three different, typical soils of the Cerrado (Latossolo amarello, Latossolo acrico, Neosolo) are incubated in soil columns on field level. On weekly bases the percolate will be collected and analysed for its NO_3 and NH_4^+ content. Due to this, the carbon turnover and nitrogen dynamic of the soils can be described as a function of the soil type and local climate, further enabling the parameterisation of the model by inverse simulation. Thus, MONICA will be able to simulate the processes involved in the conduction of sustainable agronomic management strategies, focusing on the usage of residues of the Ethanol production process (vinasse and presscake), with higher precision. The overall objective is to increase and maintain adequate levels of soil organic matter and soil fertility of sugarcane fields in Central Brazil.

Keywords: Brazil, carbon turnover, decomposition, mineralisation, nitrogen dynamic, simulation models, soil organic matter, tropical soils

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Microbial Inoculants for Sustainable Agriculture - Growth Promotion of Pigeon Pea (*Cajanus cajan*) and Finger Millet (*Eleusine coracana*) by Arbuscular Mycorrhizal Fungi and its Hyphal Spread

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Rainfed farms on marginal lands will be most affected by scarcity of non-renewable resources such as fertilisers. Mutualistic root organisms like arbuscular mycorrhizal fungi (AMF) can substantially contribute to a more resilient, ecointensified dryland farming system. We are interested to study the possibility to use AMF as "biofertilisers" in mixed-cropping schemes in Indian agriculture, planting pigeon pea (*Cajanus cajan*) seedlings pre-inoculated with AMF into a field sown with finger millet (*Eleusine coracana*). To study the potential of the AMF to spread from AMF-inoculated pigeon pea to uninoculated finger millet seedlings, we established experimental microcosms in the greenhouse, in which the pigeon pea and two finger millet plantlets were kept in separate pots, connected by a soil bridge of 5 or 12 cm length inaccessible to roots but accessible to fungal hyphae. In the longer system with *R. fasciculatus* dry biomass (63.4 % more than control) and dry panicle weight (81.4 % more than control) of the second finger millet was significantly increased. With *R. irregulare* the dry biomass of the first finger millet plant was significantly decreased (45.8 % less than control). However hyphal growth of the two species was similar. Surprisingly in the short system the third species, *C. etunicatum*, promoted growth of the second finger millet more than the other inoculants (34 % more than control).

We found that AMF hyphae could spread readily through the soil bridges from the roots of pigeon pea to the roots of finger millet, covering distances of up to 35 cm in 20 weeks, and have growth promoting effects there. Competition effects with pigeon pea only allowed the second finger millet to benefit from the symbiosis with AMF. We conclude that the row distance between the crops and the choice of AMF species play a crucial role for the application of AMF as biofertiliser.

Keywords: AMF, biofertiliser, finger millet, mixed cropping, pigeon pea

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Grain Yield Response of Maize Varieties to Intercropping with Cassava and Fertiliser in DR Congo

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Maize and cassava are the major food crops in DR Congo. Intercropping is a common practice, yet has not received sufficient research attention to establish if there are compatibility issues between varieties of the two species. Since the arrival of the cassava mosaic (CMD) pandemic cassava varieties have been changed to CMD resistant ones. The Congolese national system has continued breeding maize and released several new varieties. Thus little is known about these varieties' ability to synergistically intercrop. This study investigates three maize (Mus, short straw yellow grain 90 to 100 days to maturity (DTM); QPM1 a high protein quality variety, short straw, white grain 90–110 DTM; and QPM3 a high protein quality variety, short straw, white grain, stay green 90–100 DTM) and three cassava varieties, RAV a first generation CMD tolerant, branching variety; Lueki, a later developed CMD resistant branching variety; Obama, a CDM resistant, erect, non-branching variety intercropped and mono-cropped with and without fertiliser in 6 sites across DR Congo. Three sites were on sandy grassland soil, 2 on sandy soils after bush and tree fallow and 1 on valley bottom clay soil dominated by *Pennisetum purpureum*. Here only maize yields are reported. Maize yields were significantly different between all sites. Monocrop maize yielded more (1.7 Mg ha^{-1}) than when intercropped with Obama and Lueki (1.4 Mg ha^{-1}) yet not when intercropped with RAV (1.6 Mg ha^{-1}). However, maize yield had a site $\times$ cassava interaction: in three savannah sites on sand soil no differences between maize varieties was found, in a site on clay the monocrop maize out/yielded all intercropped treatments by 1 Mg ha^{-1}; on 2 sites established after bush or tree fallow the maize yielded highest when intercropped with cassava variety RAV. Across sites the maize yields did not differ between maize varieties. Fertiliser application increased yield by 50 % from 1.2 to 1.8 Mg ha^{-1}. Fertiliser response was site dependent, ranging from 0.38 to 0.85 Mg ha^{-1} and from 30–260 %. Highest yields were attained on sand soil after tree fallow reaching 5 Mg ha^{-1}.

Keywords: Cassava, fertiliser, intercrop, maize

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Effect of Biosimulate Nanomaterials on Yield and Fruit Quality of Mango Trees under Semi-Arid Conditions

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Mango is one of the most important fruits in the tropics and subtropics. In Egypt, mango is considered the most popular fruit and occupies the third place in acreage after citrus and grapes. The area of mango orchards reached 77003 ha (323413 feddan) producing about 876,528 tons of fruits in 2012. However, poor fruit set is considered as one of the problems facing mango productivity especially under semi-arid conditions of Egypt. Meanwhile, various trials were done to raise fruit set, minimise the percentage of fruit drop, increase tree yield and improve fruit quality by spraying trees with biosumulaters such as yeast. Nanotechnology provides the opportunity to develop improved systems for delivering biosimulaters and thus potentially enhance yields or nutritional values.

In this respect, sol-gels are used today in many fields including sensors, coatings, optical, and biological due to their numerous advantages over other materials. Furthermore, sol-gels can be formed into different forms as films, fibers, powders, and monoliths nanomaterials. Also, the processing conditions of sol-gels can be manipulated by changing the type and concentration of sol components allowing for sol-gels to be used for different industrial applications.

Nanomaterials have emerged as suitable alternatives to overcome limitations of micromaterials and monolithics which can be provided by biosimulaters like yeast, while posing preparation challenges related to the control of elemental composition and stoichiometry in the nanocluster phase.

The main goal of this work is using chemically modified nano-materials (CMNM) with desired functionality and physicochemical properties loaded on yeast and to test their application toward solutions of problems regarding the productivity of mango trees through improving flowering, fruit set and fruit quality of mango trees especially under semi-arid conditions of Egypt.

Keywords: Fruit quality, fruit set, mango trees, sol-gel nanomaterials, yeast

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Genome Wide Association Studies for Salt Tolerance in Barley

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Salt is taken up passively and distributed within the crop via its transpiration stream. Thus uptake of salt is directly related to stomatal responses to vapour pressure deficit (VPD) perceived as atmospheric drought signal. In combination with a shift in seasonal VPD, salinity effects on the crop may increase at several development stages of the crop. Salt tolerance is a complex trait characterised by interactions between genes and their environment. Consequently genotypes grown in varying VPD environment tend to respond differently to salt stress. Hence identifying patterns of polymorphism in the genome that are suggestive of the effect of the risk enhancing or protective alleles has been a major challenge in the quest to develop salt tolerant crop varieties. This research aims at elucidating the genetic basis for genotypic adaptation in barley to combinations of salt and VPD stress at different crop development stages.

A diverse set of 216 spring barley accessions of worldwide origin were screened at emergence and early seedling stage at 250mM NaCl concentrations and control. Subsequently, these genotypes were grown on hydroponics within a phenotyping platform and were exposed to varying VPD levels (0.73 and 1.85 kpa) in addition to salt level of 200mM NaCl. Using genome wide association studies (GWAS) employing 9K SNP markers (iSelect assay), we explore the genetic variation for salt tolerance in barley for traits such as seed germination rate, mobilisation efficiency of endosperm reserves, biomass accumulation and partitioning, tiller number, leaf area and leaf ion balance (Na^+, K+) for the aforementioned stress combination. Relative responses due to salt and VPD will be presented and the potentials for efficient screening for salt tolerance will be discussed. Findings on QTLs would be validated with previous research and reported.

Keywords: Association mapping, *Hordeum vulgare*, QTL, salt tolerance, SNP, VPD

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Plant Phenotyping Tests Using Anaerobic Digested Vinasse and Filter Cake from the Brazilian Sugar Cane Industry

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The ethanol and sugar production in Brazil processed 653,5 million tons of sugar cane in the 2013/2014 harvest. Approximately 700 million tons of agricultural and industrial wastes are generated, which might cause environmental pollution. The recycling of these residues regarding their contents and energy potential becomes significant. Samples of vinasse and filter cake and Red Oxisoils from sugar cane processing areas were collected and characterised. The total solid content of vinasse is 2,57 % (volatile solids 55,0 %) and filter cake 29,4 % (volatile solids 69,5 %), NPK content in vinasse is (kg t^{-1}) Ntotal: 0,4, P_2O_5: 0,36, K_2O: 2,80; in filter cake: Ntotal: 1,20, P_2O_5: 2,20, K_2O: 1,60. Blends of vinasse and filter cake were prepared and anaerobically digested. Tests in rhizotrons are designed to monitor plant traits in the same conditions as in the sugar cane producing tropical savannah of Brazil called "Cerrado" comparing the effects of applications of a blend of untreated vinasse and filter cake as well as digested. The samples are from the late dry season of October 2014. Previous batch tests performed after VDI 4630/2006 demonstrate that the biodegradation of the substrate reaches almost 90 % after circa 16 days. In addition, a recycling of the residues as biofertiliser based in organic matter, chemical and physical parameters are tested in offering improvements of soil quality and plant growth (soy bean and crotalaria) comparing application in raw form and digested. The monitoring of the industrial process confirms that the organic matter can be recovered as nutrient and bioenergy source. This work contributes to the mitigation of environmental impacts as well as to improve the carbon efficiency of the sugar cane transformation process.

Keywords: Biofertiliser, biogas, Red Oxisoil, rhizotron

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Agronomical Performance of Common Bean Inoculated with New Rhizobial Isolates

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Common bean (*Phaseolus vulgaris* L.) is a leguminous plant of great importance for the Brazilian population, especially for the poorer population by representing the main source of protein. Common bean can establish symbiosis with nitrogen-fixing bacteria to obtain N from the atmosphere through Biological Nitrogen Fixation (BNF) process. This work aimed to evaluate the agronomic efficiency of rhizobia isolates under field conditions in two sites: Guapó and Santo Antônio de Goiás, by comparison of their results with the commercial strains SEMIA 4077, 4080 and SEMIA SEMIA 4088 of *Rhizobium* tropici. We evaluated the number of nodules (NN), nodules dry weight (NDW), root dry weight (RDW), shoot dry weight (SDW), stand (S), leaf area (LA), number of pods (NP), number of grains (NG), 100 grains dry weight (100GDW), grain yield (GY) and levels of macro and micronutrients in the shoots of common bean plants. The results revealed significant differences for NN, SDW, NP, NG and GY among the treatments evaluated in Guapó. In the experiment carried out in Santo Antônio de Goiás significant differences were observed among treatments for NDW, RDW, LA, SDW, NP, NG and GY. The content of micro and micronutrients varied significantly among all of the isolates while in Santo Antônio de Goiás no significant differences were found for Fe and Mn. About 70 % of the isolates evaluated in Guapó showed relative efficiency of grain yield similar to the strains SEMIA 4077, SEMIA 4080 and SEMIA 4088. In Santo Antônio de Goiás all of the evaluated isolates showed the same efficiency of those strains. The inoculation with the isolates contributed on a significant way for the grain yield increasing with results similar to the N treatment and commercial strains. These results indicate that is possible to find isolates more efficient than the commercial strains on the BNF process.

Keywords: BNF, common bean, rhizobia, symbiosis

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Performance of Wheat Varieties under Different Tillage Systems in Bangladesh

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Wheat, as second ranked winter cereal crop both in acreage and production, plays an important role in reducing food shortage in Bangladesh. To meet the increasing demand for food cereals in Bangladesh, efforts are being made to develop improved wheat varieties and cultivation practices with high yield potential that lower farmers' production costs. Cultivation of wheat on raised beds is gaining popularity in Bangladesh. In this technique, the raised beds are prepared by a single pass using a bed planter machine that simultaneously seeds and fertilises two rows of wheat on top of the beds. Irrigation water is applied through the furrows between the beds. Typically, the bed planter is connected to a power tiller that is commonly used all over Bangladesh. These techniques have been reported to result in higher grain production, as well as reduced costs by 25 % as ploughing and seeding are done by one or two passes only in comparison to 3–4 passes under conventional system. By irrigation in furrows rather than by flooding, irrigation water can also be saved. A farmer's involved research trial was conducted in Faridpur district, Bangladesh, during the 2012–13 rabi season to observe the performance of wheat varieties under two cultivation techniques, bed planting and conventional tillage systems. Four wheat cultivars BARI Gom 25, BARI Gom 26, Prodip and Shatabdi were considered. BARI Gom 26 produced the highest grain yield (4.72 t ha^{-1}) among the varieties tested. The spike length (9.79 cm), number of grains per spike (42) and 1000-grain weight (43.24 g) were higher in plants cultivated under bed planting system compared to those in conventional tillage: 9.43 cm, 39 and 39.67 g, respectively. As such, bed planting technique gave significantly 14 % higher grain yield over the conventional tillage systems (4.05 t ha^{-1}). A significant interaction was found when BARI Gom 26 was grown under bed planting. This combination provided the highest grain yield (4.98 t ha^{-1}), while the lowest yield was obtained from Shatabdi cultivated under conventional tillage systems (3.62 t ha^{-1}). Comparing cost and benefit, bed planting reduced cultivation costs (ploughing, seeding, weeding, irrigation, rat control) by around 30 % compared to conventional tillage.

Keywords: Bed planting, conservation agriculture, conventional tillage

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An Appropriate Planting Method for Groundnuts and Cotton

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Two experiments were conducted at the university farm to study the effect of spacing and depth of planting on plant population, growth and yield of groundnut and cotton crops. All treatments were carried out on soils with the same chemical and physical properties. The experiments were extended for two seasons. A John Deere planter model 25-B was used in this study. The metering mechanism was modified to give three levels of within the row plant spacings of 10, 15 and 20 cm. Two levels of depth of planting, 2.5 and 5 cm were chosen. A randomised complete block design with factorial treatments was used. For groundnuts statistical analysis showed no significant effect on plant population due to spacing between plants in the two seasons. It was also observed that there was no significant effect on plant growth and yield due to spacing in both seasons. Depth of planting did not affect significantly the plant population, growth and yield on groundnuts in both seasons. As for cotton crops, spacing between plants showed no significant effect on plant population in the first season, but has a significant effect in the second season. Plant growth and boll formation were not affected by spacing between plants significantly. However, cotton yield was affected significantly by plant spacing in the two seasons. Wide spacing 20 cm resulted in the highest yield in both seasons. Depth of planting has no significant effect on cotton plant population, growth, boll formation and yield in both seasons.

Keywords: Cotton, depth of planting, effect of spacing, groundnut, plant population

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Changes in Hydro-Edaphological Properties Following Fire and Aerator Roller Treatments in Desert Microphylous and Rosetophylous Scrubland

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Changes in hydro-edaphological properties in desert microphylous (MS) and rosetophylous (RS) scrubland were assessed. Five treatments were established in North Mexico: control (C), aerator roll in 2004 (RA04), 2008 (RA08) and 2011 (RA11) and burned area 2011 (BA11). Variables such as permeability coefficient (CP), bulk density (BD), organic matter (OM), soil reaction (pH), electrical conductivity (EC), available water (AW), soil hardness (SH) and infiltration capacity (IC) were analysed. The analysis of variance showed significant differences in treatments for all variables in both vegetation types, except for AW. The correlation showed that the BD has a positive relation with EC (0.472) and pH (0.398). The OM was negatively correlated with BD (-0.533), EC (-0681) and pH (-0300), and positively correlated with AW (0.268). Likewise, EC presented a negative correlation with AW (-0347); in contrast showed a positive relation with pH (0.295). Comparing results with the control, treatments RA11 and BA11 increased OM to 100 % in MS and 200 % in RS. Also the RA11 and BA11 treatments showed a decrease in BD between 12 and 20 % in RS. In contrast the treatment RA11 showed a decrease of 6 % in BD in MS. The EC increased by 100 % in treatments BA11 and RA11. Also, CP decreased in a range between 5–82 % in all treatments in MS. In contrast the CP increased 300 % in RA11 in RS vegetation. The IC increased in 15 % in MS and 59 % in RS using BA11, in contrast decrease was observed in RA08 and RA11 (70 and 65 %) in MS; while the IC decrease only 10 and 5 % in same treatments in RS. The SH in the MS decreased in all treatments compared to C, showing higher decreases in BA11 (44 %) and RA04 (53 %). Also, SH decreased 50 % in RA04 and RA11 in the RS, in contrast increased 75 % in RA08. Results indicated that after using aerator roller, in the first three years OM increased and BD decreased. In contrast, after a period of 6–10 years (RA04 and RA08) the OM decreased and the BD increase.

Keywords: Chihuahuan desert, desert microphylous scrubland, desert rosetophylous scrubland, hydro-edaphological properties, roller aerator

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Evaluation of Tillage Reduction for Potato Production in Slope Areas of Los Andes Mointains in Colombia

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In Colombia, the potato is grown in mountain areas above 2800 m asl. In general, tillage and subsequent agricultural practices lead to a soil degradation by erosion, compaction of deep soil layers and loss of productive capacity. In addition, the mechanisation and inputs costs are high. In order to find a more conservationist alternative, a research in a potato growing area of the municipality of Fúquene - Cundinamarca at an altitude of 2930 m asl, was conducted. Three production systems: Conventional, minimum, and zero tillage; were contrasted. In all treatments as green manures, crop rotation, and plant cover, Caldas Oats (*Avena sativa* L.) and Turnip (*Raphanus sativus* L.) were implemented. During 8 months counted from the planting of the green manure to just before deposing the second rotation of green manure, the performance of physic and hydraulic soil properties, namely infiltration, bulk density, moisture content and cone index, as well as the change of the chemical analysis of soil were evaluated. The yield of the potato crop was also measured.
Caldas oats had a production of 4506 kg DM ha^{-1} despite having a lower seeding density than turnip. Green manure did not change soil pH; the greatest contributions of organic matter were obtained with the reduced tillage. Because of the destruction of the topsoil, the basic infiltration suffered a high reduction in the conventional tillage. The best performance of infiltration was found with zero tillage. Due to the vegetal cover during the development of the crop, the moisture content was higher in zero and minimum tillage. In the lower soil layers, the effect of machinery, promoted an increase in bulk density and cone index in the conventional tillage.
The results showed that the best treatment was the minimum tillage with turnip as green cover because it produced 16.250 kg potatoes ha^{-1}.

Keywords: Conservation tillage, green covers, potato

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Welfare Impacts of Biochar as a Soil Amendment on Urban Vegetable Markets in West Africa

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Due to the absence of refrigerated transportation, West African cities rely on urban agriculture to meet the vegetable demand of their persistently growing populations. The production of vegetables in urban areas is currently constrained by water shortages, limited access to inputs and shrinking land availability. Consequently the introduction of productivity enhancing technologies may have a significant impact on land use efficiency resulting in increased food security. Urban Food Plus, a research project funded by the German Federal Ministry of Education and Research (BMBF) under its programme GlobE (Securing the Global Food Supply) aims to enhance resource use efficiency in urban and peri-urban agriculture for improved food security in West African cities. The project has been researching the properties of biochar as a soil amendment through central field experiments in Ouagadougou, Burkina Faso and Tamale, Ghana, suggesting biochar-related yield increases for vegetables of 21–34 %. Beyond the agro-ecological effects of using biochar, the economic impact of a widespread adoption of the technology on urban vegetable markets has to be established to assess the benefits and costs to consumers and producers. This paper establishes a theoretical framework for the ex-ante evaluation of the impact of productivity enhancing technologies on market prices and on consumer and producer welfare, tailored to the specific market structures, along the whole value chain, of urban vegetable production in Ouagadougou and Tamale. This is done through establishing a market model using secondary time series data of the past 30 years on a regional and national level. Positive producer and consumer welfare changes would suggest higher adoption likelihoods. Additionally decreasing market prices, associated with increased available quantities brought about by the productivity enhancing technology, are expected to lead to improved food security. The analysis covers various plausible scenarios such as differing adoption levels. The results of the analysis pinpoint the adoption level necessary to produce a price change, and specify the welfare change brought about by a widespread adoption of Biochar. This can inform policy makers and farmers alike of the potential benefits of adopting productivity enhancing technologies.

Keywords: Agricultural economics, GlobE, theory based impact assessment, urban agriculture, UrbanFood^{Plus}, welfare

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Assessment of Ecuadorian *Rhizobium* Isolates under Field Conditions

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The study aimed to determine the influence of *Rhizobium* isolates on phenotypic parameters and yield of common bean (*Phaseolus vulgaris* L.) genotypes under field conditions. A total of seven strains previously isolated, characterised and genetically identified from soils of Loja province were inoculated on seeds of Mantequilla and Rojo Calima genotypes, besides the inoculation of wild type strain *Rhizobium* etli CNPAF512. A treatment with nitrogen fertiliser (application of urea 60 kg ha^{-1}) and a control without inoculation and fertilisation. Seeds were pelletized with the strains from the inoculants and planted in dry season on sandy loam soil. Nodulation parameters, plant biomass, yield components and agricultural yields were assessed. The results showed high capacity of nodule formation and biomass production by the treatments inoculated with isolates and wild type strain for both genotypes, compared with the native strains (control and mineral fertilisation treatments). *R. miluonense* (isolated from Catamayo), *R. tropici* (isolated from Saraguro) and wild type strain had a remarkable effect on these parameters. These treatments had similar behaviour for yield components, mainly in the number of pods and weight of grains per plant. The genotypic variability of the crop was higher for agricultural yields, where the best treats for Mantequilla genotype were obtained with *R. tropici* isolated and mineral fertilisation application, however no significat differences were observed among them. For Rojo Calima the wild type strain and *R. miluonense* showed the best results. This study validates the use of efficient interaction among *Rhizobium* species and bean genotypes to achieve yield increases through sustainable agricultural methods and to reduce the application of nitrogen fertiliser.

Keywords: Diazotrophic bacteria, inoculation, *Phaseolus vulgaris*, strains, yield

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Interactions of Arbuscular Mycorrhiza Fungus and Other Biofertilisers on Qualitative and Quantitative Traits of Pepper

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The adoption of mycorrhizal biotechnology and biofertilisers in genetic improvement of crops had enhanced yield, and offered solution to challenges associated by pollution and toxicity of the soil. Therefore field experiment was carried out at the research farm of the Department of Botany, University of Ibadan to investigate the response of five varieties of pepper to interactions of arbuscular mycorrhizal fungus (AMF); *Glomus deserticola*, poultry manure (PM) and spent mushroom compost (SMC); *Pleurotus pulmonarius*. The experiment was laid out in complete randomised design with three replicate The treatments; T1= *G. deserticola* and PM, T2= *G. deserticola* only, T3= PM only and T4= *P. pulmonarius* only, were inoculated into 5 kg of sterile soil in poly pots, while T5 was uninoculated (control). The varieties were transplanted after two weeks of planting. Data collected on morphological and yield characters were subjected to analysis of variance, while treatment means were separated by Duncan multiple range test. The mean interaction of treatments had highly significant ($p < 0.01$) effect for morphological and yield traits of pepper except number of flowers, stem girth and total dry weight, while total fresh weight and total dry weight were not significantly different at varietal level. The treatment combinations of AMF + PM produced the highest cumulative for total number of fruits (25.87), while control had the least (7.47). The leaf length and leaf width of Long pepper were significantly higher with 63 cm and 9.2 cm respectively. The highest total number of 24 fruits was recorded for Jos pepper, while Bell pepper produced the highest mean total fresh weight and total dry weight of 12.15 g and 12.05 g respectively. The plant height was positive and strongly correlated ($p < 0.01$) with stem height, leaf width, leaf length, number of leaves and stem girth at r= 0.84, 0.80, 0.83, 0.79 and 0.60 respectively. Also, there was positive association between the total number of fruits and total fresh weight (r= 0.56). However, variability in response of pepper to interactions of AMF and other bioinoculants could play major role in food security.

Keywords: Biofertilisers, food security, pepper, soil, traits

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Optimal Use of Land Preparation for Increasing Soil Moisture to Raise the Crop Productivity on Marginal Lands in Sudan

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Land preparation is one of the most important and costly agricultural operations. Success or failure of crop production depends for a large part on the good preparation of the land. In addition, tillage changes the physical properties of the soil. This study is an attempt to select the most appropriate methods for land preparation under arid and semi-arid conditions, in order to raise soil moisture and increase production and to reduce costs of using traditional methods of land preparation. This experiment was conducted in the West of Khartoum city, where the chemical and physical properties of the soil are sandy and sandy clay. To achieve the objectives of the study, two tractors with different drag force were used. The first tractor for tester and the second one for help, as well as used of two primary plows such as; (disc plow) and chisel plow and two secondary Plows such as; (Disc harrow and plow cruiser) in addition to an animal drawn plow. Five land preparation have been conducted: In a first test land has been prepared by using the initial chisel plow to a depth of 25 cm, then opening furrows using plow cruiser. The second test by using the initial disc plow to a depth of 15 cm, then furrows were opened using a plow cruiser. The third test used the initial harrow plow to a depth of 20 cm, then furrows were opened using plow cruiser. The fourth test opened the furrows using a plow cruiser to a depth of 25 cm. Only the fifth test opened the furrows using the animal drawn plow to a depth of 13 cm. The results showed that the field efficiency of (chisel, disc, cruiser, harrow and the animal drawn) plows were 88.2, 81.5, 68.2, 49.1 and 12.8 respectively. Fuel consumption in liter ha^{-1} were 7.60, 4.60, 3.30 and 2.50, respectively. The study recommended that the most suitable practice is the cruiser plow which was recorded the higher field efficiency and less fuel consumption for increasing soil moisture and raising the crop production.

Keywords: Land preparations, land use, marginal, Sudan

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Soil Properties under Manured *Tamarindus indica* in the Littoral Plain of South-Western Madagascar

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This study is part of a research project in the Mahafaly Plateau in south-western Madagascar where measures are investigated to increase cropping system productivity under multiple constrains in order to improve people's livelihoods. In the present study we assessed soil chemical and microbial parameters of soils as indicators for soil fertility from beneath tamarind (*Tamarindus indica* L.) canopies with and without deposited manure to evaluate if agroforestry systems including tamarinds may help to ameliorate soil fertility. More specifically, the effects of tamarind and manure on (1) soil chemical properties, (2) C and N mineralisation, (3) microbial biomass indices (C, N, and fungal ergosterol), (4) microbial residues, i.e. amino sugars, and (5) the germination of sorghum seeds were tested.

In September 2011, soil samples were taken from below (T+) and beside (T0) the canopy of six tamarinds growing in the coastal plain of the Mahafaly Plateau region. Three of the six tamarinds were growing in pasture zones, hence manure has been deposited beside and under these trees (M+). The remaining tamarinds were growing in agricultural fields without manure accumulation (M0).

Soil pH was lower in T+ than in T0, whereas SOC, total N, K, and CEC were about three times and plant available P was about two times higher in T+. Basal respiration was increased nearly threefold, whereas net N mineralisation remained unaffected in T+. However, net N mineralisation was increased by 74 % in M+. Contents of microbial biomass C and N, and especially fungal ergosterol, were also higher in T+. The amino sugars muramic acid, galactosamine, and glucosamine were increased threefold in T+. M+ increased the contribution of microbial residue C to SOC from 28 % to 41 % and of microbial biomass N to total N from 3.5 % to 5.6 %. The germination of sorghum seeds was not inhibited in T+.

The soils beneath the tamarind canopies show a potential for crop cultivation but further research is necessary to address the possible effects of allelochemicals on crops cultivated under field conditions, the identification of suitable and high-value crop species, and management systems that can be adopted by farmers.

Keywords: Basal respiration, ergosterol, microbial biomass, microbial residues, N mineralisation, SOC

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Exploring Effects of Aboveground and Belowground Biomass on Soil Erosion During Rubber Development by Applying USLE Model

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Aboveground and belowground biomass can both contribute to soil conservation in forestland. However, quantitative linkage among tree canopy, plant and litter cover, roots and their changing roles with growth of plantation has been rarely studied. Universal Soil Loss Equation (USLE) model has been widely used in soil loss prediction in agriculture but rarely applied in woodland system. This study applies USLE model for prediction of soil loss during rubber plantation development and identifies the major factor controlling water erosion. Soil erosion was measured in rubber plantations of 2, 10, 18, 25 and 36 years age. Rainfall, soil texture and carbon content at top 5 cm, density of fine roots, canopy radius for each age of rubber plantation, understory plant cover and litter cover were determined using Gerlach troughs, soil coring, photography, respectively. Soil loss of rubber plantation with different ages varied from 52 g m^{-2} to 277 g m^{-2} with highest soil loss of mid-age (10 and 18 years) and lowest of old (18 and 36 year) rubber. Cover and management factor of rubber plantation represents erodibility of system in USLE model. It was equal to 0.02, being thus much higher than in forest (0.005). Though canopy of tree expanded during its growth, erodibility change of the system turned out to increase from 0.01 of young rubber to 0.03 of mid rubber and decrease to 0.008 of old rubber. Erodibility of rubber system was little affected by tree canopy, however, mainly controlled by root system from trees and plant cover from understory vegetation. Fine root density and plant cover were introduced into USLE model with expression of Cpc = e-0.023pc and Croot=e-0.004fRD respectively. During rainy season, highest erodibility of rubber system was found in August due to herbicide application. It is recommended that understory plant cover should be kept over 70 % for young rubber, over 90 % for mid and 55 % for old rubber in order to maintain good soil conservation function of rubber plantation.

Keywords: Fine root, plant cover, rubber plantation, soil erosion, USLE model

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Soil Microbial Indicators for Different Land-Use Types in River Oasis of the Altay Mountains

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Agricultural intensification and rising grazing pressure in the river oases of the Sino-Mongolian Altay Mountains question the long-term productivity of the local agro-pastoral land use systems. Biological and bio-chemical parameters are reliable indicators for monitoring environmental impacts on soil as they respond more sensitive to modifications in land-use than physico-chemical ones. In view of this, this study aimed at the quantification and assessment of soil biological and bio-chemical parameters exemplarily across typical land-use types of the Mongolian river oasis Bulgan Soum. To this end, the topsoil of six different land-use types (carrot fields, hayfields, seabuckthorn fields, rangeland sites of the pediments, rangeland sites in the floodplain, saline sites) was analysed for soil biological (microbial biomass carbon (C) and nitrogen (N), basal respiration, ergosterol) and soil physico-chemical properties (texture, bulk density, pH, electrical conductivity, inorganic C, total C and N). Based on this, ratios of microbial biomass C/N, microbial biomass C/soil organic C, ergosterol/microbial biomass C and the metabolic quotient were calculated. Microbial biomass C showed minima of 212.8 μg g^{-1} soil for rangeland sites of the pediments and maxima of 816.0 μg g^{-1} soil for rangeland sites in the floodplain. For the latter sites the metabolic quotient qCO_2 was relatively low with 17.1 mg CO_2-C g^{-1} biomass C d^{-1} while highest values of qCO_2 were measured for seabuckthorn and hay fields (51.8 and 43.3 mg CO_2-C g^{-1} biomass C d^{-1}, respectively). For both irrigated agricultural sites also the portion of saprotrophic fungi to total microbial community was highest (ratio of ergosterol to microbial biomass C: 4.9 and 4.6 ‰, respectively) and the availability of organic matter to soil microorganism was lowest (ratio of microbial biomass C to soil organic C: 1.8 and 2.3 %, respectively) across all land-use types. In summary, an intensification of agriculture in the river oasis was reflected by a rise of qCO_2, an increase of the ergosterol to microbial biomass C ratio and a decline of availability of organic matter to microorganism. Therefore, results confirm the potential use of soil biological and bio-chemical parameters as indicators and allow the identification of sustainable land use systems.

Keywords: Arid steppe ecosystem, Central Asia, land-use change, soil organic carbon, soil respiration, soil salinity

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Productivity Evaluation of Maize Based Cropping Systems on Tropical Hillside Agriculture with Soil Conservation Options

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In future, agriculture have to produce more food from less area to meet demands of growing population through efficient use of natural resources with minimal impact on the environment. Intercropping and agroforestry systems are important land uses to sustain tropical hillside agriculture. In a field trial with 20–25 % slope located in western Thailand, we evaluated production sustainability of maize based cropping systems, i.e. monocropping vs. intercropping and hedgerow systems; +/-fertiliser application; tillage vs. minimum tillage plus legume relay cropping.We used above ground biomass (AGB) production, electrical resistivity tomography (ERT), Carbon stable isotope (δ^{13}C), light use efficiency (LUE) and land equivalent ratio (LER) to evaluate maizebased cropping systems. Water Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS) was also used to identify sustainable production options for investigated cropping systems. Maize AGB production (1365g m^{-2}) was highest in maize-chili intercropping with fertilisation, minimum tillage and maize chilli intercropping with hedgerow system (1250g m^{-2}) than in current farmers' practice of maize monocropping (control). ERTmeasurements and δ^{13}C showed highest soil moisture in maize chilli intercropping with hedgerow system. LUE for AGB was 1.44–1.56 g DM MJ^{-1} in fertilised intercropping and hedgerow systems, being 17–27 % higher than in the control. With fertilisation, LER of maize-chili intercropping (1.03–1.17) and hedgerow intercropping (1.21) was higher than that of the control. Hedges had a negative impact on maize closely planted maize rows due to nutrient limitation. WaNuLCAS simulations also indicated nutrient limitation between hedges and closely planted maize rows. Overall, maize chilli intercropping and hedgerows systems with fertilisations were favourable for exploiting available resources increasing biomass production of maize and chilli with higher AGB, LUE and LER in contrast to maize monocropping. Model suggested that small targeted additional N and P dressings to maize in rows close to hedges helped overcoming nutrient limitation and maintained production sustainability of maize based agroforestry system. Such crop management options are doable by local farmers and may foster future adaptation of soil conservation. Productivity evaluation showed that inclusion of hedgerows and intercropping in tropical hillside agriculture is promising in enhancing crop production and food security.

Keywords: Agroforestry, intercroping, LER, maize, Thailand, WaNuLCAS

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Characterisation of Biochar from Maize Residues Produced in Lab-Scale Batch Reactor without Using Carrier Gas

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Maize residue is one of the most abundant crop residues worldwide, but it is still underutilised. Therefore, it can be converted into biochar for simultaneously addressing agricultural, environmental, and energy issues. In this study, the effects of different operating temperatures (300, 450, 600°C), heating rates (5, 10, 15°C/min), and residence times (30, 60, 90 min) on four response variables including volatile matter content, ash content, pH, and electrical conductivity (EC) of biochar were evaluated. Biochar was produced from four maize biomass fractions (cobs, stalks, husks, and leaves). The experiments were arranged according to the Box-Behnken design using the response surface methodology. The optimal pyrolysis conditions to obtain the best quality biochar in terms of volatile matter content, ash content, pH and EC for soil amendment were identified. The biochar was further characterised by using the elemental analyses and scanning electron microscopy (SEM). ANOVA results indicated that the operating temperature had the most significant influence on the four responses of the biochar. Ash content, pH, and EC of all biochars were significantly increased with increasing operating temperature; while the volatile matter content drastically decreased. The residence time and heating rate showed less effect on these four responses. It was found that the husk and leaf biochar were more desirable for soil amendment with the optimal conditions of 600°C, 5°C/min, 90 min and 600°C, 15°C/min, 79 min, respectively. The leaf biochar contained the highest C content and increased with rising operating temperature (76.3 to 89.2 wt. %). Nitrogen content was found to be higher in leaf biochar (1.60 to 1.98 wt. %). For the elemental composition, the leaf biochar presented the highest Ca and P contents; while the highest K and Mg contents were found in the stalk biochar. Cob biochar was characterised with the lowest contents of Ca, K, Mg, and P. The SEM images verified the existence of porous structures in the biochar. Based on these findings, it could be recommended that maize husk and leaf were suitable to be converted into biochar for soil amendment at 600°C.

Keywords: Biochar, lab-scale batch reactor, maize residues, response surface methodology, scanning electron microscope

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In-Field Biochar Production from Crop Residues: An Approach to Reduce Open Field Burning in Northern Thailand

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In recent years, people in northern Thailand have been suffering from severe air pollution. The main sources were found to be forest and field fires. The latter caused by smallholder farmers who burn crop residues in order to clear their land, make nutrients available and presumably improve soil sanitary conditions for the next cropping cycle.

This study compares emissions from open burning of maize stover to the emissions from producing biochar in an experimental kiln. Experiments were carried out at four locations in three provinces in northern Thailand: Mae Hong Son, Chiang Mai and Nan. On each site, the experiments were done in triplicates on 10 m × 10 m plots. Total fresh and dry biomass in the field was measured. Labour requirement for biomass collection and charring was recorded. Temperatures of the open field burning and kiln charring were measured. Production of exhaust gases of open field burning and kiln charring was determined under laboratory conditions at Chiang Mai University.

The results show that during the pyrolysis of corn stover emissions of CO, NO, NO_2 and SO_2 did not occur. This indicates that there was a complete combustion of the synthesis gases, releasing only CO_2 to the environment. In contrast, the open combustion showed elevated emissions and high levels of particulate matter (PM) 10. Burning of residues on the field did not increase soil temperature, while the temperatures 10 cm above ground ascended to 500–700°C, however, for less than two minutes. Thus, the phytosanitary effect of the burning was found to be negligible. An average of 22 % of fresh biomass was converted to biochar, which can be used as a soil amendment. The major disadvantage of charring was the high labour demand of 120 man minutes per $100m^2$ at present state of the art.

This study was the first carried out in cooperation with farmers under field conditions in remote areas of the northern Thai Highlands. It shows that emissions can be reduced substantially by applying pyrolysis instead of open field burning. Further research is needed to optimise the size of the kiln and the ergonomics of biomass collection and biochar handling.

Keywords: Air pollution, combustion, highland, pyrolysis, smoke

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Addition of Biochar and Clay Increase the Nutrient Retention of a Tropical Arenosol

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Arenosol is one of the main soil types in the Itaparica region, located in the semi-arid northeast of Brazil. This sandy soil typically has low nutrient content and limited capacity to retain water and nutrients. Our overall goal is to contribute to food safety in the region by using locally available and inexpensive materials that serve as long-term amendments to improve the fertility of Arenosols. We tested locally produced pyrolized biochar, made of feedstock of the invasive tree *Prosopis juliflora*, and a clayey lake sediment on the laboratory and field scale for their ability to increase the retention of nutrients.

Both materials were mixed into the Arenosol. In batch experiments according to OECD 106 the sorption capacities of nitrate, ammonium, phosphorous and potassium were investigated for different Arenosol-biochar, respectively Arenosol-clay ratios. In a field trial planting holes with an untreated control, 5 % biochar, respectively 10 % clay share (each v/v) were established, each of them in an unfertilised variant and another variant fertilised with mineral NPK. The native tree species *Spondias tuberosa Arruda* was planted in all holes. The nutrient leaching out of the planting holes in 70 cm depth within an eight month period was quantified by self-integrating accumulators (SIA).

Our results show that biochar increases the sorption capacity of nitrate and, consequently, reduces the leaching of nitrate in the field, whereas clay has no influence on nitrate retention. Both materials lead to a slight increase of ammonium sorption. Biochar also slightly increases the sorption of phosphorous, whereas clay has a marginal higher potential to sorb phosphorous. Clay strongly increases potassium sorption, in contrast to biochar, which releases a high amount of water soluble potassium. According to these results we conclude that biochar and clay have the potential to increase the retention of the tested nutrients and therefore can meliorate the fertility of an Arenosol. We also assume that the application of a mixture of both materials would result in an even higher increase of the nutrient retention capacity. To prove this assumption further experiments are needed.

Keywords: Brazil, leaching, NPK, soil amendment, soil fertility, sorption

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Homogeneous Management Zones: An Approach to Improve Agricultural Efficiency of Sugar Cane Cultivated in Marginal Lands

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More efficient farming and land use systems are mandatory in a world where the demand for food, fiber and fuel is constantly rising. This demand required an increment in area dedicated for agricultural production, forcing the inclusion of marginal areas in production systems. As an optimal approach, non-food agricultural production should focus on marginal land to avoid competition with food crops (and impact food security). However, marginal areas usually have limitations which in aggregate can severely constrain production. Brazil actually cultivates more than 9 million hectares with sugar cane (with a considerable share of marginal areas), resulting in a total production of 600 million tons, of which 50 % are used for ethanol production, generating an immense amount of residues. The correct management of these residues is also of economic and environmental importance.

The objective of this work was to establish an approach to manage field variability on a site-specific basis, optimising the agronomic practices and agricultural efficiency using residues of sugar cane for bioethanol cultivated on marginal land in Brazil.

The homogeneous management zones (HMZ) were defined as sub-regions of a field with a relatively homogeneous combination of yield-limiting factors (such as low pH, soil organic matter, high bulk density, etc.). Instead of focusing in the maximum agricultural output (yield) of a HMZ, this approach aimed to rationalize the agronomic management to obtain the highest efficiency out of this area. As a result, for example, in areas limited by water availability (because of the soil texture or compaction) an over fertilisation not necessarily increased the output, but increased costs and caused pollution. The HMZ approach, in this case, reduces the amount of fertiliser applied in such area and balances the amount of residues to be applied, just to allow the best possible output considering the limitations. An important feature is that the HMZ approach was focused on the use of residues of ethanol production (especially filter cake), aiming to close the nutrient cycle for this crop.

Keywords: Crop residues, ethanol, filter cake, land use, natural resources management, precision farming, *Saccharum officinarum*, yield

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Changes in the Physicochemical Properties of Biochars as Influenced by Feedstock Type and Pyrolysis Temperature

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The interest in the use of biochar as a soil amendment to improve soil productivity and therefore mitigate climate change has been receiving attention in recent times. However, our understanding of the effects of feedstock and pyrolysis conditions on biochar properties is limited and the exploration of waste biomasses as potential feedstocks continues. In the quest to explore other potential biomass and deepen our understanding of the properties of biochars as a function of feedstock and pyrolysis temperature, we characterised 12 biochars made from 3 feedstocks; corn cob (CC), rice husk (RH) and mahogany saw dust (MG) at 4 pyrolysis temperatures of 400, 500, 600 and 700°C, using muffle furnace. Parameters investigated included biochar yield (%),volatile matter, ash and fixed carbon (FC), BET surface area, pH, EC, hydrophobicity (molar ratio and contact angle method), and total macro and micronutrients (Ca, Mg, N, P, K, Cu, Zn, Mn and Fe). The CC biochars had the highest pH, EC, FC values and the highest total nutrient concentrations of K and N. Rice husk biochar (RH) had the highest average biochar yield (43 %), ash content (50 %) and total P. Generally, the MG biochars had the highest volatile matter content, BET surface area, total nutrient concentrations of Ca, Mg and Fe. Biochar properties significantly influenced by both biomass and pyrolysis temperature were pH, EC, ash, biochar yield, volatile matter, BET surface area, total Ca and Mg. Biochar properties significantly ($p < 0.05$) affected by biomass only were total K, Na, Cu and Zn. Hydrophobicity generally increases with higher pyrolysis temperature and decreased in the order MG $>$ CC $>$ RH. The results indicated that most biochar properties were influenced by feedstock and pyrolysis temperature and RH biochars have the potential for correcting acidic soils CC and MG biochars with particularly high C sequestration potentials.

Keywords: Amendment, biochar, BMBF-GlobE, soil, UrbanFood^{Plus}

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Soil Amendment Impact on Root and Root-Tuber Development of Umbu Trees

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The Caatinga in northeastern Brazil is a semiarid ecosystem that comprises with 850,000 km^2 almost 10 % of the Brazilian territory. With 20 million inhabitants it is the most densely populated semi-arid region of the world. It is a highly endangered ecosystem mainly through deforestation, fires, and pasture establishment. The umbu tree (*Spondias tuberosa* Arr.) is one of the native Caatinga trees that can survive the high temporal and spatial variability of water supply. The umbu fruit is an important nutrition source for humans and the wild life in the Caatinga. Humans use the Umbu fruit to produce juice, sweets, licorices, and others. The high pressure on this ecosystem by humans together with water scarcity, however, impede the emergence of new young trees. Therefore this study investigates how different soil amendments as biochar, goat manure, and mineral fertiliser added to planting holes can influence the rooting system of young umbu trees to potentially increase water uptake during infrequent and small rainfall events. This includes the development of root tubers which are essential for the survival of the tree during dry seasons, since they are able to store water, minerals, and organic solutes. The qualitative description of the root-system of three year old seedlings of S. tuberosa will include the vertical and horizontal extent of primary and secondary roots, as well as the number and size of root-tubers. To harvest the root-tubers the entire rootstock was manual excavated and the root-tubers are collected and the total number, fresh weight, and size of tubers are recorded. Root length density of fine roots and fine root biomass within the planting hole are measured in manual washed samples out of a volumetric soil sample taken in two different depths (0 – 300 mm and 300 – 600 mm). Finally the comparison of root systems with above-ground biomass might help to understand underlying processes that favour young umbu tree survival.

Keywords: Biochar, root length density, soil amendment, umbu

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Evaluation of Biological Nitrification Inhibition (BNI) Capacity in a Biparental Mapping Population of *Brachiaria humidicola*

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Soil nitrogen (N) loss due to rapid nitrification (oxidation of ammonium to nitrate) is a serious problem with economic and environmental implications. As a result, a large proportion of N fertilisers applied to crops are lost to the environment via nitrate leaching and nitrous oxide emissions. The tropical pasture grass *Brachiaria humidicola* (Bh) exudes organic molecules from roots that inhibit the soil nitrification process. This ability, termed biological nitrification inhibition (BNI), has great potential for restoration of soil fertility, reduction of nitrogen pollution from agriculture, and improvement of nitrogen use efficiency. In the present study, three methodologies were standardised to quantify the intrinsic BNI-potential of plant genotypes. Specifically, BNI-potential was measured in 121 hybrid progeny of a bi-parental population constructed from a cross between Bh germplasm accessions of CIAT 26146 $\times$ CIAT 16888, differing in BNI-potential (medium-high and high, respectively). Root extracts from each hybrid were evaluated for intrinsic BNI-potential using a bioluminescence assay that uses a recombinant Nitrosomonas europaea. The soil incubation method was also employed to measure nitrification rates in soil samples collected from pots where the Bh hybrids were grown for a year. These results were further validated by quantifying nitrifying microorganisms using qPCR, using the amoA gene as a functional marker. We identified groups of Bh hybrids with contrasting BNI-potential based on differences observed in the bioassay, nitrification rates and nitrifier population size. The capacity for BNI in mapping population was normally distributed indicating that the trait is quantitatively inherited. Quantitative trait loci (QTL) mapping resulted in identification of minor QTLs that are associated with BNI capacity. Results from this study indicated that using three different phenotyping methods it is possible to identify promising Bh hybrids to assist the on-going *Brachiaria* breeding efforts. This study also contributed towards establishing correlations among BNI capacity in roots, soil nitrification rates and the amount of nitrifying microorganisms present in the soil.

Keywords: Bioassay, biological nitrification inhibition (BNI), *Brachiaria*, nitrification, nitrogen, phenotyping, QPCR, QTL

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Impact of Biochar Addition on Nitrification and CO_2 Evolution from an Acid Palexerult

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Biochar amendment to soil has been proposed as a means to increase soil fertility and also carbon sequestration. However, its effect on soil nitrogen (N) and carbon (C) cycles is poorly understood especially in acid soils. A short-term (60 days) incubation experiment was carried out to investigate C and N mineralisation in an acid Palexerult from SW Spain after application of biochar (B), pruning waste compost in two different stages of maturity (30 days old; C1 and 6 months old; C2) and their mixtures, where 50 % of C was provided by B and 50 % by C1 and C2, respectively (C1B and C2B). Simultaneously, greenhouse assay for agronomic performance of perennial ryegrass was set up. Soil respiration was monitored throughout the study and microbial biomass, ammonium N (NH_4^+-N) and nitrate (NO_3^--N), water soluble C (WSC), N (WSN), soil pH and electrical conductivity (EC) were determined after one month and at the end of the incubation. The results showed that soil respiration was significantly higher in compost-amended treatments, resulting in 19 and 14 % loss of added carbon in form of C1 and C2, respectively, while only 9.8 % of C added as biochar was mineralised. Nitrogen mineralisation slightly decreased after biochar amendment respect to control, however, C1B resulted in higher mineralisation than C1 application where mineral N was immobilised. Aboveground biomass production of ryegrass was increased by all treatments with no significant difference between compost and biochar amendments. Our results indicate that combination of compost with biochar could maintain the crop production while decreasing CO_2-C losses by mineralisation and potential nitrate losses by leaching. Further field studies would be necessary to acquire a better understanding of the effects of biochar on N and C cycles.

Keywords: Acid soil, biochar, carbon mineralisation, nitrogen mineralisation

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Water management in crop production systems

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Determinants of Cotton Farmers' Water Use Efficiency in Arid Northwestern China

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Cotton production constitutes a major source of income for the rural population in the arid northwestern Chinese Aksu-Tarim Region (ATR), with around 60 % of total sown crop land being cultivated with cotton. In this ethnically diverse region of China a continuously positive economic development is indispensable to ensure social stability. However, the increasing overuse of scarce fresh water resources for irrigation agriculture not only leads to a severe ecological degradation, but also endangers stable yields and farm profitability. Therefore it is of vital importance to understand what determines the water use efficiency (WUE) of cotton producers in the region. Applying a stratified random sampling approach 228 cotton producing farm households were interviewed with standardised quantitative questionnaires. In the regression analysis the application of drip irrigation technology (over the traditional flood irrigation method) and owning a groundwater well were identified as the major determinants of farmers' WUE, with drip irrigation having a greater impact between the two. While drip irrigation can be considered positive throughout, the practice of owning a well is more debatable. While it ensures stable irrigation water supply during times of seasonal surface water shortage and thus ensures against water stress induced yield reductions, the continuous exploitation of groundwater resources may have detrimental effects on the regional hydrological system in the long run. In the next step the determining factors for the decisions to adopt drip irrigation and to install wells were determined using a probit model with the same set of independent variables. Results showed that among others the individual farmer's cotton harvest area had a significant positive effect on both decisions. Finally, the factors influencing farmers' intention of installing new wells in the near future were analysed. With the perceived soil salinity, the perceived water quantity development in the region, and the reliance on surface water being among the significant determinants, it is demonstrated that installing wells clearly aims at overcoming on-farm water scarcity and related problems. Results from this study can help policymakers in devising strategies for improving WUE, while reducing groundwater depletion in the study region.

Keywords: China, cotton, groundwater, irrigation, regression analysis, water saving

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Effects of Water on Recovery of Weed Seedlings Following Burial

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Recovery of common agricultural weeds following burial by the soil was studied in four greenhouse and three field experiments. Species studied included velvetleaf (*Abutilon theophrasti* Medik. ABUUTH), Powell amaranth (*Amaranthus powellii* S. Wats. AMAPO), common lambsquarters (*Chenopodium album* L. CHEAL), barnyardgrass (*Echinochloa crus-galli* (L.) Beauv. ECHCG) and giant foxtail (*Setaria faberi* Herrm. SETFA). Seedlings were bent over prior to burial to simulate the effect of the impact of soil thrown by a cultivator. Altogether, over 35,000 seedlings were marked and observed for recovery. No seedlings were recovered from 4 cm of burial. Recovery from complete burial under 2 cm of soil ranged from 0 to 24 % depending on experiment, species and watering treatment, but recovery greater than 5 % was rare. Large seeded species tended to recover from complete burial under 2 cm of soil better than small seeded species. The study did not reveal any difference in recovery of grasses relative to broadleaf weeds. Overall, seedlings tended to recover best when water was applied daily after burial, worst when water was applied once on the day of burial and to an intermediate extent when no water was applied. However, difference in recovery from no water and watering once treatments was usually small, and many species combinations showed no significant difference between watering treatments. When even a small portion of the seedling was left exposed, the recovery generally exceeded 50 %. Recovery from burial could pose a substantial weed management problem in some circumstances, particularly for large seeded species. Maximizing burial depth is important for limiting recovery. Recovery from burial can be minimised by withholding irrigation for several days following hilling-up operations.

Keywords: Cultivation, irrigation, mechanical weed management, rainfall, soil cover

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Biomass Allocation Responses of *Tamarindus indica* Seedlings to Limiting Resources: Water Stress and Recovery

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In order to test whether allocational plasticity occurs in tamarind seedlings, we tested the hypothesis that biomass allocation responds differently to optimal and drought stress conditions. Seedlings of eight provenances from Asia, Africa and America were grown from locally gathered seed in a fertilised soil with three levels of drought stress and recovery in a greenhouse of the University of Antwerp, Belgium. The seedlings were harvested after a 600-d growth period (120-d period subjected to drought and recovery terms) to determine the growth and allocation responses: natural logarithm (ln) of root:shoot ratio vs. biomass, ln root mass vs biomass, ln stem mass vs biomass, ln specific leaf area vs biomass and ln leaf area vs. biomass. Biomass allocation showed significant amounts of ontogenetic drift in root mass ratio, leaf mass ratio and specific leaf area across the three drought stress treatments, suggesting allocation was sensitive to drought stress. Allometric relationship between root mass and plant mass showed that, allocation pattern changed during both drought stress and recovery phase. Our results showed significant differences between moderate and high drought stress levels in root mass ratio, whereas there was no significant differences between control and high drought stress levels. In spite of these no significant differences, the allometric approach showed that root was sensitive to drought stress and allocation to root development was greater under drought stress condition. We found that, for this species, plasticity in biomass allocation patterns occurs and this species adjusted biomass allocation patterns in response to water availability. Our results support a better way of examining the patterns of allocation to biomass development with examining the allometric relationships in response to limiting resources.

Keywords: Allometry, biomass allocation, drought stress, tamarind

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Nutrient and Virtual Water Flow Analysis for Tamale, Ghana and Ouagadougou, Burkina Faso.

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Nutrients and virtual water in the form of food and other organic goods are transported from the rural hinterland to urban centres. In particular in developing countries, poor waste management in growing cities and the potential to recover nutrients and water for agricultural production have raised interest in quantifying these flows. What are the quantities of organic materials that enter and leave a city? Which materials carry the most important nutrient and virtual water flows? Where does nutrient and water depletion take place?

This study has been conducted within the UrbanFood^{Plus} project (www.urbanfood plus.org) to assess organic material flows and their quantitative nutrient and virtual water contribution for the cities of Tamale in Ghana and Ouagadougou in Burkina Faso. Matter flows (unprocessed foodstuff, firewood, fodder, non-timber forest products, etc.) from regional, national and international sources were systematically recorded at all roads leading to Tamale and Ouagadougo. Organic matter from urban sources aand stocks were captured at major markets. The survey has been conducted within two years covering the peak (November) and lean season (April) for six days in a row.

The study maps the virtual water and nutrient transfers of different types of traded food products and other organic goods. The results will improve our understanding of the urban metabolism, and may support the development of standardised methodologies for assessing virtual water and nutrient flows.

Keywords: Food flows, GlobE, urban metabolism

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Response of Rice to Changes in the Green and Far-Red Light Ratio

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Plant production in artificial or semi-artificial environments such as greenhouses, growth chambers or the newly emerging "vertical farms" typically requires high levels of artificial light and calculations show that energy costs for illumination are generally the greatest cost factor for such installations. Due to their increasing electric efficiency, LED light-panels have become the standard for plant lighting in the last years. Light emission from LEDs typically covers light in a narrow 20–30 nm range of the waveband, but full spectrum white LEDs are also available. Research has shown that these white LEDs have certain benefits for plant growth compared to grow light that is composed from narrow bandwidth single colour LEDs. Although white LEDs cover the full range of the photosynthetic spectrum, the absolute levels of far red light in their spectrum is low and hence, the ratio of red to far red light (R/FR-ratio) is much higher as compared to that of sunlight. Since the R/FR-ratio is an important parameter in photobiology as it is part of plants' shade-detection mechanism, we were interested, if a manipulation of the R/FR ratio under illumination of white light LEDs has an effect on growth and morphology of plants. As current research also indicates that the ratio of green light in the spectrum could also play a role in shade-detection, we conducted an experiment including 3 morphologically contrasting rice genotypes (a dwarf, a full-dwarf and a super-dwarf line). We equipped 12 ventilated tubes (15 cm diameter, 48 cm height) with a white LED (8 Watt). The R/FR-ratio and the level of green radiation in the spectrum were increased by adding a far red or green LED respectively to each 4 of the tubes. Plants were harvested after 4 to 6 weeks and biomass production and allocation, morphological features and gas exchange parameters were accessed. Results indicate no clear effect of the manipulated light qualities on plants and differences in biomass production found in one variety did not establish in the others. Results will be presented in more detail and a technical explanation of the experimental setup will be given.

Keywords: Green light, LED, R/FR-ratio, rice, superdwarf rice

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Morphological and Ecophysiological Status and Leaf Hyperspectral Indices as a Tool to Investigate Drought and Flooding Stress Tolerance in Citrus Seedlings

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Morphological and ecophysiological status, and leaf spectral reflectance indices in relation to both drought (DS) or flooding (FS) stress were conducted in one-year-old seedlings of Carrizo (CC), Troyer (CT) and C35 citranges [*Citrus sinensis* (L.) Osb. × *Poncirus trifoliate* (Raf.)], sour orange (SO) (*C. aurantium* L.), *C. volkameriana* (CV) and Citrumelo 4475 (Cit) [*P. trifoliata* Raf. × *C. paradisii* Macf.] growing in 3L plastic pots under greenhouse conditions in Antwerp, Belgium. A mixture of sand:peat in 2:1 ratio was used as a substrate. Drought-stressed seedlings were subjected to water deficit by withholding irrigation, whereas flooding was obtained by submerging seedlings in plastic water tanks and the water level was 4 cm above the soil surface for 21 days. Control seedlings were well-irrigated and drained, so the substrate was maintained at field capacity. The objectives of this experiment were to (i) evaluate response to drought and flooding of citrus rootstocks in terms of total biomass production, photosynthesis rate (P_n), stomatal conductance (g_s), leaf chlorophyll content and relative water content (RWC), (ii) and study whether photochemical reflectance index (PRI), water index (WI), normalised difference vegetation index (NDVI) and stress index (SI= R550/R980) could be used for evidencing plant reactions in response to flood and drought stress. At the end of the experiment, both drought and flood had reduced total biomass for all rootstocks. This decrease was more pronounced for flooding (78.2 %) than for drought (50.2 %) in SO, whereas the reverse was true for the other seedlings. Submergence did not affect total biomass of C35. Total leaf chlorophyll content decreased more by flood than drought for all rootstocks, especially in SO (54.6 %), Cit (42.8 %) and CV (59.6 %). Flooding had no effect on RWC whereas drought significantly reduced RWC. Under drought, RWC was higher in SO (61.7 %), C35 (53.6 %) and CC (48.4 %) compared to RWC of other rootstocks ($<$ 43.9 %). P_n and g_s decreased more due to drought than to flooding but the greatest decreases occurred under drought conditions in SO (83.9 %) for P_n and in CV (85.70 %) for g_s. Flooding and drought significantly decreased F_v/F_m for SO, CV and CT. Based on RWC, gas exchange, and chlorophyll parameters, SO is more sensitive to flooding and the rootstocks C35, while CC and CT appeared to be flood-tolerant rootstocks. In addition, C35 and CC showed a higher drought tolerance than

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the other. PRI, WI and SI of leaves of all rootstocks allowed to assess drought and flood effects better than NDVI. PRI correlated with P_n (r^2=0,410) and g_s (r^2=0,415). A good correlation was also found between WI and P_n (r^2=0,417) and between WI and g_s (r^2 = 0,392). SI correlated significantly with total chlorophyll content (r^2 = 0.371) and g_s (r^2 = 0.34). Overall, PRI and WI ranked better than NDVI for tracking photosynthesis rate and stomatal conductance, whereas SI was the best indicator for total chlorophyll content. This study shows that SI, PRI and WI measured at leaf level can be used for fast, non-destructive detection of flood and drought stress effects on citrus plants.

Keywords: Citrus rootstock, drought stress, plant physiology, stress index, submergence stress

Saving Fresh Water Resources through Cultivation of Salt Tolerant Perennial Grasses under Marginal Environment

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Cultivation of salt tolerant perennial grasses using saline water irrigation is potentially an important strategy to save fresh water resources and maximise the forage yield of small-scale farms in the marginal environment. Field evaluation of 40 Buffel grass (*Cenchrus ciliaris* L.) genotypes was conducted at ICBA, Dubai, UAE over eight years (2006–2013) under three irrigation water salinities (EC: 5, 10 and 15 dS m^{-1}) to identify salinity tolerance potential based on plant growth, biomass yield and quality attributes. Total annual and average fresh (FW), and dry biomass (DW) varied significantly among genotypes under all salinity levels. Lower DW producing accessions were higher in nutritive value while higher DW producing accessions had lower nutritive value in terms of crude protein (CP) and neutral detergent fiber (NDF). From multivariate analysis,it was shown that accessions 37, 2, 3, 12, and 15 were salt tolerant, high biomass production with adequate nutritive value at different salinities. In contrast, genotypes 21, 23, 24, 25, and 40 were salt sensitive and low yielding. Genotype 37 (Grif 1619) was the most stable and high yielder at all salinity levels. The local accession 38 (MAF 74) had a higher yielding then to 37 but only declined sharply at the highest salinity levels that made it suitable for medium level salinity. It is concluded that wide genotypic diversity exists among a diverse collection of (*C. ciliaris* accessions for salinity tolerance, and Multivariate analysis facilitated the grouping of stable and high yielding accessions into clusters. These salt-tolerant perennial grasses can be grown to maximise forage production and to combat desertification in arid environments.

Keywords: Buffel grass, forage quality, genotypes evaluation, water salinity, yield

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Improving Barley Production by Optimising Water and Nitrogen under Land and Water Limiting Conditions

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Traditionally, water and nitrogen fertiliser applications have been overused due to the need ensuring adequate agricultural productivity for an increasing rate of population. However, this cannot be continued due to the limitation of water resources and the environmental damages. Hence, for production maximisation, it is important to calculate the optimal amounts of applied water and nitrogen. The aim of this study was to calculate the optimal amount of water and nitrogen for barley under limited water and land conditions. This experiment was performed with 4 levels of irrigation regimes (0, 50, 75, and 100 % irrigation requirement) as main plot and 4 nitrogen fertiliser levels (0, 70, 140 and 210 kg N ha^{-1}) as subplots using spilt plot design with 3 replications and their effect was investigated on barley (cv. Reyhaneh 0–3).
The relations between benefit (grain and straw) and cost per unit area were derived as a function of irrigation depth and applied nitrogen. The optimal amounts of water and nitrogen were obtained 0.51 m and 179 kg N ha^{-1}, respectively, under land limited condition (by maximising the net benefit per unit area), and 0.30 m and 276 kg N ha^{-1} for water limited condition (by maximising the ratio of net benefit per unit area to the amount of applied water), respectively. It was concluded that the increase of nitrogen fertiliser can enhance plant production under water limited condition. The amounts of water and nitrogen obtained for water limited condition were not related to water price.

Keywords: Barley, land limit, optimisation, water limit

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Effect of Irrigation Techniques on the Efficiency of Dyked and Free End Furrow Irrigation

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This study was conducted at the University of Khartoum Top Farm from November 2010 to November 2011. The treatments included four furrow irrigation techniques namely; surge flow, bunds, cut-back and cut-off. The soil was classified as clay soil. the techniques were applied on free end furrows and dyked end furrows. The furrow length was 190 m, the four techniques were randomly distributed in the experimental area and the design followed was the split plot design with three replicates. The results showed that the highest application efficiency of 60.3 % was obtained with surge irrigation technique with dyked furrow end ($P \leq 0.05$) followed by surge irrigation with free end furrow (50.1 %), bund irrigation techniques with dyked furrow (46.0 %), bund with free end furrow (41.4 %), cutback irrigation technique with dyked furrow (35.8 %), cutback irrigation with free end furrow (44.0 %); cut-off irrigation with dyked furrow (29.3 %) and cutoff irrigation technique with free end furrow (29.2 %). The highest distribution efficiency of 96.3 % was also obtained under surge irrigation technique with dyked furrow end. Whereas the lowest distribution efficiency of 73.1 % was recorded under cut-off irrigation technique with free end furrow. Surge irrigation technique with dyked furrow end recorded the heist storage efficiency of 87.7 % compared with all other techniques with both dyked and free end furrows. While the lowest storage efficiency of 42.5 % was obtained under cut-off technique with free end furrows.

Keywords: Bunds, cut-back, cutoff, furrow irrigation, irrigation efficiency, surge irrigation

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Bioirrigation and Biofertilisation for Sustainable Intercropping of Pigeon Pea and Finger Millet

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Food security for the growing population and achieving the zero hunger target by 2050 is a major challenge for humanity. Sustainable intensification of agriculture, i.e. increasing food production while at the same time reducing the environmental impacts, has been proposed as the way forward to address this challenge. In this study we propose a sustainable cereal - legume intercropping agroecosystem model employing the concept of bioirrigation and biofertilisation. "Bioirrigation" is based on the principle of hydraulic lift (HL), where transfer of water occurs through roots from wet soil layers to dry soil layers as a consequence of a soil water potential gradient. Specifically, the process of bioirrigation describes the water supply of a deep-rooted plant to a neighbouring shallow-rooted plant. In our study, we designed an experiment to test the effects of bioirrigation and biofertilisation in the growth and yield of a intercropping system that included pigeon pea (*Cajanus cajan*) as a deep-rooting plant to bioirrigate the neighbouring shallow rooted finger millet (*Eleusine coracana*). In order to increase efficacy of water transfer from pigeon pea to finger millet, AMF (arbuscular mycorrihzal fungi) and PGPR (plant growth promoting rhizobacteria) were applied as biofertilisers. The results that we will present were generated testing the following hypotheses: (i) hydraulic lift performed by pigeon pea has the potential to bioirrigate the neighbouring finger millet; (ii) the presence of AMF and PGPR increases the efficacy of transfer of hydraulically lifted water and (iii) only in the presence of pigeon pea, finger millet can access the deep water. We envision that sustainable intercropping using bioirrigation, as tested in our experiment, will help maintaining the stability of agriculture and food security, especially in rain-fed areas, when applied to real-world agroecosystems.

Keywords: Biofertilisation, hydraulic lift, intercropping, sustainable agriculture

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Irrigated Sunflower as a Strategy for Diversification and Intensification of Land Use in Midwestern Brazil

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In recent decades many technologies have been developed for the diversification and intensification of food, fiber and bioenergy production systems in the Cerrado in Midwestern Brazil. Agricultural practices such as no-tillage and irrigation have been allied with a selection of species and cultivars adapted to dry winter conditions, which allows up to three harvests per year. However, much remains to be done in regards to diversifying production systems, since the predominance of soybeans and corn crops are highly risky especially when sowing late in the season. Thus, this study assessed the productivity of different sunflower cultivars, with and without supplemental irrigation, at different sowing dates in the 2013 and 2014 winter season. In 2013 we used BRS 324 and Aguará 4 cultivars, and the seeding was carried out on the 27th of February and on the 27th of March. However in 2014 we used the BRS 323 and Aguará 6 cultivars, and planting was performed on the 18th of March and on the 5th of April. The experiments were conducted in oxisol in Dourados, Mato Grosso do Sul state, at 22°13'16" South latitude, 54°17'01" West longitude and 430 m altitude. The precipitation level was within normal limits in 2013, 1606 mm, and below the historical average in 2014, 1366 mm. In the 2013 season, the sunflower BRS 324 cultivar showed the highest yield, 1315 kg ha^{-1}, with supplementary irrigation and by the 27th of February sowing date. In the 2014 season, the highest yield was obtained with the Aguará 6 cultivar, 2117 kg ha^{-1}, by the 5th of April sowing date in the rainfed system. Nevertheless, grain yield increased 51.7 % and 7.4 % on average with supplemental irrigation in 2013 and 2014 respectively. Supplemental irrigation also promoted greater plant height, 22.4 %, and oil production, 39.5 %, in 2013. Based on these results it is possible to recommend planting sunflower in rainfed or irrigated systems after March 10, considered the time limit for second crop corn planting in the Midwest region of Brazil, which gives the producer the option for diversification and intensification of the crop rotation system.

Keywords: Crop rotation, *Helianthus annuus*, no-tillage system, oil plants, second crop

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Water Use Efficiency of Sunflower Genotypes under Drip Irrigation

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This investigation was conducted to determine the productivity and water use efficiency for new sunflower genotypes obtained from selfing and induce mutation. Ten sunflower genotypes were evaluated under drip irrigation using two treatments of irrigation (100 and 70 % from water requirement of sunflower). Statistical analysis showed that there were significant differences among genotypes, as well as between irrigation treatments and the interaction between them. The interaction between irrigation treatments and genotypes was significant in all studied traits except for head diameter. Results indicate that decreasing the amount of irrigation water from 1500 to 1130 mm ha^{-1} significantly reduced all studied traits. The conspicuous differences among the genotypes suggest the presence of genetic differences and this illustrates the using of selfing and induce the mutations in the creation of new recombination differ significantly from its parents. Mutation (M1–63) surpassed all the other one genotypes in seed yield and water use efficiency (WUE). Lines which gave the highest seed yiel have a WUE under drought conditions higher than WUE under normal irrigation. The lowest depression in seed yield due to drought conditions compared to the seed yield under normal irrigation has been registered for Line 20, Line M1–63 and Sakha 53 genotypes (11, 18 and 16 %, respectively), but the highest depression recorded for Line 48, Line M3–63 and Line M4–63 (49, 46 and 43 %, respectively). The genotypes (Line 20, Line M1–63 and Sakha 53) are more drought tolerant than others and can be used in breeding programme to develop sunflower hybrids suitable for cultivation under drought conditions.

Keywords: Inbred lines, mutation, sunflower genotypes, water use efficiency

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Growth Response of Rice to Different Vapor Pressure Deficits and Diurnal Temperature Patterns

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In arid and semi-arid environments, rice plants are challenged by large diurnal temperature amplitudes and high evaporative demands by the atmosphere. In rice grown under typical lowland conditions, the plant's meristem is below the water surface and therefore, water temperature can have a larger effect on plant growth than air temperature. The impact of either water temperature or vapour pressure deficit (VPD) on rice growth has been widely investigated; however, the interactive effect of day/night temperature patterns at root and meristem level under varying VPD has barely been studied so far. The aim of our greenhouse study was to determine growth responses of two rice varieties (IR64, Sahel108) to three water temperature regimes (constant temperature: 23°C; warm day/cold night: 28/18°C; cold day/warm night:18/28°C) under two VPD levels (2.2 and 0.92 kPa). Individual plants were grown in temperature-controlled nutrient solution. Leaf elongation rate (LER) was measured for the 9–10th leaf of the main tiller for 48 hours. Under low VPD, LER was higher than under high VPD for both varieties. Interestingly, under high VPD, highest LER were found during the night and in the early morning (0–8 am), whereas under low VPD, LER was highest between 8am and 4pm. Under low VPD conditions, constant temperature led to a higher LER but only for IR64, whereas under high VPD, highest leaf growth was observed under cold day/warm night conditions for both varieties. Under low VPD, cold day/warm night conditions led to a greater total root length, a larger root surface area, a higher root/shoot ratio and more total dry matter in both varieties, while under high VPD this effect was only found for IR64, but not for Sahel 108. Our results suggested that VPD has a lager impact on diurnal leaf growth patterns than temperature. Since under high evaporative demand, rice leaves mainly grow during the night and in the early morning, night temperature can have a larger effect on plant growth than day temperature. Furthermore, cold day/warm night conditions largely increased root growth, with might enable rice plants to tolerate a high VPD during the day and therefore promote plant growth.

Keywords: Hydroponics, leaf elongation rate, lowland rice, VPD

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Effect of Water Stress on German and Israeli Table Grapes - Tolerant or Sensitive?

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Table grape production in Israel and Germany will be particularly endangered due to the effects of climate change. In Germany, decreasing summer precipitation parted with rising temperatures lead to increasing severity and durations of drought periods, while Israel is already combating with severe water scarcity. Both situations, in Germany and Israel, will lead to water use conflicts if there is no adaption of plants on drought periods and water use efficiency is increased. Based on this background, especially the physiological drought response of table grapes and its cultivar and rootstock specific characteristics are of major importance in order to establish distinct recommendations regarding the choose of cultivar and rootstock as well as the management and scheduling of irrigation measures. Therefore two Israeli table grape varieties will be screened as new potential varieties for German table grape production. The objectives of this study are to (I) characterise the four most relevant German and two Israeli table grape varieties according to their physiological drought response, (II) assess the effect of drought stress on relevant internal and external quality traits, (III) determine rootstocks' influence on drought stress and evaluate rootstock-scion interactions of selected cultivars and genotypes and (IV) test selected sensors regarding their ability to identify drought stress of table grapes. Until the end of 2016, two Greenhouse pot-experiments will be conducted at the University of Hohenheim. During the experiments plant growth and development parameters will be determined as well as daily water consumption, gas exchange, chlorophyll florescence and stomatal conductance. Furthermore external and internal quality traits like berry weight and size, titratable acidity, content of sugars and polyphenols will be assessed. It is expected to get an insight into physiological reactions of table grapes and to find solutions how plants and humans can adapt to coming environmental changes.

Keywords: Climate change, drought stress, Germany, Israel, table grapes, water use conflict

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Effect of Irrigation before Planting, after Planting and Urea Applied to Seedcane, on June Planted Sugarcane

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Two experiments were conducted in the seasons 2011/12 and 2012/13. The objective was to improve the germination of June planted sugarcane by improving the conditions of germination. Treatments consisted of irrigation before planting versus no irrigation; irrigation immediately after planting versus irrigation on the second day, and a dose of 50 kg of urea given to seedcane eight weeks before cutting versus no urea application. The results showed superiority of immediate irrigation and irrigation before planting over other treatments on germination in both seasons. There was a positive interaction between the named treatments, namely a visually better growth of the early germinated plants in the first season due to the interaction of treatments of irrigation immediately after planting and irrigation before planting. Therefore the practice of split ridging, usually done by machine, was done manually to avoid destruction of bigger plants (resultant of the positive interaction) or burying of smaller ones (resultant of the negative interaction). Moreover, no effect of urea application to seedcane was shown for the two seasons. The results also showed no significant differences between other measured agronomic and quality characters of sugarcane for the two seasons in response to all the tested treatments. The study confirmed the importance of June planting of sugarcane in Sudan as a very high cane yield can be obtained. Further, the suggested means to improve the germination of the planted sugarcane in June included irrigation before planting and irrigation immediately after planting. These treatments will increase the number of millable stalks and final cane yield when planted in commercial areas.

Keywords: Germination, irrigation, millable stalks, planting, positive interaction, seedcane, urea

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Weed Biomass Production and Cassava Yields in Varying Cassava Cropping Systems

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Weed control constitutes the largest portion of labour in cassava cropping in Africa. Weed control is still largely based on manual weeding. A BMGF funded weed management project in Nigeria is seeking agronomic, mechanical and chemical means of weed control to ease the burden on mainly women and children and to increase cassava productivity. Here the results of agronomic measures on weed biomass are reported. Weed biomass was determined at 4, 8, 12 and 24 weeks after planting in a five factorial trial testing two cassava varieties, ridge-tillage versus flat land, intercropping with maize versus monocrop, fertiliser application versus nil and cassava density effects on weed biomass on a coarse textured poor sand soil and a sandy loam of contrasting chemical properties. The trial served to establish the most suitable agronomic measures reducing weed biomass in a system using manual weeding. Weeds were manually removed from all plots after each weed sampling. Weed biomass was larger on sand than on sandy loam, pointing at the need for site specific approaches. Ridge-tillage reduced weed biomass strongest compared with all other measures. Differences between cassava varieties were significant. Intercropping maize and the application of fertiliser had no significant effect on cumulative weed biomass. Differences between treatments at the individual weed samplings show that dynamics of weed growth is influenced by the presence of an intercrop (maize) and fertiliser application. Several factors interacted significantly indicating that the correct factor combination is likely to reduce weed biomass beyond reductions attainable by single factors. On the poor sand soil the combination of ridge-tillage, 12500 cassava plants ha^{-1} as monocrop, variety TME419, with fertiliser application had the second lowest weed biomass (168 g m^{-2}) and the highest cassava fresh root yield (25 Mg ha^{-1}). On the sandy loam highest cassava root yields (28 Mg ha^{-1}) were attained with the treatment combination ridge-tillage, 10000 cassava plants ha^{-1} as intercrop, variety TME419, with fertiliser application, yet had the highest weed biomass production (82 g m^{-2}) as well. On the more fertile soil weed competition appears to be a lesser problem if weed control is conducted early and at the recommended intervals.

Keywords: Cassava, fertiliser, intercropping, tillage, weeds, yield loss

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New Approaches for Banana Xanthomonas Wilt (BXW) Disease Management in South Kivu, DR Congo

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Banana Xanthomonas wilt (BXW) is a devastating bacterial disease causing large yield losses in Central and East Africa. The recommended control approach involves the uprooting of diseased 'mats', which is highly labour intensive. Disease avoidance is possible with an additional set of practices, including tool disinfection, early male bud removal, stopping all leaf cutting, and barring browsing animals. Single diseased stem removal (SDSR) has been proposed as a reduced labour alternative to complete mat uprooting, and was validated in agronomic trials in South Kivu in 2014. When complemented by the disease avoidance measures, SDSR has been shown to reduce BXW incidence to less than 2 % within 3 months.

A transdisciplinary research project was established in South Kivu, DR Congo, in early 2014, with the objective of developing new recommendations for the application of SDSR that take into account the needs, constraints and possibilities of different types of farmers. On farm-research with self-help groups suggested that individual management was possible and collective control was not needed. This was tested and confirmed in the agronomic trial. Despite intensive training and weekly follow-up, it was observed that not all group members applied the disease avoidance steps correctly. There was also significant theft of leaves cut with potentially contaminated tools. Neither was found to have an adverse affect on members' ability to drive down BXW incidence.

The findings allow the recommendation for controlling BXW in the project area to be greatly simplified: regularly cut down all diseased plants at ground level, and subsequently sterilize the cutting tool. Because individual control is possible, BXW does not need to be controlled by unwilling or absent neighbours. From a scaling perspective, success can be claimed when all farmers are aware of the simplified control package and are in a position to apply it. For each farmer, the importance of banana in their livelihood strategy will determine whether the 'costs' of control are justified.

Keywords: Banana disease control, BXW, single diseased stem removal

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Developing an Aflatoxin Biocontrol Product Against Aflatoxin-Producing *Aspergillus* spp. in Zambia

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Food quality and safety issues resulting from widespread aflatoxin contamination is an obstacle to improved health status and livelihoods of smallholder maize and groundnut farmers, and hampers their linkages to markets in Zambia. Produced by toxigenic isolates of *Aspergillus* section Flavi, aflatoxins are highly toxic carcinogens associated with stunting and immune-suppression. The International Institute of Tropical Agriculture (IITA) and its partners have developed the environmentally friendly and cost-effective biocontrol product aflasafe for minimising aflatoxin levels in highly susceptible crops. However, knowledge on *Aspergillus* spp. community structure is limited and there is a need to understand the interaction between aflasafe and *Aspergillus* in the soil to interpret product performance. The main aim of this study was to establish the relationship between aflasafe and the soil community profile of *Aspergillus spp.*, and their potential effects on aflatoxin levels in maize and groundnut. In an on-farm research trial, two candidate aflasafe biocontrol products, comprising of non-toxin-producing *A. flavus* strains were applied in maize and groundnut fields, 2–3 weeks before flowering at a rate of 10 kg ha^{-1}. Soil was sampled prior to aflasafe application and 3 months after crop harvest, while crops were collected at harvest. Microbiological assessments were performed for soil and grain, and aflatoxin assessment for grain, from both treated and control fields. Our results showed that high aflatoxin producing S-morphotypes and *A. parasiticus* formed the most predominant component of *Aspergillus* spp. (85.7 %) in soils cropped to maize and groundnuts. Consequently, heavy aflatoxin loads (>20 ppb) were detected in untreated grains, especially groundnuts. Treating maize and groundnut fields with aflasafe altered *Aspergillus* spp. soil community structure leading to a significant reduction in aflatoxin levels by 89.6 % compared to control fields. Thus, the biocontrol holds great promise for fighting the aflatoxin burden on maize and groundnut in Zambia. Adoption of the biocontrol products aflasafe ZM01 and aflasafe ZM02 to address aflatoxin could sustainably improve grain nutritional quality and safety for better health and greater income of Zambian smallholder farmers.

Keywords: Aflasafe, aflatoxin, food safety, groundnut, maize, Zambia

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Resistance Reactions of Sunflower against the Parasitic Weed *Orobanche cumana*

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Sunflower broomrape (*Orobanche cumana* Wallr.) is a holoparasitic plant that specifically attaches itself to the roots of cultivated sunflower (*Helianthus annuus* L.) and drains them of water and nutrients. This causes severe yield loss and sunflower broomrape has become the most serious threat to sunflower cultivation from the Mediterranean region to China. Resistant sunflower genotypes were used to control the parasite, but all yet available resistance genes were rapidly overcome by more virulent *O. cumana* races. To find new measures to control the problem, it is important to better understand the mechanisms of susceptibility and resistance. Hence, early infection stages of resistant and susceptible host-parasite-combinations cultivated in root chambers were examined microscopically. In both combinations, *O. cumana* seeds were induced by the host to germinate. The germtubes of the highly reduced seedlings attached themselves to the host roots. In the susceptible interaction, *O. cumana* penetrated the host root and formed a tubercle, which developed into a shoot. In the resistant interaction, the development of *O. cumana* stopped after attachment to the host root. Semi-thin sections of *O. cumana* seedlings attached to resistant host roots revealed that penetration stops at the host rhizodermis. There was no resistance reaction of the rhizodermis cells visible with light and fluorescence microscopy. This suggests rather a biochemical than an anatomically based type of resistance. A possible explanation for this phenomenon could be the presence of inhibitors for enzymes of the parasite that degrade middle lamellae and cell walls of host cells, thus preventing the parasite from penetrating host root tissue. Further studies to unravel the biochemical and molecular mechanisms in this resistance will guide breeding to improve sunflower germplasm and to secure crop yield.

Keywords: Broomrape, *Helianthus annuus*, microscopy, *Orobanche cumana*, resistance, sunflower

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Additive and Synergistic Interaction Amongst *Orius laevigatus*, Entomopathogens and Neem for Western Flower Thrips Control

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There is a global tendency towards reducing the use of synthetic pesticides because of the associated problems of resistance, environmental contamination, adverse effect on non-target organisms and demand for pesticide-free foods. This has stimulated the search for novel and diverse control strategies as in the case of western flower thrips (WFT), a deleterious pest in several horticultural crops. However, when WFT occurs in high densities and continuously, use of a single biocontrol agent may not ensure fast and reliable control. The use of soft selective biopesticide for fast knock down effects in combination with slow reacting but persistent biocontrol agents may be a sustainable solution. Moreover targeting specifically foliage and soil dwelling life stages may enhance control efficacy. Hence, this study evaluated the interaction among the foliage-dwelling predator *Orius laevigatus*, and soil applied entomopathogens and neem for the control of WFT. The predator *Orius laevigatus* (Fieber) Re-natur was introduced at different rates and also targeted different life stages of WFT. Commercially available biocontrol products evaluated for soil treatment were *Steinernema carpocapsae* (Weiser) Nemastar®, and a non commercial isolate of *Metarhizium anisopliae* (Metschnikoff) Sorokin ICIPE-69 and Neem Azal-T solution. Interactions among the treatments were mostly additive except of two (Orius + Neem and Orius + *M. anisopliae* ICIPE-69 + *Steinernema carpocapsae*) showing synergistic responses. Efficacy against WFT was significantly improved when the treatments were combined achieving, 83–97 % reduction in WFT emergence, compared to single treatments resulting in reductions of 45–74 %. Significant differences were observed between efficacy of Orius and *M. anisopliae* ICIPE-69 as well as among combinations with Orius and other combinations. Adding secondary mortality due to mycosis for the fungi based treatments total effects of 93–99.6 % reduction in survivals were recorded. The combined use of the foliage dwelling predator and the soil application of Neem Azal-T and the entomopathogens may be the most promising measures to increase the efficacy and reliability of biocontrolling WFT.

Keywords: Additivity, Azadirachtin, biorationals, *Frankliniella occidentalis*, *Orius laevigatus*, synergism

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Assessment of Level, Extent and Factors Influencing *Striga* Infestation of Maize in the Dry Savannahs of Nigeria

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Infestation of maize fields by *Striga* species constitute a major constraint to crop productivity in the savannahs of northern Nigeria. About 50 million ha out of about 93 million ha, have been reported to be already moderately or severely infested in the country leading to severe crop losses. In order to develop effective *Striga* management strategies, the relationships between *Striga* levels and other biophysical characteristics of the crop production environment need to be properly understood. This study assessed level and extent of infestation of maize fields by *Striga* in Bauchi and Kano States of the Nigerian dry savannahs. It also assessed the relationship between soil properties, *Striga* infestation and the yields of maize. A three-stage sampling technique was used to select communities and fields in targeted Local Government Areas in the two States.

The soils in the two States were generally of low fertility, characterised by low levels of total N, organic C, available P and exchangeable bases. In Kano State, *Striga* incidence ranged from 0 to 100 %. One hundred percent of the maize fields sampled in Bauchi State had Striga. In general, *Striga* population was more than twice higher in Bauchi State [3.1 plants m^{-2}] than in Kano State [1.4 plants m^{-2}]. There were differences in *Striga* population and severity of attacks between the States and between communities within States. In Kano State, the *Striga* population was negatively related to latitude, total N, and exchangeable K and was positively related to sand and silt. In Bauchi State, *Striga* was negatively related to clay, exchangeable K, and Ca, and was positively related to pH and latitude. In both states, the *Striga* population was negatively correlated with maize grain yield. Up to 75 % of the variations in maize grain yield in Kano State could be explained by *Striga* population and soil organic C. Management of *Striga* usually requires several measures, however, improving the levels of soil fertility should be the central component of any integrated *Striga* management approach.

Keywords: Grain yield, maize, soil parameters, *Striga*

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Effects of some Bio-Insecticide against *Tuta absoluta* (Meyrick) in Tomato Fields

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Tomato leaf miner, *Tuta absoluta* (Meyrick), is a very devastating leaf mining moth with a strong preference for tomatoes. The pest is considered the major pest that attacks tomato in many countries. Chemical control is still most frequently used practice to control *T. absoluta*. Integrated plant protection programs including bio-pesticide application are developed for successful control of the pest. Short and long term effects of some bio-insecticide, *Bacillus thuringiensis* (strain Krustaki), Azadirachtin, and mix of *B. thuringiensis* and Azadirachtin, against *T. absoluta* were evaluated and their efficacies were compared with a current chemical insecticide, indoxacarb, and a control without insecticide. All trials were performed in a tomato field and used a randomised complete block design with four replicates. The degree of control was estimated by the larvae number and fruit damage. Sampling to determine of *T. absoluta* density in each treatment, was performed 1, 5, 8, 14 and 19 days after treatment (DAT). Results showed that all pesticides had no significant effect on *T. absoluta* 1DAT. Bio-pesticides and indoxacarb had significant effect on 5DAT but indoxacarb effect on the pest reduced 8DAT. The bio- pesticides, *B. thuringiensis*, Azadirachtin and mix of *B. thuringiensis* and Azadirachtin, remained effective until last sampling date. Results indicate a reduction in fruit damage for indoxacarb treatment 1DAT but it was increased in the next days. In all insecticide treatments, fruit damage decreased at 5DAT. A reduction in fruit damage was accured between 0 % to 2 % for the mix of *B. thuringiensis* and Azadirachtin applications in 9, 14 and 19 DAT. So, *B. thuringiensis* and Azadirachtin mixture is strongly recommended to control of *T. absoluta* in tomato field because of their long term protection and low side effects on non-target organisms.

Keywords: Biopesticides, chemical insecticide, tomato leaf miner

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Fertiliser and Water Regime Influence Preference of *Solanum scabrum* (Solanaceae) by Tomato Red Spider Mite

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Fertiliser and water supply are important agronomic practices in crop production that have profound impact on plant quality and may influence host selection by herbivorous arthropods. According to the preference–performance hypothesis adults should prefer traits that maximise fitness, i.e. provide best performance for offspring. One of the most serious pests, the tomato red spider mite, *Tetranychus evansi* (Acari: Tetranychidae) is an invasive pest in Africa that causes severe damage to solanaceous plants including African nightshades, i.e. economically and nutritionally important indigenous leafy vegetables. In the context of the HORTINLEA project (www.hortinlea.org) effects of fertiliser and water supply to African nightshades, *Solanum scabrum* var. Olevolosi, on host plant preference by the tomato red spider mite were investigated in laboratory and greenhouse experiments with the aim to develop integrated pest management of African leafy vegetables. A petri-dish assay with leaf discs obtained from plants receiving different fertiliser and water treatment combinations was used. The fertiliser treatments were full (1), 1/2 and 1/4 strength concentration of Hoagland nutrient solution and watering regimes at 40, 60, and 80 % field capacity. Greenhouse experiments were laid out as a complete block design with plants receiving six different fertiliser rates positioned on a circle (1 m diameter) with a donor plant placed at the centre. Laboratory bioassays showed that *T. evansi* preferred leaf discs supplied with high rates of fertiliser and water. In greenhouse studies, mites on nightshade plants treated with full strength of the nutrient solution were 5 times more than the other treatments. The indication that *T. evansi* prefers plants that are highly nourished suggests implications for management of water and fertiliser against this pest in smallholder vegetable farming systems in Africa.

Keywords: Host selection, leafy vegetables, plant nutrition, *Tetranychus evansi*

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A First Survey on Plant Virus Infections of African Nightshade from Small Farms in Kenya

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A first survey on plant viruses in African nightshade was carried out in small farms of western Kenya. Food security and income generation of subsistence and semi-commercial farmers in African countries is one of the world´s key challenges. In this context, diverse abiotic and biotic stresses affect the productivity of protein-, fat- or vitamin-packed vegetables. Among biotic factors, viral diseases of vegetables gain considerable negative economic impact by compromising plant health, thereby affecting both yield and quality. In developing countries farming practices are usually smaller in scale and of lower input cost. Traditional growing of self-produced seeds, often due to inaccessibility of certified seed, and also growing of traditional, unimproved varieties increases the risk of infection. Virus disease management measures available are often poorly adapted to technological and educational standards of local agriculture. Concerted efforts to develop a sustainable integrated pest and disease management are therefore of high priority, furthering the sustainable production of healthy vegetables. Detection of viral pathogens at initial stages of infection is a critical element in local disease management. Furthermore, routine diagnostics are important tools in large scale virus testing and also in the production of virus-free planting and propagation material. The objective of this study is to get an overview on the potential incidence of virus infections in African nightshade. In this regard different farms in Kenya were surveyed for visual inspection of their Nightshade crops in Uasin Gishu, Bungoma and Kakamega counties which are the major African nightshade producing areas in Kenya. Fresh material of indigenous/traditional African nightshade varieties (*Solanum scabrum*, *Solanum villosum*, *Solanum nigrum*, and *Solanum americanum*) as well as self-produced seeds were taken and investigated. Laboratory analyses to identify viral pathogens in African nightshade comprise mechanical transmission to different indicator plant species and ELISA techniques to test for putative infections with Cucumber mosaic virus (CMV), Tobacco mosaic virus, Tomato mosaic virus, Tomato spotted wilt virus, Tomato yellow leaf curl virus, and potyviruses, known to be economically important pathogens of a wide range of crops in Africa. Results indicated towards CMV and potyviruses occurring in single or mixed infections in African nightshade.

Keywords: African nightshade, Kenya, plant viruses

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Virus Indexing of Cassava – Developing Standardised Serological Methods for Field Diagnosis

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Cassava is an important staple crop in Africa and it is particularly vulnerable to pest attacks and diseases. The most serious cassava diseases are caused by viruses and those causing the Cassava mosaic virus diseases (CMD) are found wherever cassava is grown on the continent. More recently, Cassava brown streak virus (CBSV) has emerged in East Africa and because of its current spread it poses a potential threat to Central and West Africa.

Early disease diagnosis is most significant for disease prevention and control; to produce and disseminate clean planting materials only and to prevent spreading viruses to new areas. For virus detection under field conditions, serological tests are most fit for the purpose and to this effect, serological reagents for cassava virus detection were developed at the DSMZ Plant Virus Department. Antisera and monoclonal antibodies were produced and triple antibody sandwich enzyme-linked immunosorbent assay (TAS-ELISA) protocols were optimised and protocols established. Using these tests it was possible to detect and differentiate between African cassava mosaic virus (ACMV) and East African cassava mosaic virus (EACMV) and the species causing brown streak diseases in cassava, Cassava brown streak virus (CBSV) and Uganda Cassava brown streak virus. To determine the best materials for virus testing, virus distribution and quantity of ACMV and CBSV was assessed in naturally infected cassava plants by testing leaves for presence and quantity of virus. To elucidate the correlation between symptoms and virus titre, leaf samples with and without symptoms were collected from greenhouse-grown cassava to detect and quantify ACMV using TAS- ELISA; CBSV and UCBSV using TAS- ELISA and quantitative PCR. ACMV was present in the youngest symptomatic leaf tissues while CBSV and UCBSV were better detected in middle and older symptomatic leaves. Virus accumulation differed and depended on the genotype of cassava. In summary, we have developed serological assays for detection of mosaic and brown streak viruses infecting cassava which is a first step in the standardisation of methods to support decision making in nurseries, plant clinics and quarantine stations.

Keywords: Cassava, cassava brown streak virus, cassava mosaic virus, quantitative RT-PCR, TAS-ELISA

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First Report of Natural Infection by Cassava Polero-Like Virus (Family: Luteoviridae) of Cassava in Colombia

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Cassava (*Manihot esculenta* Crantz) production in Colombia can be severely affected by a complex of viruses. Among these, the ubiquitous presence of cassava polero-like virus (CsPLV; Family Luteoviridae; tentative genus *Polerovirus*) suggests the potential of aphids as virus vectors in cassava, since all known members of the family Luteoviridae are transmitted by this type of insects. To ascertain whether CsPLV can be acquired naturally, a total of 270 virus-free cassava plants of two different genotypes (CM4919–1 and CM6740) were planted in two important cassava growing regions in Colombia during 2014: Sucre (North Coast) and Valle del Cauca (South/Center). Another 28 plants were kept in an insect-proof greenhouse at the International Center for Tropical Agriculture (CIAT). Four months after planting, total RNA was extracted from leaf samples and CsPLV was detected by RT-PCR. Forty eight percent (48 %) of the material planted in the field became infected and the expected 1140 bp PCR amplicon that encompasses the 3' end of P2 (Replicase), an inter-genomic region and the 5'end of P3 (coat protein) and P4 (tentative MP-VPg) was cloned and sequenced. Nucleotide sequence analysis showed that isolates collected in this work have 93–96 % identity to previously reported CsPLV isolates and form a separate phylogenetic group (Accession Nrs: KC505249.1). Furthermore, the virus-free cassava plants taken to Sucre and Valle del Cauca became infected by distinct phylogenetic groups of CsPLV isolates whose sequences indicated geographically independent infection events. Additionally, none of the control plants maintained in the insect-proof greenhouse developed CsPLV infection. These results together, indicate that horizontal transmission of CsPLV happens in the field at a significant rate that is comparable to rates reported for other Luteoviruses. The identification of the vector(s) needs further investigation. This is the first report of natural infection of cassava by CsPLV. The high incidence and early infection of CsPLV may contribute to the accumulation of mixed virus infections leading to significant cassava yield losses in the region.

Keywords: Cassava, epidemiology, natural intection, virus

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Survey for Pest and Natural Enemies of Amaranth and African Nightshades in Kenya and Tanzania

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In the context of the HORTINLEA project (www.hortinlea.org) baseline survey activities were conducted to identify the diversity, distribution, incidence, and damage of arthropod pests and natural enemies infesting leafy indigenous vegetables, i.e. amaranth and African nightshades in 289 farms (15 counties) in Kenya and 209 farms (16 districts) in Tanzania for two rainy seasons of the year 2014. The survey findings were important in identification of the key pests that to be addressed and the potential natural enemies that could be used for their management. Visual examination of the plants, shaking and beating, sweeping as well as destructive samplings were carried out. For leafy amaranth, lepidopteran defoliators (*Spoladea recurvalis*, *Spodoptera sp.)*, stem weevils (*Hypolixus sp.)*, aphids (*Aphis gossypii*, *Myzus persicae)* and stink bugs (Coreidae and Pentatomidae) were the major pests, accounting for 1.9 %, 12.6 %, 25.1 %, and 4.6 % respectively of all the pests collected for instance in Kenya. In both countries, aphids (*Aphis sp.*, *Myzus persicae*), flea beetles (*Phyllotreta sp.*, *Epitrix sp.*), and spidermites (*Tetranychus sp.*) were the major pests on African nightshades accounting for 15.0 %, 5.7 % and 58.8 % respectively for the Kenya survey. Natural enemies were frequently recorded in both seasons. Most important predacious species were ladybird beetles, Orius bugs and *Phytoseiulus spp.*, while parasitoid species belonged mainly to the Braconidae family. Generally higher pest pressure and natural enemy (8666 individuals) abundance was obtained in the long rain season as compared to the short rain season (2356 individuals) in Kenya from the two crops. However, lepidopteran defoliators were more abundant in the short rainy season (143) than in the long one (75) in Kenya. Moreover, in Tanzania, more stem weevils (135) were recorded in short rain season compared to the long rains season (22). Higher abundance of flea beetles (166) was observed in the high altitude region of Tanzania as compare to the low altitude (23). This study reveals that aphids, beetles, lepidopteran defoliators, and spidermites are key pests in production of leafy amaranth and African nightshades. The population dynamics, infection pathways, and profiling of viruses transmitted by aphids on African nightshades are being studied.

Keywords: African indigenous vegetables, Aphids, Lepidopteran defoliators, parasitoids, predators, spider mites, stem weevil

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The Importance of Alternative Host Plants as a Source of Infestation in Kenyan French Bean Production Areas

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Western flower thrips (*Frankliniella occidentalis* Pergande 1895) (WFT) is an invasive species that rapidly developed to one of the most important pests of French beans (*Phaseolus vulgaris* L.) in Kenya. Within the context of the BMZ (Federal Ministry for Economic Cooperation and Development, Germany) funded project "Implementation of integrated thrips and tospovirus management strategies in small-holder vegetable cropping systems of Eastern Africa" the importance of alternative host plants for western flower thrips populations, its crop colonisation patterns, and seasonal abundance of WFT within cultivation areas was studied. Results from this work revealed huge regional variation of the importance of WFT and indicated an importance of several weed species and intercrops as source of crop infestation.

In the current pilot study we wanted to corroborate these results using a molecular approach. Therefore thrips samples were collected by hand at seven different field sites in important Kenyan French bean growing regions in the provinces Rift valley and Central. Samples were determined and then genotyped with six polymorphic microsatellite markers. We calculated the amount of dispersal (gene flow) between alternative host plants (weeds and intercrops) and crops and between regions, genetic diversity and checked for migrants using assignment tests.

With the limited data set, we already can show that *F. occidentalis* populations show considerable genetic differentiation between host plants which can partly be explained by low dispersal rates and a possible specialisation on different plant species, indicating that alternative host plants are not important as a source for infestations of French beans in these regions. These promising results are a good starting point for further studies on this topic.

Keywords: Dispersal, host plants, microsatellites, *Phaseolus vulgaris*, specialisation, Thripidae, Thysanoptera

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Molecular Characterisation of Root-Knot Nematodes Obtained from African Nightshades in Western Kenya

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African nightshades are in focus of an interdisciplinary and international research project. Root-knot nematodes (RKN) of the genus *Meloidogyne* spp. are polyphagous phytopathogens of global importance infecting the African nightshades. Diagnosis of RKN species is the first step for effective pest management. This study represents the first molecular characterisation of a RKN species from Kenya based on partially sequenced 18S of rDNA cistron. A total of 250 root samples were collected from five agro-ecological zones (AEZs) in Uasin Gishu, Bungoma and Kakamega counties. Polymerase chain reaction (PCR) was used to amplify a specific 1.8 kb sequence of the ribosomal RNA of single females from 22 populations of RKN. Sequencing was performed using six primers and SSU rDNA was amplified as two partially overlapping fragments using three universal (988F, 1096F and 1813F) and one nematode specific primer (1912R). Primer 988F or 1096F was used in combination with primer 1912R. The second fragment was amplified with primers 1813F and 2646R. Preliminary results from 22 RKN isolates subjected to PCR reaction and sequencing revealed that isolates from the study areas were most closely related to *M. javanica, M. incognita, M. ethiopica, M. cruciani, M. arenaria* and *M. hapla*. *Meloidogyne javanica* was identified in Upper midlands (UM)1, UM2 and UM3 agro-ecological zones while *M. arenaria* was found in UM1 and Lower midlands area 1 (LM1). *Meloidogyne incognita* predominantly occurred in UM2, UM3 and UM4 zones while *M. hapla* was found in farms from UM4 and LM1. Both *M. ethiopica* and *M. cruciani* were identified in farms from UM4. The isolates identity to GenBank references ranged from 91 % to 99 % with *M. javanica* and *M. incognita* predorminantly occuring in 80 % of the AEZs, followed by *M. arenaria* and *M. hapla* with 40 % and *M. ethiopica* and *M. cruciani* distributed in UM4. Mixed populations of RKN occurred in a single farm hence causing different unspecific symptoms on AFNS. All the isolates were distantly related to *Coslenchus cancellatus*. These results contribute to the understanding of the variability of RKN species and provide data on the identification of RKN on AFNS lines from Kenya.

Keywords: African nightshades, diagnostics, *Meloidogyne* spp., phylogeny, ribosomal DNA, SSU

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Ex-post Analysis of the Scaling Processes of BXW Control Methods in Rwanda, Uganda and DRC

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Banana Xanthomonas Wilt (BXW) disease has been raging through Eastern and Central Africa since it was first apparent in Uganda in 2001, having spread from Ethiopia. During the years that followed, BXW spread from Uganda through Kenya, Rwanda, Burundi, Tanzania and the (Eastern) Democratic Republic of Congo. The devastation it has caused to the banana crops called for a concerted push to scale control methods to help limit the spread of the disease. Based on the main modes of transmission (tools, animal grazing and insect vector transmission), a control package was drawn up. This package included early male bud removal, disinfecting farm tools, not exchanging planting material, only using disease-free planting material, keeping grazing animals off infected fields, and the removal of BXW infected 'mats'. In the worst case scenario, where BXW infection was too high to control (a threshold of about 14 % was used), it was recommended that the whole field be uprooted. It was also often advised that farmers leave the fields where banana plants were uprooted fallow for at least 6 months. This set of control methods was scaled across the various countries, with varying degrees of success. This research is using a triangulation of research methods (a psycho-behavioural survey with farmers, in-depth interviews with farmers and key stakeholders, and workshops with key stakeholders (including farmers)) to understand the dynamics behind the scaling process. The aim is to identify key mechanisms within the scaling process that have either constrained or facilitated the process, in order to gain insights into scaling processes around the scaling of BXW control methods, as well as wider scaling dynamics. The results of this work will also feed into the current work being done on a new and improved set of BXW control methods.

Keywords: Banana disease control, Banana Xanthomonos Wilt, scaling processes

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Integrated Pest Management: Response of the Beneficial Egg Parasitoid *Trichogramma oleae* (Hymenoptera: Trichogrammidae) to Semiochemicals

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Insecticides are used in agriculture, medicine, industry and the household. The use of insecticides is believed to be one of the major factors behind the increase in agricultural productivity in the 20th century. Nearly all insecticides have the potential to significantly alter ecosystems. Many are toxic to humans and others are concentrated in the food chain. Semiochemicals are very important to the whole world including African countries not only in industry and agricultural production, but also in public health. Semiochemicals help natural enemies locate and recognise their hosts. Therefore, knowledge of the nature of these chemicals and their functional roles is important in the design of programmes that use parasitoids as biological control agents. *Trichogramma* spp. has been found to parasitise egg masses of the lepidopterous insect pests and hence play a great role in reducing the impact of noxious insect pests. The present study was aiming to developed an IPM for lepidopterous olive pests, based on natural enemies and pheromones. The study investigated the kairomonal effect of *Prays oleae*, and *Palpita unionalis* sex pheromone components, frass and scale extracts. Petri dishes were used for the choice test. A filter paper (PS- Whatman 9 cm) was placed at the bottom of the Petri dish. The filter was separated to quadrants. Egg masses of *Sitotroga* eggs were glued in each quadrant. Testing chemicals were applied to each of the two opposite quadrants at a appropriate rate pure solvent was applied to each of the two remaining quadrants. Five wasps, 3 days old, were introduced into the centre of the Petri dish. Wasp movements to the treated and control quadrants was observed at regular times interval. The number of black (parasitized) eggs was recorded after 5 days. The results indicate in general a deterrent action of some Pheromones, especially unsaturated aldehydes. Experiments investigating the influence Extracts of scales and Frass indicated, in general, a neutral and or attractive action. However, the results showed that the effects were dose and persistence dependent.

Keywords: Frass and scales extracts, integrated pest management, pheromones, semiochemicals, *Trichogramma* spp.

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The Incidence of Maize Root Rot in Oman and Exploring the Maize Rizosphere Microbiome from Differentially Managed Fields

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Root rot diseases are considered as the most important factor limiting maize production in Oman. A survey was conducted in six maize growing governorates in Oman: AlBatinah South, AlBatinah North, Muscat, Dhofar, AlDahira and AlDaklyia. Fungi and oomycetes from plant samples were isolated using culture-dependent methods and identified using 16s rRNA sequencing. Additionally, the culture independent approach was used to investigate the rhizosphere microbiome in a field treated with compost and another sprayed with fungicides.

Maize root rot infection was present in all surveyed areas with disease incidence levels ranging from 0 to 35%. This was associated with nine fungal or oomycete species. *Pythium arrhenomanes* and *Fusarium fujikuroi* are new records in Oman. Pathogenicity tests on maize were conducted in the laboratory. *P. arrhenomanes* was the most pathogenic to maize compared to other pathogenic fungi. However, an additive effect of more than one of the other pathogens seems to enhance pathogenicity compared to individual pathogens resulting in effects similar to those of *P. arrhenomanes*.

Large differences were observed in maize disease incidence between two fields with similar environmental conditions but one managed organically with compost amendments and one conventionally without compost. Both farmers had used maize from the same seed source. The abundance of *Trichoderma* species in the maize rhizosphere microbiome in the field treated with compost was considerably higher than in the field sprayed with fungicides. The presence of *Trichoderma* was associated with lower disease incidence and direct antagonism could be observed in the laboratory.

Our findings indicate that more than one pathogen is associated with root rot disease in Oman. Also, results showed that the use of organic compost amendments enhance soil health that was clearly reflected in better plant protection, growth and production.

Keywords: *Fusarium fujikuroi*, maize root rot, *Pythium arrhenomanes*, rhizosphere microbiome

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Control of Immature *Bemisia tabaci* Stages by Natural Enemies on Cassava in Eastern DR Congo

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Cassava is the main food crop in DR Congo and is produced, processed and consumed in all provinces of the country. Nevertheless yield remains low due to multiple factors, of which cassava mosaic disease (CMD) and cassava brown streak disease (CBSD) are among the greatest threats. Resistant varieties are highly effective in controlling CMD, but these varieties, like local landraces, are infested by super-abundant populations of the whitefly vector, *Bemisia tabaci*, and are susceptible to CBSD. In attempting to search for an alternative control method for whiteflies and the viruses they transmit, a survey investigating the impact of native natural enemies on the mortality of younger whitefly stages was conducted from February to April 2010. The survey sites were the Ruzizi Plain, Kabare and, Walungu in SouthKivu; Lwama, Katako, Wamaza and Kalima in Maniema; and Rutshuru and Beni in North Kivu. Cassava fields aged between 3 and 9 months were sampled. Plants bearing whitefly larvae were selected. From the top of the plant, the youngest leaf carrying whitefly pupae and all older leaves were picked, placed in plastic bags and then in a cool box. Using a stereo microscope, we distinguished third and fourth instar larvae, pupae and exuviae. A portion of the leaves carrying parasitized pupae were incubated until hatching occurred. Larvae were recorded as healthy, dead, parasitized or predated. Healthy larval instars were more abundant compared to predated, dead or parasitized instars. Parasitism was the main cause of death with 28.5 % of larvae being parasitised, 7.8 % being dead and 7 % predated. Adults of two genera of aphelinid parasitoids emerged from parasitized whitefly pupae. The most frequent were those from the genus *Encarsia*, followed by *Eretmocerus* individuals. In conclusion, the mortality of whiteflies caused by native natural enemies in cassava fields is low and thus unlikely to reduce the spread and impact of CMD and CBSD. There is likely to be merit, however, in exploring measures that would enhance levels of parasitism, or alternatively identifying and introducing other parasitoid species that are more efficient in controlling cassava *B. tabaci* than the presently occurring species.

Keywords: Biological control, cassava mosaic disease

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Seed Dressing Using Plant Growth-Promoting Rhizobacteria *Bacillus amyloliquefaciens* FZB42 Reduces Aphid's Proliferation in Cotton

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The intensive use of chemical fertilisers leads to soil degeneration and promotes the proliferation of insect pests such as aphids. *Aphis gossypii* (Glov.) is a polyphagous sucking insect which reproduces almost exclusively by parthenogenesis in tropical conditions and has a biological cycle of just 5–6 days, which means it multiplies spectacularly. It is necessary to look for alternative crop fertilisation system enabling reduction of the proliferation of this insect pest. The rhizobacterium *Bacillus amyloliquefaciens* is known as bio-fertiliser. The present work is aimed at assessing the population dynamics of the aphid *Aphis gossypii* Glov. in cotton based on different fertilisation materials, namely: *B. amyloliquefaciens* FZB42 and mineral fertilisers (NPKSB). Three treatments were tested: soaking cotton seeds in the rhizobacterium suspension, application of mineral fertiliser, and control (no fertiliser). To perform this study, cotton plants (Variety H279–1) were grown in 7 L flower pots placed outdoors in the experimental station. The effect of tested fertilisation materials on the populations' dynamics of aphids was assessed in 2 different experiments. For that, we counted the number of aphids on each plant every 3 days.
In general, results showed that the cotton plants fertilised with *B. amyloliquefaciens* FZB 42 attracted significantly fewer aphids compared to those fertilised with NPKSB. At the end of first experiment, aphid mean number per plant was respectively 7.1 ; 22.23 and 72.03 for the control, FZB42 and NPKSB. We suggest conducting trials on this PGPR in field under practical cotton production conditions in West Africa to assess its potentiality as integrated pest management (IPM) component.

Keywords: *Aphis gossypii*, aphids, *Bacillus amyloliquefaciens*, crop protection, PGPR, rhizobacteria

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Efficacy of *Bacillus subtilis* and *Trichoderma asperellum* Against Damping Off in Ethiopian Kale and African Nightshade

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Damping off is a disease of economic importance in vegetable seedling causing losses of up to 100 % in Ethiopian kale and African nightshade. In Kenya this disease is mainly controlled through prophylactic application of synthetic chemical fungicide. Greenhouse studies were carried out to determine the efficacy of two biological control agents, *Bacillus subtilis* BS-01 and *Trichoderma asperellum* T-900 against damping off disease. Sterilised coco peat was inoculated with the *Pythium aphanidermatum* one week before sowing. Seeds coated with the biological control agent at concentration of 10^7 were sown in the *Pythium* spp inoculated media in trays. *B. subtilis*, *T. asperellum* and a combination of the two biological control agents reduced incidence of pre-emergence damping off by at least 30.8 %, 43.9 % and 34.3 % respectively compared to control which had an incidence of up to 60.6 % in African nightshade. The biological control agents similarly resulted to a drop incidence of pre-emergence damping off in Ethiopian kale to a range of 25.2%-31 %. The post-emergence damping off incidence also declined in *B. subtilis* and *T. asperellum* and combination treatments to 24.3 % - 27.1 % in contrast to high incidence in the control of up to 63.8 % for the two vegetables. Single biological control agent treatments were not significantly different from the combination treatment but these treatments were significantly different from control. Therefore utilisation of *Bacillus subtilis* and *Trichoderma asperellum* singly and in combination can provide potential to management strategy for both pre-emergence and post-emergence damping off disease caused by *Pythium aphanidermatum* in Ethiopian mustard and African nightshade.

Keywords: African indigenous vegetables, biological control agents, *Pythium aphanidermatum*

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Preferences of the Aphid Parasitoid *Diaeretiella rapae* (Braconidae) for Different Aphid-Host Plant Combinations

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The cabbage aphid is a damaging pest with increasing importance in many Brassica production areas worldwide. Management of the pest is mainly by use of pesticides. Therefore promotion of biological control agents is a sustainable tool to reduce the indiscriminate employment of agrochemicals. The aphid parasitoid *Diaeretiella rapae* is specialised on the mealy cabbage aphid Brevicoryne brassicae and is always present in the field. Nevertheless its efficiency is frequently too low to maintain the pest below the economic threshold. Hence, it is important to investigate factors related to the host location process of this parasitoid in more detail to improve its use in field.

In order to investigate the preferences of *D. rapae* for different host-plant-systems, a multiple-choice experiment with 12 choices was conducted. Treatments included the interaction of three factors: host plant (broccoli var. Marathon F1, Brussels sprouts var. Hilds Ideal, cauliflower var. Fremont), aphid species (*B. brassicae*, *Myzus persicae*) and aphid population density (8 or 12 aphids per plant). Number of developed mummies was the indicator for preference of the parasitoid. Overall results indicate that D. rapae preferred the host-plant-system on which it was reared, i.e. *B. brassicae* / Brussels sprouts, due to the larval conditioning. However, *D. rapae* frequently accepted also alternative host-plant-systems (i.e. *B. brassicae* / cauliflower and *B. brassicae* / broccoli), which indicates that associative learning, i.e. the acceptance of new host-plant-combinations might play an additional role in the host searching process. Finally there is a trend in the results that wasps select plants with higher host population levels despite the fact that resource limitation never occurred. The results of this study suggest that the host plant species, aphid species and population density significantly influence the efficiency of the parasitoid.

Keywords: Cabbage aphids, *Diaeretiella rapae*, preferences, vegetables materials

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Comparison of Coleoptera and Lepidoptera Response to Insect Control by Radio Frequency Heating

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Insect pests of stored products are a key issue for achieving post-harvest handling of agricultural produce. The use of clean and safe treatments with no chemicals for maintains product quality is competitive in the market. This research aims to gather research involving the use of heat from radio frequency (RF) to control the insect pest. The study consisted of the growth stages of in sects that are resistant to RF. The effect of RF on the number of insects in the progeny was investigated. The appropriate temperatures and time used in eliminating insects. The study found that growth stages of order Coleoptera insect that resistant to RF frequency of 27.12 MHz were pupae and larvae stages. The insects in the order Lepidoptera such as rice moth (*Corcyra cephalonica* (S.)) found that egg stage was resistant to most RF followed by a pupal larva and egg stage, mortality rates were 100 % respectively. The insects in the order Lepidoptera showed the growth stage of eggs and larva that resistant to radio frequency heat treatment. Angoumois grain moth (*Sitotroga cerealella* (O.)) in the pupal stage was strongly resistant to RF followed by egg and larvae stages, respectively. Red flour beetle (*Tribolium castaneum* (H.)) adult stage was resistant to most RF treatments, followed by egg and larval instars and larvae stage respectively The temperature and the treatment duration for completely controlled were varied. The temperatures used for control both families of insects were in the range of 55–74°C with the treatment duration approximately 1 to 3.40 minutes.

Keywords: Coleoptera, heat treatment, insect pest control, Lepidoptera, radio frequency

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Investigations on Pheromone Blend Variation among Geographically Different *Maruca vitrata* Populations

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The larvae of the legume pod borer, *Maruca vitrata* (Lepidoptera: Crambidae), cause severe damage on leguminous crops throughout the tropics. Pest control relies mainly on insecticides but results are not satisfactory because the larvae feed predominantly protected inside of plant organs. Pest monitoring by pheromone lures can help to perform more target-oriented control measures. Previously, (*E,E*)-10,12-hexadecadienal was identified as the major sex pheromone compound of *M. vitrata*, and (*E,E*)-10,12-hexadecadienol and (*E*)-10-hexadecenal were described as minor pheromone components. A blend of these components in a ratio of 100:5:5 attracted males in field trapping experiments in Benin, but not in Taiwan, Thailand, and Vietnam. These findings indicate geographic variation in the sexual communication among *M. vitrata* populations.

We investigated the pheromone composition of insect populations from Thailand, Taiwan, and Vietnam compared to a reference population from Benin. We developed a sensitive gas chromatography – mass spectrometry method using selected ion monitoring to analyse single pheromone gland extractions. In behavioural experiments, we compared responses of male moths from Taiwan and Benin to calling females and pheromone gland extracts of females from both origins.

We confirmed the presence of (*E,E*)-10,12-hexadecadienal and (*E,E*)-10,12-hexadecadienol in all target populations, but surprisingly (*E*)-10-hexadecenal could not be detected in any sample. However, the ratio of (*E,E*)-10,12-hexadecadienal and (*E,E*)-10,12-hexadecadienol did not vary significantly between the different *M. vitrata* pop-

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ulations. Males from Taiwan and Benin were similarly attracted to all pheromone sources.
So far, we did not identify differences in the sexual communication between Asian and African insect populations which explain the low success of synthetic pheromone lures in the field. The research is part of the Project HORTINLEA, funded by the German Federal Ministry of Education and Research and the German Federal Ministry of Economic Cooperation and Development within the framework of the programme GlobE – Global Food Security.

Keywords: Geographic variation, *Maruca vitrata*, sex pheromone

The Physic Nut Plant *Jatropha curcas* (Euphorbiaceae) in Pest Management

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The physic nut tree, *Jatropha curcas* (Euphorbiaceae) is an oil seed plant widely distributed in tropical and subtropical regions. Traditionally, this tree is grown as a natural hedge and used in ethno medicine. Several phytochemicals from this plant are known for their toxic properties against herbivorous insects. In fact, the toxicity of the seed oil is attributed to several phytochemicals including saponins, lectin (curcin), phytates, protease inhibitors, and curcalonic acid; but the main toxic action has been assigned to the Phorbol Esters, a diterpenoid fraction contained in the seed oil. In this study, we tested the insecticidal effects of two different extracts: the Phorbol Ester Enriched Fraction (PEEF) and the essential oil extracted from the seeds (JP-32). The PEEF was tested on the cotton bollworm *Helicoverpa armigera* (Lepidoptera) by mixing the artificial medium with different concentrations. This fraction was also tested on the cabbage root fly *Delia radicum* (Diptera) by soil drench of cabbage plants infested with the eggs of this pest. Also, different concentrations of the essential oil of the seeds (JP-32) were tested on the black bean aphid *Aphis fabae* (Hemiptera) under greenhouse conditions. The results evidenced the insecticidal effect of PEEF on *H. armigera* and show a significant effect at 10 % of PEEF on the survival rate of *D. radicum* compared to the control plants. The essential oil of the seeds shows a concentration-dependent toxicity on *A. fabae* after 5 days. These bioassays allow insight into the biocidal effects of phorbol esters and the opportunities provided by *Jatropha curcas* as an additional measure in pest management.

Keywords: *Aphis fabae*, *Delia radiucm*, *Helicoverpa armigera*, *Jatropha curcas*, mortality, phorbol esters

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Influence of Bacterial Secondary Symbionts (BSS) on *Sitobion avenae* (F.) Mortality and Fecundity Caused by Isolates of *Beauveria bassiana* and *Metarhizium brunneum*

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Symbiotic associations are ubiquitous in nature and have played a vital role in the evolution of life on earth. The importance of bacterial secondary symbionts (BSS) contributing to protection of aphids against their natural enemies is progressively being recognised. Historical evidences reveal that entomopathogenic fungi have played a critical role in insect control and are, therefore, regarded as good candidates for biological control. Here, we explored whether the bacterial secondary symbionts *Hamiltonella defensa* or *Regiella insecticola* provide protection to the wheat aphid (*Sitobion avenae* F.) against different isolates of entomopathogenic fungi *Beauveria bassiana* and *Metarhizium brunneum*. *H. defensa* and *R. insecticola* conferred protection to wheat aphids when exposed to *B. bassiana strains* (Bb1022 and EABb 04/01-Tip) and *M. brunneum* strains (ART 2825 and Bipesco-5) by significantly enhancing their survival as compared to wheat aphids lacking these bacterial secondary symbionts. *M. brunneum* strain Bipesco-5 was found the most lethal to wheat aphid clones lacking the bacterial secondary symbionts as compared to other fungal strains. Fungal strains typically needed five days for successful infection and fungal pathogenicity to wheat aphids without *H. defensa* and *R. insecticola* was much faster as compared to wheat aphids harbouring bacterial symbionts. Bacterial secondary endosymbionts also positively influenced the fecundity of their host wheat aphids as compared to aphids lacking symbionts when treated with the fungal pathogens. Providing protection to their insect hosts is a way for secondary endosymbionts to boost their frequency within host community and has a prominent influence on the evolution of their hosts.

Keywords: Biological control, entomopathogenic fungi, secondary symbionts, sitobion avenae

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Efficacy of Augmentative Release of *Habrobracon hebetor* Say (Hym. Braconidae) for Biological Control of *Helicoverpa armygera* (Lepidoptera: Noctuidae)

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Cotton bollworm, *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae), is a polyphagous pest and major economic threat which causes severe yield losses on a wide variety of agricultural crops, including cotton, chickpea, corn, tomato, eggplant, sorghum, canola, soybeans and groundnuts worldwide. Larvae of *H. armigera* are voracious foliar feeders as early instars and late-instar larvae attack developing seeds, fruits and bolls leading to reductions in yield. A renewed interest has been generated in using integrated management of *H. armigera*, with special emphasis on biological control because of the hazards associated with pesticide use. *Habrobracon hebetor* Say is a valuable biocontrol agent of the larval stage of many important agricultural pests such as the Noctuid and Pyralid moths, including *H. armigera*. Efficacies of augmentative release of *H. hebetor* for biological control of *H. armygera* and the larva parasitism of the pest by *H. hebetor* in tomato fields were evaluated during the cropping season 2011/2012 in Masjed Soleiman, Khuzestan province, Iran. Number of parasite larvae were recorded 1, 4, 9 and 14 days after the release (DAR). In this study, the field parasitism percentage was 34.85 and contributed 73 % to total larval mortality. Results showed that maximum parasitism was occurred 4 DAR and it declines in 9 and 13 DAR. According the research, *H. hebetor* could parasites *H. armigera* till 60 % under field condition. It seems that *H. hebetor* alone is no efficacy potency to control *H. armigera* and must be integrated with a suitable and bio-pesticide. The result of the study could be employed in the IPM programs of *H. armygera* in tomato fields.

Keywords: Bio-control, parasitoid, tomato, tomato fruitworm

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Laboratory Evaluation of *Metarhizium anisopliae* and *Beauveria bassiana* Isolates for the Management of Cowpea Aphid

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Cowpea, *Vigna unguiculata* (L.) Walp, is a popular African indigenous vegetable in the tropics that is grown and consumed widely as a source of proteins, minerals, vitamins, carbohydrates, dietary fibre and as a source of income. It is also used as fodder and in management of soil fertility. Production of cowpea in Africa is low compared to other parts of the world. The cowpea aphid (*Aphis craccivora* Koch) is one of the most damaging pests contributing to a yield loss of up to 100 % if not controlled. The use of synthetic chemicals to manage the pest is a widespread approach among smallholder farmers but this is associated with harmful effects on human, the environment, and non-target organisms. Entomopathogenic fungi are known to attack cowpea aphid in nature but no fungal-based biopesticide have been commercialised in Africa yet, specifically for the management of cowpea aphid. However several commercial products are available in other parts of the world. In the present study 10 isolates of *Metarhizium anisopliae* and *Beauveria bassiana* were evaluated for their pathogenicity against apterous cowpea aphid in an effort to identify and select candidate isolates that could be further developed for the management of *A. craccivora*. Among the isolates tested cumulative mortality varied from 34–88 % at 7 days after treatment with ICIPE 62 incurring the highest mortality of 88 %. The promising isolates will be evaluated under screen house and field conditions to determine their optimal performance. This study demonstrates the potential of this isolate for development as biopesticide for the management of *A. craccivora* on cowpea.

Keywords: *Aphis craccivora*, biopesticide, cowpea, entomopathogenic fungi, pathogenicity

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Assesing Vascular Wilt Disease Progression and Severity in Babaco (*Vasconcellea heilbornii* var. Pentagona Badillo) by Artificial Inoculation under Greenhouse Conditions

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Ecuador is a country known for its biological richness, due to a wide variability of climate from polar to tropical, also it has different ecological zones ranging from desert to tropical rainforest. Thus we have, the vast biodiversity in agricultural crops including his ancestors, makes our country unique offering for growing non-traditional species such as Babaco (*Vasconcellea heilbornii* var. Pentagona Badillo). However, in recent years, our country has suffered a considerable decline in production volumes of Babaco as a result of the disease known as Vascular Wilt Babaco. In our study we assessed the pathogenicity of twelve *Fusarium* spp. isolates from Babaco plants under greenhouse conditions. To this end, an artificial inoculation procedure was devised and applied to 65 Babaco seedlings in a completely randomised experimental design with five replicates. The substrate used for the experiment consisted of soil-sand-peat mixture (2-1-1) and sterilized at 121°C for two hours. Each *Fusarium* spp. culture was inoculated to plants roots by the immersion method. To monitor the progression of the disease, the scale proposed by Veintemilla (2000) was used. Fungus re-isolation in the laboratory was performed to re-confirm that the tissue was in fact colonised by the original strain used in each treatment. All data were statistically analysed by SPSS v.22 IBM, using ANOVA and Tukey tests ($p < 0.05$). Our results revealed that four of the twelve isolates showed a high degree of disease severity (CHA 1 *F. oxysporum*, *F. oxysporum* COC1, REY1 *F. oxysporum* and TUN1 *F. temperatum*) while the rest of clustered on two groups of medium (6 isolates) and low severity (2 isolates). The four highly severe strains are instrumental for molecular studies e.g. mutant generation, fluorescent microscopy of the Fusarium-Babaco pathosystem.

Keywords: Babaco, *Fusarium oxysporum*, isolation, pathogenisity test, roots immersion

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Space - Time Analysis of Forests Attacked by *Dendroctonus mexicanus* (Coleoptera: Curculionidae) in Nuevo Leon, Mexico

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The mexican pine beetle, *Dendroctonus mexicanus* Hopkins (Coleoptera: Curculionidae: Scolytinae), is among the most important agents of ecological disturbance and economic loss in pine forests from South-Eastern United States to Guatemala. It is considered as a polyphagous insect within the *Pinus genus*.

In recent decades, the Mexican pine beetle increased the infested area of *Pinus cembroides* Zucc. forests of southern state of Nuevo Leon, Mexico. To understand the attack behaviour of this bark beetle we implemented a surveillance system in Aramberri, south of the state of Nuevo Leon, Mexico. The monitoring was conducted from October 2008 to October 2012 in 11,693.5 ha of *P. cembroides* forests. The monitoring system included aerial and ground surveillance to detect outbreaks of *D. mexicanus* spots. Every two years the infested area was quantified as well as the topographical characteristics and the direction of the spreading heads. Between October 2008 and October 2012, *D. mexicanus* infested 1428.95 ha of *P. cembroides* forests (12 % of the forest). The number of hectares damaged was down significantly from the beginning of the experiment in 2008 when there were 438.5 ha to the last assessment in 2012 when we found only 74.1 ha attacked. Most infestations were presented at the summits and upper parts of the slopes, the spreading heads had a downward movement. The success of bark beetle populations could also be influenced indirectly by the effects of climate on community associates and host-tree vigour, although little information is available to quantify these relationships.

Keywords: Bark beetle, *Dendroctonus mexicanus*, *Pinus cembroides*, Scolytinae, spatio-temporal

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Bio-Ecology of *Anacridium melanorhodon melanorhodon*, (Orthoptera: Acrididae) on *Acacia senegal* in North Kordofan State, Sudan

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As consequences of changing land-use pattern in some areas of North Kordofan State, Sudan from natural pasture into plantations of *Acacia senegal* the main producer of gum arabic, the tree locust, *Anacridium melanorhodon melanorhodon*, (Orthoptera: Acrididae), which was once considered as sporadic pest in this area, now is considered as a major pest that jeopardised gum arabic production. This study was conducted in *Acacia senegal* plantations 35 km South East of Elobeid city, North Kordofan State during the years 2008–2009. The main objective was to investigate the bio-ecology of the tree locust. Field survey was conducted during study period and observation on the locust were recorded on weekly basis, whereas the laboratory study was conducted in Gum Arabic Research Centre in the University of Kordofan, Sudan. Results revealed that the eggs laid in moist soil during rainy season around mid-July and the estimated average incubation period was 40 days, eggs hatched giving nymphal stages that develop during August and early September, while the last nmphal stage which moult into fledgling adult in late September to October towards the end of the rainy season. The adult getting sexually mature in dry season but gonad restore activity at the onset on the coming rainy season. The correlations of adults and hoppers density showed that, there were variations on density of the nymphs and adults on the trees at different growth of the levels with means (4.71 ± 1.257 & 8.20 ± 0.034) and (0.05 ± 3.636 & 0.31 ± 0.107), respectively, whereas, the means of population structures were started from 0.00 to 14.0783 in 2008, whereas, in 2009 started from 0.00 to 4.8867. The hard and soft of males and females showed that the point of development started from mid-September to October and males were developed earlier than females, in each season. Moreover, insect feds more on the new sprout than the full developed leaves. The results obtained during this study may be of great value for further investigations on the locust bio-ecology and it may unequivocally pave the way for environmentally friendly locust management operations in the future.

Keywords: *Acacia senegal*, *Anacridium melanorhodon melanorhodon*, Gum Arabic Kordofan, locust bio-ecology, Sudan

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Quantifying the Role of Amphibians and Reptiles as Biological Control Agents in Dry Forest Agroecosystems of Northeastern Brazil

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In tropical dry forests of northeastern Brazil (Caatinga) herbivory through arthropods is, next to climatic limitations, one main driver for limited natural food resources in agroforestsystems, where livestock farming is one of the most important perpetual sources of income. A paramount EES is biological pest control by vertebrate predators, in case of tropical dry forests, particularly mostly opportunistic amphibian and reptile predators. Analyses along a land-use gradient showed a negative correlation between herbivory of the two main tree species of the Itaparica reservoir (Pernambuco, Brazil), *Poincianella pyramidalis* and *Aspidosperma pyrifolium* and abundance of amphibian and reptile species. To detect a functional link of the Herpetofauna as biocontrol agents, we analysed arthropod community using different methods (pit-fall traps, Malaise traps, sweeping net and beating net) in combination with diet analyses (stomache flushing of 200 individuals) of the common amphibian and reptile species of the study region. Five major insect orders (Coleoptera, Hemiptera, Isoptera, Lepidoptera and Orthoptera) account for the majority of observed herbivory. Most efficient method for sampling of potential arthropod pest species was the sweeping and beating net. Pit-fall traps showed less number of potential pest species, as the preferred habitat of most arthropod pest species seemed to be in the canopy region. Furthermore, pit-fall traps had a high rate of failures, caused by mammals and extreme climatic events, for which reason it is of uttermost importance to choose the right sampling method to detect potential arthropod pest species. The same insect orders determined for herbivory were also found to represent the largest percentage of prey items retrieved from stomach content samples in monitored amphibians and reptiles. Analyses of quantitative arthropod assessments and dietary indicated that both reptiles and amphibians are significant predators of several potential arthropod pest species. This highlights the important role of the herpetofauna controlling pest species abundances and impacts and therefor providing food resources for livestock in the tropical dry forest system of northeastern Brazil.

Keywords: Amphibians, Caatinga, herbivory, natural food resources, pest-control, reptiles

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Pastoralism and forage systems

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Polarisation in (Post-)Nomadic Resource Use in Eastern Morocco – Insights Using a Multi-Agent Simulation Model

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Mobile pastoral resource use is a well-adapted and successful strategy to ensure food security under scarce and highly fluctuating rainfall conditions. It has been the traditional way of life for a considerable number of people in arid regions. However, in the last decades this land use type has been exposed to change, such as technological, climate or social change. This has led to contrasting patterns of mobility and a change in lifestyle which we also observe in a case study in the Eastern High Plateau, Morocco. Here, a polarisation of pastoralists into two groups has occurred: highly mobile ones with large herds, and those with very low livestock numbers who have almost become sedentary. We are interested in understanding the causes for this polarisation among pastoralists.

However, this land use system is shaped by complex interactions between ecological, social and economic components. Therefore, to understand the impact of change at the local level, feedbacks between these components need to be taken into account. Social-ecological modelling, and in particular agent-based modelling, offers an approach that allows to incorporate these aspects and to analyse the behaviour of the land use system in time and space.

We developed a spatially-explicit agent-based model incorporating the interrelations of vegetation dynamics, herd mobility as well as herd sizes and monetary stocks of the pastoral households.

We investigated whether polarisation arises between two groups of pastoralists. Starting with both groups being homogeneous, we stepwise increased heterogeneity in terms of their mobility costs and resource endowments. The agent-based approach allowed us to explicitly incorporate the interaction of households and their competition on grazing land.

Our results indicate that different initial resource endowments and mobility costs for the pastoralists lead to polarisation only under harsh environmental conditions.

Building on these findings, we discuss the potential of policy instruments to counteract polarisation and increase the livelihood security of pastoralists.

Keywords: Livelihood security, Morocco, pastoralism, social change, social-ecological modelling

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State Policies and Farmers' Acquisition of Rangeland in Northern Benin

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The Republic of Benin strives to become an agricultural power and emerging economy in the medium term. Many reforms were undertaken in various sectors to achieve this vision and numerous partnerships created regionally and internationally. However, the implementation of state policies involves different interpretations that can empower some actors over others in access to natural resources. Through an ethnographic study conducted for ten months in Gogounou district (North Benin), we scrutinized how state policies influence the relationships between grassroots actors who co-use resources. We adopted a political ecology perspective, assuming that ecological changes at the local level are highly correlated with the unbalanced power relations between actors. We also borrowed elements from actor-network theory that uses the concept of "translation" to show how a technology promoted in a given context can acquire meanings that the designers had never imagined. We found that the translation power with regard to different technologies provided through state policies is crucial in the way farmers and pastoralists use and control resources and thus impact on their peaceful interactions. The farmers in Gogounou were able to use herbicides supplied by private businesses for crop production to contest with herders by spraying the chemicals on large cultivated and uncultivated areas. They were also able to use seedlings provided through reforestation and environmental projects to increase their cashew plantations on rangeland, animal corridors and Fulani settlement areas. The farmers of Gogounou could also use the Rural Tenure Plans established in some villages within a context of new land policy to reassert their autochthony over Fulani pastoralists, and thereby challenge the latter's citizenship and claim ownership of local land. These strategies led to forms of farmers' acquisition of rangeland that make it difficult for pastoralism to continue in the region. The future seems increasingly uncertain for the Fulani of northern Benin, who are sometimes forced to migrate to other countries (Togo and Ghana). Our results could help create greater awareness of the ways farmers are giving different meanings to the promoted technologies and could lead to political action that allows more equitable access to local resources for all users.

Keywords: Benin, food security, natural resource management, pastoralism

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Enhancing Livestock Market Access for Sustainable Rangeland Management and Improved Livelihoods in Kenya

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Despite the value of rangelands terrestrial ecosystem services, their stewardship is undermined by various factors leading to considerable rangeland degradation around the world. In Kenya, productivity of rangelands is limited by increasing crop farming especially in more fertile range areas, decoupling formerly intact rangeland landscapes. This encroachment by crop farming on rangelands occurs as a response of the rural livestock producers' to economic opportunities with the development of local and international crop markets. We hypothesise that the existing market inefficiencies characterising livestock markets, especially the price disincentives that livestock producers face, are a major risk rangelands face. Using Narok County as a case study we analyse the effect of livestock market conditions on rangeland management. We draw data from a countrywide comprehensive household survey and economic modelling tools. A stochastic dynamic programming model for livestock systems is developed to analyse the effect of improving livestock market access on rangeland management. A positive mathematical programming (PMP) model is used to assess rangeland allocation decisions under improved market access conditions. Results indicate that market price disincentives among livestock producers' mainly arise from livestock traders' rent seeking behaviour and high transport costs to terminal markets. Linking livestock producers to the end market and adoption of efficient methods of transporting livestock at the prevailing road infrastructure conditions increases the livestock producers' margin by more than 50 percent as a percentage of selling price. Higher producer margins lead to less modifications and conversions of rangeland and higher sales volumes of livestock. The optimal livestock units also increase while the livestock densities are much lower from the base scenario characterised by high exhortations by middlemen and high transportation costs of livestock to terminal markets. Given the strong relationship between responses to economic opportunities, rangeland use decisions and sustainability of the ecosystems, policy implications drawn by this study encourage strategies that increase returns from rangeland uses to ensure the sustenance of the ecosystems.

Keywords: Ecological-economic model, extensive livestock production, Kenya, market access, mathematical programming model, positive

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Competitiveness of Pastoral Livestock Production in Case of Mongolia: application of Policy Analysis Matrix (PAM)

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The aim of this study is to analyse the competitiveness of livestock production in Mongolia and policy effects using Policy Analysis Matrix (PAM). Our research focuses on selected livestock production systems that take into account private and social revenues, costs, and profitability of the production systems. Increasing number of goats causes pastureland degradation or environmental pressure exceeding grassland carrying capacity (Social Cost), which is due to eating habit of the cashmere goats. A single reason for growing more goat than other type of livestock is cashmere for cash income (Private Revenue) among herder community. However, there is minor studies touched upon an issue of comparison of profitability of livestock products in private and social perspectives and policy impacts in two senses: 1) nomadic pastoral livestock production system, in case of Mongolia; 2) disaggregated primary data for each herder households, which is not common in PAM studies as traditional PAM requires aggregated secondary data. Latter point is considered to be methodological contribution of the study to similar type of studies. We interviewed 197 herder households in Bulgan Soum, Khovd province of Mongolia in summer 2012, and analysed meat, milk, skin/hides of five types of livestock, including goat, sheep, cattle, horse and camel, and goat cashmere, wool of sheep and camel. Cost estimation is done for multi-products of livestock under an assumption that share of each product in total revenue is equal to share of cost for that product. The goat is socially not profitable livestock, but privately it is comparing to the other four types of livestock.

Keywords: Competitiveness of livestock production in Mongolia, cost of land, domestic factor, efficiency, pastoral livestock production, pastoral nomadic livelihood, private and social cost, profitability, social and private profit of livestock products

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Can Intercropping Food Crops into Perennial Pasture Improve Water Use Efficiency, Risk Profile and Sustainability of Degraded Dryland Systems?

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Population growth in sub-Saharan Africa (SSA) and drought demands an increased agricultural productivity and precipitation use efficiency (PUE). Till recently increased productivity has been achieved through the expansion of cropping areas into rangelands and overstocking. This has degraded 65 % of the arable and 30 % of the grazing land thus reducing PUE. Rainfed semi-arid agropastoral communities are particularly vulnerable. Climate change further threatens the PUE and risk of such systems. In response to these challenges a food crop-perennial pasture intercropping (PI) approach was tested under dryland field conditions at the University of Pretoria, South Africa. The primary objective was to assess the PUE and risk reduction qualities of such a system. Various crops (*Sorghum bicolor* = S, *Vigna unguiculata* = C, *Vigna radiata* = M, *Lablab purpureus* = L) and established *Eragrostis cervula* (P) were assessed as a monocrop (MC) and intercrop (PI) within the established P. PI with C (PIC) was tested over two seasons (2013, 2014). All treatments were rain-fed nutrient non-limiting trials. Crop growth parameters, soil texture and moisture measurements and meteorological data were measured for MC and PIC. Season 1 and 2 received 685 mm and 211 mm of rain respectively. When comparing PI between legumes and cereals, only PIC (3.5 t ha^{-1}) was advantageous with an LER = 1.4. Legume screening for PI found L (1.2 t ha^{-1}) suffered the lowest yield penalty. Overall PIC showed an 81 % (4.23 t ha^{-1}) and 279 % (3.86 t ha^{-1}) total DM yield advantage in season 1 and 2 respectively. Conversely C showed a higher yield penalty in the drier season 2 of 72 % (1 t ha^{-1}) versus 34 % (1.79 t ha^{-1}). There was a 81 % (6.24 kg mm^{-1} ha^{-1}) and 306 % (15.46 kg mm^{-1} ha^{-1}) PUE advantage with PI over season 1 and 2. Adding the P forage before planting, the total DM yield advantage was 138 % (7.23 t ha^{-1}) and 519 % (6.86 t ha^{-1}) higher than their respective C monocrops single harvest. PI is ideal for livestock oriented system with significant PUE and forage advantages in a dry season, however the food crop suffers severe yield penalties under drier conditions.

Keywords: Dryland, pasture cropping, precipitation use efficiency

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Effects of Clipping and Irrigation on Grass Carbon Allocation: Implications for Rangeland Management and Food Security

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Predicting whether rangeland grasses have the potential to mitigate increasing atmospheric CO_2 requires understanding how individual grass responds to major rangeland stressors, herbivory and drought. Yet, achieving such understanding has been hampered by the difficulty of quantifying grass below-ground C pools, and little experimental research has been conducted on this aspect.

We estimated above and belowground carbon production in two native grassland species (*Chloris gayana* and *Cenchrus ciliaris*) in mature stands, along with a corresponding pot and plot experiment using seedlings of the same two species in Borana rangelands, southern Ethiopia. We simulated grazing by clipping at different frequencies, and also simulated climate change in the pot and plot experiments by increasing precipitation by 5 % and also decreasing precipitation by 30 %.

Results of our study indicated that when we applied clipping as a single factor, aboveground grass organic carbon (agOC) was significantly higher in the unclipped compared to clipped grass tufts in both *Chloris gayana* ($p = 0.0001$) and *Cenchrus ciliaris* ($p < 0.0001$); on the other hand, below-ground grass organic carbon (bgOC) was significantly higher ($p = 0.0303$) in clipped tufts than in unclipped ones. When we applied two factors combined (clipping frequency and irrigation amount), both factors significantly influenced agOC and we found higher agOC and bgOC in clipped than in unclipped treatments; limited irrigation (30 % decrease of average annual rainfall), however, resulted in significantly lower agOC and bgOC. Interactions between the two factors were observed only in the pot experiment of *C. gayana* affecting bgOC.

Our study indicated that both grazing frequency and rainfall amount significantly influenced grass C allocation potentials. This implies that unless appropriate grazing management is in place, the potential of grasses to sequester C and store it in biomass and soil will be greatly limited by existing herbivore pressure and high variability of rainfall amount in the course of climate change; soil C sequestration is a versatile strategy as it restores degraded soils, enhances land productivity (improve food security), improves biodiversity and mitigates climate change.

Keywords: Carbon, carbon dioxide, climate change, clipping, food security, grazing, herbivory, irrigation, rainfall amount

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Observations on Adaptability and Grazing Behaviour of Camels (*Camelus dromedarius*) Reared at Different Production Systems in Sudan

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The adaptability and observations about camel's behaviour during grazing and browsing were observed during wet summer season in two different production systems (traditional nomadic and semi-intensive system) in three states of Sudan (Khartoum, Gezira and Sennar) from July to August 2013. A total number of 3501 of apparently healthy native Arabian camel of different ecotypes (Kenani, Butani and Nefidia) at different ages were used in this study. Camels in the traditional nomadic system were observed to choose plant, while under the semi-intensive system camels were kept in pens and fed concentrates and green fodder. Observations on grazing, standing, and walking time were done with a 12 hours interval during 3 to 9 days. During the wet summer season, the average time spent on grazing, standing, or walking for Nefidia and Butana camels were found to be 9.8 and 10 hours/day, respectively and the rest of day time were ruminating or sleeping. There are significant differences between the semi-intensive system and the traditional nomadic systems in adaptability and grazing behaviour of camels under the nomadic system due to their environmental and anatomical adaptations. The study concluded that the differences in adaptability and observations on grazing behaviour of camels in the different production systems will have an impact on the performance of the camel under different management systems.

Keywords: Adaptability, camels, grazing behaviour, production systems, Sudan

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Informal Institutions and Climate Change Adaptation among Indigenous Communities of Southern Ethiopia

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Climate induced livelihood transitions are increasingly likely in the pastoral land use system of Ethiopia. Even though considerable progress has been made in understanding household's adaptation to impacts of climate change, there is a limited knowledge on what explains indigenous pastoral community's adaptation. The presentation highlights National Adaptation Program of Action in the context of pastoralism and development policies of Ethiopian government, by comparing against adaptation actions of the indigenous pastoral communities. Navigating through these adaptation options and corresponding theories, we show how informal institutions shape adaptation of the indigenes in the face of unfavorable interventions.

Using multistage sampling procedure, the empirical data was collected through Participatory Rural Appraisal techniques between February-April 2015 in Hamer district to understand the mechanisms how informal institutions shape adaptation. Consulting on the theories of indigenous communities' adaptation, institutions, transaction cost, and the empirical data, culturally viable adaptation practices and challenges were identified. Choice of adaptation option is shaped by local norms, previous experience, affordability and sustainability of the actions. Households purposes of production and adjustment to the climate variability is highly influenced by traditional rites of passage the community performs.

Many stakeholders and different approaches have been tried to build adaptive capacity of the communities. However, there lays a mismatch between the 'settlement/farming oriented', market based adaptation approaches, and the norms of the community that historically allowed the community to survive. The contradictions, besides wasting efforts, are leaving the pastoral communities with a short term, survival oriented, and costly reactive actions prompted by lack of fitting alternatives. In conclusion, the pro-farming development approach of the government and its partners, which seldom consider most binding traditional institutions of indigenous communities', are leaving efforts of the indigenes to ending up in maladaptation.

Keywords: Adaptation, climate change, indigenous communities, institutions, pastoralism

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The Impact of Health Extension (HES) on Health Care Practices of Pastoral Households in Ethiopia

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Ethiopia's health care policy aims at accelerating the expansion of primary health coverage through a comprehensive Health Extension Service (HES) as one of the most effective framework to achieve the MDGs. Disease prevention and control, family health, hygiene and environmental sanitation, and health education are focus areas of the HES which is implemented through recruitment and training of Health Extension Workers(HEWs) who are expected to devote 50 to 75 % of their time to household and community outreach services on raising awareness of communities on reproductive health, maternal and child care and sanitation. However, it is not yet clear how these interventions are successful in shaping the maternal and sexual behaviours of rural households in pastoral areas where access to health service, social institutions and basic infrastructure are very limited. In this paper, we applied propensity score matching and double difference analysis on two period panel data collected from Afar region of Ethiopia to estimate the average treatment effect on the treated (ATET) of the health output and outcome indicators in the HEW intervention and non-intervention localities. Empirical findings from propensity score matching model and double difference models seem to confirm that families living in the health extension intervention areas have better awareness of HIV transmission ways, safe sex practices, and importance of child delivery at health facilities. The results further showed that mothers in the treated areas are more likely to follow child immunisation programs compared to areas not reached by the HEWs. Similar results were obtained from our analysis on sanitation and hygiene output and outcome indicators. The research provided some useful insights on how the HES currently being implemented through trained HEWs is helping to improve maternal and child health outcomes as well as sanitation and environmental health outcomes in pastoral areas of Ethiopia.

Keywords: Health extension service, health extension workers, maternal and child health, sanitation and environmental health, sexual and reproductive health

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Institutional Tools for Sustainable Natural Resources Management and Protection of Pastoral Mobility in Niger

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The combination of population growth, decreasing soil fertility, and climate change are challenging food security in the Sahel, and are driving changes in land use patterns. Agricultural cultivation is increasingly infringing onto pasture previously reserved for pastoralism. This increased competition for land is a growing source of tension and conflict between farming and pastoral communities. It is further exacerbated by a multitude of competing parallel land tenure systems: traditional rights, Islamic law and modern law. However mobility remains a key factor for pastoral livelihoods, enabling a rational use of natural resources in semi-arid and arid conditions, where rainfall is both spatially and temporally unpredictable.

Niger's "Code Rural" is a tool for sustainable natural resources management. Established in 1993 it consists of both (i) a juridical provision with legislative and regulatory texts, and (ii) an institutional provision with local and national structures to apply and oversee these rules.

The Code Rural's sectoral pastoral law of 2010 recognises and protects the mobility of pastoralists as a fundamental right. A north-south border exists: the north is a purely pastoral zone where solely collective land rights are recognised; in the south, pastoral corridors and pastoral zones are clearly defined in order to protect mobility. Furthermore, water is defined as a public good and, throughout the country, herds cannot be denied access to a water point.

The institutions foreseen under the Code Rural (Commissions Foncières) are its true innovation. Two key features underlie the approach. Firstly, the Commissions Foncières are decentralised institutions for land management working bottom up from the village, to the communal, regional and national levels. Thus decision-making is adapted to local specificities. Secondly, they are multi-stakeholder, composed of representatives from state structures, local elected officials, traditional authorities and representatives of farmer and pastoralist organisations. They focus on consensus-building and recognise traditional land rights.

Keywords: Food security, land rights, natural ressource management, pastoralism

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Market Integration and Food Security in the Moroccan Mountains

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In the High Atlas mountains of Morocco, the largely self-sufficient agro-pastoral economy of the past is all but gone. Most families have abandoned cereal farming and transhumant livestock breeding over the past three decades in favour of market-oriented fruit production, activities in mountain tourism, and various types of wage labour in the region and beyond. As a result, locals today sell the fruits of their agricultural production or their labour force in order to provide their families with food.

Based on a large-scale household survey and ongoing empirical research we have carried out in the High Atlas municipality of Asni, this paper addresses these profound shifts in the local production system and discusses their consequences on food security. Specifically, we ask under what circumstances these developments have the potential to increase food security for the local population.

Undoubtedly, cash incomes and better access to ever-expanding basic infrastructure have improved living conditions, health indicators, and educational opportunities for many families in the area. However, their access to markets remains asymmetrical and has thus introduced new risks and vulnerabilities. Four examples illustrate this: first, the market price for apples dropped substantially in 2014/15 and although the harvest was good, warehouses in Asni were still full with last year's crop which had not sold as expected. Second, the number of tourists who bring cash to the mountains is directly linked to the perceived security situation in other parts of North Africa. Third, the purchase price of imported staple foods needed by the families is subject to financial flows and political decisions which are increasingly made in remote locations. And fourth, social institutions of mutual aid and solidarity within the villages have been weakened along with the decline of traditional forms of land use.

Therefore, we argue that the main threat to food security in this region today is the unreliability of cash income caused by the farmers' dependence on global markets, rather than climate risks or ecological constraints. As a reversal of market integration is not an option, state agencies and international organisations should assume more responsibility in buffering these new income risks.

Keywords: Food security, markets, Morocco, mountains, pastoralism, social geography

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Analysis of Stratified-Livestock Production Models as Option for Enhancing Cattle Marketing in Pastoral Areas, Kenya

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Livestock marketing in pastoral areas is often characterised by low and fluctuating prices, and weak access to high-value markets, thus perpetuating food and income insecurities among pastoral households. Improved livestock marketing is hence considered imperative for poverty alleviation and socio-economic development. Previous marketing interventions including introduction of group ranching, commercial destocking and support for collective actions have either failed or lack sustainability. Alternative livestock marketing approach is now emerging in Kenya, which involves bringing lean animals produced in pastoral areas to areas of comparative feed advantage for the purpose of fattening and accessing high-value markets. Such arrangement of livestock production into separate stages is term as stratified livestock-production in the context of this study. However, whether stratified livestock-production have potential to enhancing cattle marketing in pastoral areas is seldom investigated. Using interviews of key informants and analysis of literatures, we characterise existing models of stratified-cattle production and analysed their constraints and opportunities as option for enhancing cattle marketing. We found the models of individual traders and that of ranch-companies in which the breed of Borana cattle is often purchased from pastoral areas and managed by providing daily watering, weekly dipping or spraying and deworming. Efforts to meet sanitary and phytosanitarty standards through vaccination against foot and mouth disease, anthrax and contagious bovine pleuropneumonia were also observed but largely constrained by informal livestock movements and wildlife-livestock integrations. This create little prospect for reaching export markets but opportunity exist in targeting high-end domestic markets that offer prices based on animal live-weight and level of fat-content achieved.

Keywords: Beef, fattening, high-value markets, pastoralists, ranchers, traders

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Pastoral Landuse Systems and Sustainability in a High-Tech World

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Pastoralism is a landuse system where livestock use natural vegetation in marginal areas that are too dry, too high, too steep or too infertile for cropping. To achieve food security with increasing human population, such non-arable areas where people are accustomed to producing food under unpredictable conditions will become increasingly important.

Many "modern" high-tech interventions supposed to increase production in marginal areas bring only short-term improvements and waste scarce resources like water and nonrenewable resources like fossil fuels and other inputs. A widespread belief in high-tech "solutions" overlooks that animal agriculture is being practised in "problematic" areas by making the most of the natural limitations: making efficient use of vegetation and water with few external inputs to produce high-protein food from plants that humans cannot consume.

The high-tech interventions not only deplete nonrenewable resources; they also destroy pastoralist livelihoods and threaten the future of pastoralism. Donor and government support is given especially for irrigated cropping in lowland valleys: areas that pastoralists need at critical times of the year to be able to maintain their production system and use the drier areas at other times. This breaks a vital link in the annual production cycle.

Investors' interests in short-term gains collide with interests of people who have used the areas for generations and have the knowledge and skills to continue doing so. They have proven to be highly adaptive to change in climatic, economic and political conditions, especially due to their mobility. Yet pastoralism has not remained the same for generations. Pastoralists have embraced modern technologies that improve their production and marketing, using e.g. veterinary drugs; trucks to move animals to pastures or markets; and mobile phones to inform themselves about weather, security and disease conditions along different routes and about markets. Some pastoralists are involved in insurance schemes according to satellite-based assessment of vegetative cover.

We examine evidence of how African pastoralists are adapting to change and explore the question: which forms of modern technology make food production sustainable in the drylands?

Keywords: Food security, landuse, modernisation, natural resource management, nonrenewable resources, pastoralism, sustainability, technology

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Impact of Large-Scale Land Holdings on Fulani Pastoralists' Livelihoods in Agogo Traditional Area of Ghana

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Following growing demand for land in Africa, there is increased land tenure insecurity for minority groups including pastoralists, limited resources for pastoralists, and contestations over access and use of land. The situation intensifies with increasing land value and scarcity as a result of commoditisation, individualisation and commercialisation of land within a new era of 'land grabbing' where there are increased investments in land by bigger agro-companies as well as farmers desire to increase their production. This has many consequences for pastoralists' livelihoods as they have limited access to land and resources for their cattle. This paper examined the impacts of large-scale land holdings on Fulani pastoralists' livelihoods in Agogo, Ghana through comparison of pastoralists land acquisitions and the insecurity thereof on one hand and the large-scale land acquisition of Scanfarms Ltd and two other plantation companies in the area. The study used a case study of Scanfarms Ltd land acquisition and also interviews with farmers, officials of Bunfuom Teak Plantation Ltd, Bernard Kojo Offori Teak Plantation Ltd, Fulani pastoralists, cattle owners, chiefs and officials of the land commission (137 respondents) for the analysis of the paper. The study found that due to perceived 'land grabbing' and the economic value of land, there are increased competitions for land. Small-scale holder farmers, Fulani pastoralists and large-scale companies are scouting for more land run through common property management. These competitions for land by large scale land holding companies and farmers alike have tended to affect pastoralists livelihoods negatively. As the pastoralists continually have limited access to land and crops are grown on pasture lands and paths, there is increased destruction of crops by cattle leading to violent conflicts. Besides, pastoralists face high land tenure insecurity as farmers and land owners seized their leased lands and are reacquired by agro companies which affect resources for pastoralists' cattle. Grazing Lands in areas like Dukusen, Bebome, Abrawapong and Afrisire, hitherto acquired by Fulani pastoralists for their cattle were seized and now turned into farms and plantations making it difficult to get land for grazing pasture.

Keywords: Agogo, Fulani pastoralists, Ghana, impact, large-scale land holdings, livelihoods

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The Social Sustainability of Sheep Pastoralism in Western India: Impacts on Food Security

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In the semi-arid drylands of western India, mobile sheep pastoralism integrated with crop cultivation is practised by the Raika, a caste/community of traditional livestock keepers with a rich body of indigenous knowledge on all aspects of livestock keeping. The system provides multiple benefits with respect to food security, foreign currency earnings (most of the mutton is exported), organic manure and environmental services.

But an increasing number of young Raika abandon the traditional profession and migrate to the cities to find menial jobs. As a result the sheep population is in decline, with impacts on food security and the ecology of the region. In order to better understand their motivations, semi-structured extended interviews were undertaken with 52 Raika youths. 65 % of the interviewed persons responded that the financial returns from shepherding had decreased and that they expected to earn better incomes in the cities. Furthermore, migration was considered as exhausting, lonely and very hard work. Another major distraction is the increasing dissection of the landscape with difficulties accessing grazing areas. The bad image of herders as being dirty, poor and uneducated is another reason why young people aren't willing to stick to their traditional job. Unfortunately most of the young Raikas in the cities fail to reach their goal of earning more money than in their traditional herding profession (63 %).

For the sake of food security, both directly (production of meat and also milk) and indirectly (production of organic manure), it is imperative that societal recognition of sheep pastoralism is improved and the state governments support rather than ignore or disregard mobile shepherding as a food production strategy.

Keywords: Food production strategy, food security, indigenous knowledge, mobile shepherding, pastoralism, Raika, Rajasthan

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Management of Arid Land Use Systems: Critical Review of the Algerian Experience

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Algeria is facing a serious problem of land degradation and desertification due mainly to an inefficient management of steppe ecosystems. The latter is located in Algerian High Plateaus, a key area with pastoral activity, which covers 27 million hectares. This steppe undergoes significant degradation, especially in the eighties. The combination of severe drought, the most important of the century, and an exponential increase in livestock had a huge impact on pastoral resources. The vegetation cover, which was generally greater than 30 % before 1980, is now less than 15 %. Phytomass, which exceeded 1 t ha^{-1} year^{-1} in 1980, is now less than 450 kg ha^{-1} year^{-1}. In response to this deterioration, the Algerian government, from the seventies defined a strategy to manage and land use Algerian systems, according to the main known factors of degradation; an increasing in livestock and crops. It had several technical solutions to manage these systems and we could divide them in three main options. The first was to increase pastoral and agricultural production; the second was to reduce the livestock; the third was to stop or limit the crops in arid areas. In the first approach, agroforestry plantations were performed on 217,549 ha with different species, particularly the genus Atriplex, Medicago and Opuntia. Small hydraulic entities were also built to irrigate 410,000 ha and to increase the planted area. The exclosures were established on 3 million hectares. This fodder production is insufficient to respond to the livestock needs. The second option, reducing the livestock was not retained, because theses areas are dominated by pastoral activity. The third option was quickly, abandoned following pressure unemployed youth. We will discuss the difficulties to establish a strategy when the reality shows that the facts are often in contradiction with the objectives pursued. The result is that the government's strategy is not clear, and sometimes seems at odds with the objectives of the combat against land mismanagement. Worse yet, we will show that in some cases, the Algerian government seems paradoxically to be supporting the steppe degradation.

Keywords: Overgrazing, pastoralism, rangelands, steppe, unemployment

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Pastoralism and Land Management in Niger - The Example of the PASEL Project

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Poor soils are a constant in the Sahel. Soil poverty is at the very core of the precariousness of pastoral resources and is exacerbated by the increasing frequency of cycles of drought. This is certainly one of the reasons why the FAO has declared 2015 the International year of soils. Together with an increasing population growth (eg Niger has one of the highest population growth rates in the world), poor soils induce an increasing pressure on rural land. This affects the potential conflictual relationship between livestock keepers and crop farmers and is a major concern for stakeholders at all levels, civil society organisations, development partners, etc. The phenomenon of land grabbing this already worrying situation and is depriving countries of essential factors of production and thus increasing food insecurity.

The management of sporadic conflicts between "users of the rural space" did not provide effective and definitive answers and conflicts have become increasingly violent. The need to establish a more comprehensive framework becomes more apparent.

In Niger the collaborative development of the "Land Development Scheme (LDS)" and its implementation has become mandatory after the adoption of the Rural Code texts. Despite inconsistencies (in particular in relation to the changing context with the new constitution and the General Code of Local Authorities in 2010), this provision is a valuable opportunity to harmonious and sustainable development and effective prevention of rural conflicts.

The PASEL project (funded by the Swiss Cooperation and implemented by a consortium VSF-B / SNV / CESAO-PRN) supports 3 regions (Dosso, Maradi and Tillaberi) in the development of LDS. The processes are still ongoing but important lessons can already be drawn from this innovative experience in Niger. As the LDS go together with the decentralisation and difficult transfer of power to local authorities, the action highlights such complex issues and challenges that sometimes cause tensions between the stakeholders involved and accompanying structures. Accompanying regional actors has allowed to implement consensual roadmaps with success indicators but especially to identify the needs in terms of capacity development of the concerned stakeholders and in terms of empowerment throughout the LDS development.

Keywords: Decentralisation, devolution and transfer of skills, demography and pressure on rural land, land development scheme vocations of rural areas, land grabbing, land security, pastoralism, roadmap, rural issue, rural land

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Reproductive Performance of Small Ruminants in the Transhumant Grazing Systems of the Chinese - Mongolian Altay Mountains

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Situated at the Chinese-Mongolian border, the semi-arid pastures of the Altay Mountains are mainly utilised by transhumant livestock keepers. Their sheep (S) and goats (G) serve the increasing demand for meat (S: particularly in China), and Cashmere wool (G: particularly kept in Mongolia). While these demands generate income opportunities for livestock keepers, large herds potentially threaten the sustainability of the rangeland-based systems in this fragile environment.

To better understand biological and socio-economic determinants of herd expansion, we conducted progeny history interviews on breeding females in Qinghe county of China (120 S, 73 G) and neighbouring Bulgan county of Mongolia (83 S, 173 G), yielding data on reproductive performance, mortality and culling of these animals and their offspring (Qinghe: 280 lambs, 185 kids; Bulgan: 330 lambs, 462 kids).

The results show marked differences between both regions, with animals reaching first parturition age (in months) earlier in Qinghe (S: 20.9, G: 17.8) than in Bulgan (S: 35.7, G: 38.3), while parturition interval deviated by one month only between the two counties. The abortion rate was very low or not recorded in Qinghe but relatively high in Bulgan (S: 6.5 %, G: 6.7 %); in consequence, parturition rate was higher in Qinghe (S: 100 %, G: 109 %) than in Bulgan (S: 85 %, G: 93 %). Overall mortality averaged 1.0 % (S) and 5.4 % (G) in Qinghe, and 4.0 % (S) and 2.6 % (G) in Bulgan. Given the different production objectives for both species in the two counties, culling rates were higher in Qinghe (S: 30.5 %, G: 14.6 %) than in Bulgan (S: 11.1 %, G: 3.3 %). At an average small ruminant herd size of 93.2 animals in Qinghe and 68.8 in Bulgan, and a share of 88 % and 24 % sheep, respectively, this values indicate rapid expansion of small ruminant numbers in Qinghe and a bit slower in Bulgan. Thus, measures to avoid overuse of pastures must (and are) particularly be taken in China, while in Mongolia this threat is less severe. Yet, biomass yield on pastures are higher on the Chinese than on the Mongolian side (see contribution of G. Jordan, ID 419, this Tropentag) and have also to be taken into account.

Keywords: Cashmere goats, Central Asia, culling, progeny history, sheep, sustainability

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The Role of Environmental Factors and Grazing on Rangeland Productivity Along an Altitudinal Gradient in the Chinese and Mongolian Altay

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The alteration of traditional grazing management including changes in herd size and composition and diminished spatial distribution of livestock is likely to affect rangeland productivity in the Chinese-Mongolian Altay Mountains. Traditionally, herds seasonally shift between desert steppe, flood plain, mountain steppe and alpine belt. The study aimed to assess the interaction of soil, vegetation, and climate parameters and grazing management on quantity and quality of pasture biomass. Environmental variables (altitude, topographic position), vegetation cover, and above ground biomass were assessed at 359 sampling locations in China and 510 in Mongolia. Biomass samples were analysed for neutral detergent fiber, crude protein, calcium and phosphorous. At 166 locations soil samples were taken and analysed for carbon, nitrogen, organic matter, pH and phosphorous. Moreover, one cow and one goat carried GPS collars to record the temporal and spatial extent of pasture use on either side of the border. The difference in altitude between the lowest and highest pasture was 1195 m (China) and 1430 m (Mongolia). Biomass availability at the onset of a grazing period (kg DM ha^{-1}) ranged from 847/554 in the desert steppe to 1685/535 in the alpine belt (China/Mongolia). In both countries, altitude was the main influencing variable, corresponding most likely with rainfall. With rising altitude, carbon, nitrogen and organic matter concentration in soil increased (rs>0.61, $p < 0.001$), while pH decreased (rs= -0.60, $p < 0.001$). In China, biomass quality (neutral detergent fiber/crude protein) showed a moderate correlation with carbon and nitrogen concentration (rs> -0.56, $p < 0.001$ / rS>0.39, $p < 0.001$). In Mongolia, animal density seemed to be a main determinant of biomass availability (vegetation allowance, rs= -0.84, $p < 0.001$), and soil carbon and nitrogen concentration were negatively correlated with the herds' duration of stay on the pasture (rs= -0.61, $p = 0.020$). In conclusion, the type of pasture utilisation was not the main determinant on pasture productivity in China, probably due to strict political regulations on grazing management. While in Mongolia the pasture productivity could be enhanced by alteration in pasture utilisation due to reduced stocking densities or shorter grazing of herds.

Keywords: Central Asia, GPS tracking, vegetation and soil parameter

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Does High Impact Grazing Change Plant Species Composition or Diversity of Northern Argentinean Grasslands?

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Rangelands of northern Argentina are core areas for livestock production but the seasonality of net primary productivity with a high accumulation of standing dead biomass is limiting the stocking rates of cattle. High impact grazing has been shown to be a promising management tool to reduce standing dead biomass as an alternative to the burning practice, however, effects on plant species composition and grassland diversity were not analysed so far.

A grazing experiment was established on the experimental station (INTA-Corrientes) on a 24 ha large grassland area, split into three paddocks with 12 plots and a control area without high impact grazing. Heavy impact grazing with 150 cattle ha^{-1} day^{-1}stocking rate was conducted in spatially confined paddocks and within different seasons of the year. To investigate the changes in botanical composition, we assessed species abundance and plant cover during the main growing season in February.

The analysis of biodiversity parameters showed no significant variation of species richness. The Shannon-Wiener diversity index (H) and Shannon's equitability (EH) were at the same level in the heavy impact grazing plots and the control, also the plant species composition did not change. Analysing the plant functional groups, we found a shift in the green biomass proportions towards C3 species. The proportion of mono- and dicotyledonous species did not change after a heavy impact grazing. Seasonal impact timing had no effects on plant species composition. The repeated bunch trampling by grazing cattle enhanced the growth of new patterns with more favoured C3 fodder plants (Poaceae species: *Leersia hexandra*, *Paspalum notatum*).

We conclude that intensive trampling and grazing disturbance does not change the composition of the existing flora of the grassland of Corrientes. A slight shift towards C3 plants might contribute to the cold season rangeland productivity. However, more detailed studies are needed to cover long term effects of high impact grazing disturbance and to analyse the species composition during the winter. High impact grazing seems to be a promising alternative to the extensively used burning practice and could therefore contribute to a sustainable management of northern Argentinean rangelands.

Keywords: Grassland management, intensive grazing, natural pasture

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Mapping and Management of the Main Watering Points Planned for the Nomadic Cattle in Benin

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Animal husbandry, second economic activity after agriculture in Sudanese Africa, contributes to food security in pastoral and agro-pastoral communities. This livestock keeping is still extensive and largely based on the use of natural resources for cattle feeding and watering. In order to increase its contribution in the countries economy, a policy has been set up in the decades 70–90 to promote agro-pastoral systems. The aim of the various programs was to secure pastoral mobility in a dynamic planning of the territory and to guarantee the continuity of appropriate management of the structures and the pastoral areas. Despite the development of a pastoral water infrastructures programme in the north of Benin, the preoccupation of pastoralists and agro-pastoralists still focuses today on improving watering points in existing grazing areas. For a better assessment of the available watering points, an exhaustive inventory of the area water infrastructures was done and, using ArcView software, a map with all watering points was created. The Analysis of the management of the water infrastructures was realised thanks to interviews addressed to 180 actors determined previously thanks to SWOT tool. These questionnaires were treated with Sphinx plus software. In total 152 water infrastructures comprising dams, rivers and wells have been inventoried in the study area. The results coming from the description of these infrastructures allowed to point out their functionality and the quality of their maintenance. The difficulties of accessing these infrastructures and the uses of the other water points saved for non-pastoral use have also been highlighted. It can be concluded, that the absence of access roads to the water points and settlements for vegetable cultivation around these points are the main concerns of the nomadic livestock keepers. Indeed, the settlement of the corridors is source of numerous conflicts between farmers and livestock keepers and the difficulties of accessing the water infrastructures particularly put the livestock keepers under pressure.

Keywords: Food security, natural resources, pastoralism

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Contribution of Agro-Silvo-Pastoral System in the Livelihood of Rural Households in Central-West of Sudan

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Despite the proper role of agro-silvo-pastoral system (ASPS) in enhancing ecological services as well as soil conservation, the contribution of the system to the household income and livelihood in Sudan is still relatively limited. This study aimed to determine the income generated by the best land use alternative mix of farm activities in an agro-silvo-pastoral system. It is focused on the profitability of trees mainly *Acacia senegal* and other non-timber forest products with comparative benefits of important crops and animals in the area. The data were derived from a field survey that was carried out in 2014 in three localities in North Kordofan, namely Wad Banda, Elkhawei and En-Nuhud), Central-West Sudan. Structured questionnaires were distributed to 250 farm households. A cluster random sampling technique was used for the selection of sampling. Subsequently, focus group discussions with key informants in the village communities were also conducted. Partial budget and benefit cost analysis were used to analyse the data. A sensitivity analysis was conducted to test the effects of some assumptions concerning an increase in tree product establishment costs and reduction in tree product prices. The results showed that within the three study zones livestock activities dominated and acquired higher net revenue in comparison to other components of the agro-silvo-pastoral system (ASPS). Regarding the comparison between the zones, the results revealed that ASPS is the dominating production system in En-Nuhud. ASPS recorded a high net revenue in all three zones. Wad Banda showed the highest income from tree products, Elkhawei recorded higher net revenue in livestock and En-Nuhud revealed that crop production remunerated most. Following the application of sensitivity analysis the result showed relatively high net revenue under the assumption (5 %, 20 % and 40 %) increase and decrease of tree product costs that could be incentives for people to invest in such activities. Based on the findings, the study suggests that in order to improve the agro-silvo-pastoral system, government should help to formulate a supportive policy that enhance alternative "land use mixes" for sustainable agro-silvo-pastoral systems.

Keywords: Agro-silvo-pastoral, household, livelihood, partial budget, profitability

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Participatory Epidemiology: Approaches, Methods, Experiences in Pastoral Areas in Northern Kenya

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Animal keepers and their practical knowledge are a neglected information source for the much needed analysis of animal disease problems. Therefore, participatory epidemiology (PE) applies a combination of practitioner communication skills and participatory methods to involve of animal keepers in implementation and evaluation of disease control programmes. PE relies on the widely accepted techniques of participatory rural appraisal, ethno-veterinary surveys supported by triangulation of data with conventional veterinary diagnostic methods. This information can be used to design better animal health projects and delivery systems in order to design more successful surveillance and control strategies. PE has particularly proven instrumental in livestock response programmes in Marsabit and Turkana Counties of Kenya where conventional laboratory diagnostic systems failed to reach the target groups. In an ongoing development project the PE approach has been used in livestock disease surveillance to obtain timely responses to livestock disease outbreaks. It also served as an early warning system for droughts based on diminishing livestock body condition reported by the herders.

Veterinary technical personnel based at sub-county level were trained on PE to enhance data gathering from livestock keepers. Veterinary personnel thereafter selected community focal persons whom they also trained. Disease surveillance is conducted by engaging a dozen of livestock owners at satellite villages in discussions through PRA methodology to identify and rank diseases based on their understanding and perceptions of important diseases.

Disease identification and ranking was based on description of clinical signs and proportional piling by herders. In Laisamis sub-county three main livestock species are kept: camels, sheep and goats. Hemorrhagic septicemia disease was ranked first in camels, in goats and sheep. Peste des Petits Ruminantes was ranked as most important in all villages sampled while Contagious Caprine Pleuro Pneuomia was ranked as second most important for goats.

Keywords: Animal health, food security, natural resource management, participatory epidemiology, participatory rural appraisal, pastoralism, surveying

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Screening for Water Saving Traits of Common Fodder Grasses Used in Integrated Crop-Livestock-Forestry Systems of Central West Brazil

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The humid subtropical climate of central west Brazil mostly provides sufficient rainfall and adequate temperatures to support year-round agriculture production in integrated tree-crop-livestock production systems. However, high rainfall variability during the drier winter is increasingly compromising one of the most productive agricultural regions in Brazil. In addition, climate scenarios indicate up to 30 % less rainfall during winter and increasing frequency of dry periods for central-south Brazil within the forthcoming decades. Information focusing on plant water use dynamics of intergrated crop-livestock-forestry systems is rare and insufficient to estimate the system's adaptive capacity to temporal water limitations and climate variability or change. The objective of this research is to characterise whole plant transpiration of selected common cultivated fodder grasses in response to atmospheric drought and shading.

Whole plant transpiration rates [mmol m^{-2} s^{-1}] of the fodder grasses *Brachiaria brizantha* cv. Marandu, *Brachiaria humidicola* cv. Llanero, *Brachiaria decumbens*, *Brachiaria ruziziensis*, *Panicum maximum* cv. Mombaca and *Panicum maximum* cv. Tanzania was measured in a transpiration chamber with adjustable atmospheric vapour pressure deficits (VPD) and three different radiation intensities (420 μmol m^{-2} s^{-1}, 730 μmol m^{-2} s^{-1}, 1200 μmol m^{-2} s^{-1}).

The results show that with increasing vapour pressure deficit and radiation intensity the transpiration rates for each fodder grass species increased linear but with different slopes. While under low VPD levels the radiation impact on transpiration rates was rather small, the effect was considerably increased under high VPD levels.

Our results suggest that common cultivated fodder grasses in Brazilian pastures reveal different response dynamics to light intensity and VPD. Both abiotic factors are highly variable within integrative crop-livestck forestry systems and improved understanding of the plant's water use traits will contribute to a resource use efficient, climate smart, and sustainable land use management.

Keywords: Brazil, fodder grasses, integrated crop-livestock-forestry systems, radiation, transpiration, vapour pressure deficit

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Sustainable Management of Rangelands – Integrating Practitioner's Knowledge

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Arid and semi-arid rangelands provide a living for more than 370 million people worldwide and about 80 per cent of the nutrition for livestock. Resource degradation, fostered by climate change and maladapted land use, has become a serious challenge in such rangelands, negatively impacting ecosystem function, livestock production and the livelihoods of the people worldwide. In Namibia, the driest country of sub-saharian Africa, 45 percent of the national land area can only be used as rangeland and the livelihoods of a majority of Namibians directly or indirectly depend on natural rangeland vegetation and related water resources.

Thus, to prevent further degradation of natural resources the implementation of adapted sustainable management techniques becomes vital. However, these ecosystems are very complex with regard to the close interactions between vegetation dynamics, soil moisture, groundwater recharge, and soil erosion, posing challenges for good management choices. Furthermore, altered management options may be impeded by social or economic incentives, believes and preferences.

Within the interdisciplinary Optimass project, we focus on management options of commercial livestock farmers in Namibia. Their opportunities for action were identified and the impact on the ecosystem and the societal utilisation interests analysed. We aim to better understand the link between actors and rangeland ecosystems by applying participatory modellingtechniques, taking local knowledge and experience into consideration. Conducting qualitative interviews with farmers and other experts, their practical knowledge will be combined with scientific knowledge from a process-based eco-hydrological model in iterative steps. While process based models can improve the understanding of the complex links between water and soil, qualitative and quantitative assessments with resource users are required to elucidate drivers for management.

We will present preliminary results from interviews, workshops and models on management options, challenges and impacts in Namibian rangelands. Our final aim is to derive recommendations for policy and practice while new possibilities of knowledge exchange will be created within the process. Progress in rangeland ecology can be achieved by integrating local and scientific knowledge with regard to the drivers and the impact of land use and environmental variability on the natural resources.

Keywords: Local knowledge, Namibia, participatory modelling, rangeland management, Savannah

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Use of Feed Resources in Intensive Urban Ruminant Production Systems: A Case Study from Burkina Faso

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A longitudinal study was conducted in the built-up area of Bobo Dioulasso in Burkina Faso to (i) assess the resource use efficiency in zero-grazing beef cattle production enterprises through quantification of inflows of feeds and outflows of manure; (ii) determine the animals' live weight (LW) gains; and (iii) evaluate whether the feeding regime was able to meet the animals' energy requirements for maintenance and growth, so as to assess the system's overall efficiency. Five representative farms were purposively selected out of a total of 133 surveyed in a previous study. The average number of cattle per farm was 5.4 $\pm$ 1.99, and measurements were carried out in bi-weekly intervals from August 2012 to May 2013. LW of animals averaged 270 $\pm$ 128.8 kg and LW gain ranged from 162 $\pm$ 60 to 423 $\pm$ 200 g d^{-1} with an average of 290 $\pm$ 161 g d^{-1}. The average daily supplies of crude protein and metabolisable energy (MEoffer) of 29 $\pm$ 8.9 g kg-0.75 and 1.5 $\pm$ 0.44 MJ kg-0.75, respectively, clearly exceeded the animals' requirements for maintenance plus growth; hence calculated feed conversion ratios were very low. The same was true for the ME use efficiency (4.4 $\pm$ 2.65 g LW gained MJ^{-1} ME offer) determined. These results suggest that the feeding management of urban beef cattle keepers in Bobo Dioulasso is resource inefficient, and most likely also improvident. It is advisable that extension services inform urban livestock keepers about the quality of feeds on offer to avoid wastage of feed energy and nutrient resources available to them.

Keywords: Cattle fattening, energy use efficiency, feed conversion ratio, live weight gains, urban livestock keeping, West Africa

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Determinants of Crop-Livestock Integration by Small Farmers' in Benin

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Despite the numerous work conducted on integrated crop-livestock systems in sub-Saharan Africa, very little is known about factors determining farmers' trend to integrate. Our study aimed at a socioeconomic characterisation of endogenous crop-livestock integration in Benin and identification of determinants of farmers' decision to use these practices. Two hundred and forty farmers were surveyed in three agro-ecological regions of Benin. A semi structured questionnaire was used to collect information on farmer's characteristics, production factors and agriculture and breeding by-products valorisation practices. On the basis of main links between both productions, three integration levels (no integration, NI: 36%; partial integration, PI: 55%; total integration, TI: 9 %) were identified and characterised according to socioeconomic characteristics of farmers. Then the multinomial logistic regression technique was used to predict the integration level of a given farmer in function of its socioeconomic characteristics. The three integration levels differ significantly ($p < 0.001$) according to variables such as membership in farmers' association, educational level, weight of agricultural experience, farm equipment and size of animal herds. The decision by a farmer of the no integration type to choose the total integration type significantly depends ($p < 0.001$) on the size of his cattle herd, his membership in farmers' association and his equipment value. For a farmer of the partial integration type, it depends on the size of his cattle herd and the weight of his agricultural experience. Cattle breeding remain the motor of real crop-livestock integration. This study gives precious information on socio-economics characteristics of farms that need to be improved for better adoption of integrated crop-livestock systems in small scale farms in sub-Saharan Africa. One perspective issue in the Beninese case is to analyse resource flows in the endogenous crop-livestock integration systems.

Keywords: Food security, natural resources, pastoralism

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Evaluation of the Establishment of Livestock Feed Association for Tropical American Systems

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In order to evaluate the agronomic adaptation and response of the grass - legume association in the establishment phase, experimental plots of 2700 m^2 and 5400 m^2 (local control) were sown in Patia (Cauca), an interandean valley located in the south of Colombia, at 608 meters above sea level, characterised by having soils of medium fertility and long dry periods (8 months a year in two seasons).

A completely randomised design with four replications was used, the established grasses were *Brachiaria* hybrid cv. Mulato II, *Brachiaria brizantha* - Toledo, *Panicum maximum* cv. Mombaza and *Dichantum aristatum* (local control) as a monoculture; in the same way the following associations were sown: *Brachiaria* hybrid cv. Mulato II + *Canavalia brasiliensis*, *Brachiaria brizantha*- Toledo + *Canavalia brasiliensis*, *Panicum maximum* cv. Mombaza + *Canavalia brasiliensis*, for a total of seven treatments represented in 28 experimental plots on 8.6 hectares. Vigour, height, coverage, production of green forage in dry matter, presence of pests and diseases were evaluated.

Through a variance analysis, statistical differences were found ($p = 0.05$) for the vigour, coverage, plant height, presence of pests and dry matter production variables. *Panicum maximum* cv. Mombaza alone and associated with *Canavalia brasiliensis* showed the best agronomic performance in terms of vigour (4.73, 4.67), coverage (88.8 %, 85.9 %), height (134.7 cm, 132.8 cm) and dry matter production (78.82 ton ha $^{-1}$ per year, 75.76 ton ha^{-1} per year) respectively. These two forage options stood up when they were evaluated against pastures of *B. brizantha*, *B.* Hybrid and *D. aristatum*. The introduction of improved forages in monocultive and/or associated with *Canavalia brasiliensis* showed better agronomic performance than the local control.

Establishment costs were higher in associations with *C. brasiliensis*, due to the higher price of seed and labour for legume sowing. Also, Mombaza was the specie of lower cost of establishment, due to its strength, coverage and high growth rate, requiring minor management tasks and therefore in the cost of inputs and labour, against the other forage options evaluated.

Keywords: *Brachiaria brizantha*, *Brachiaria* hybrid, *Canavalia brasiliensis*, forages establishment, *Panicum maximum*

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Degradation of the Important Fodder Tree *Euphorbia stenoclada* in Southwest Madagascar and Approaches for Improved Management

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In dry, rural southwest Madagascar, livestock keeping contributes significantly to food security of local people. The locals frequently buffer food shortages from failures of subsistence crop production by selling animals for the purchase of staple food. However, livestock keeping in this region is increasingly difficult due to fodder shortages. In the coastal zone of the Mahafaly region, the succulent evergreen tree *Euphorbia stenoclada* ("Samata") is a very important dry season fodder resource. Yet, it is heavily affected by increasing degradation of stocks of juvenile as well as adult trees, which is aggravating fodder scarcity. Empiric evidence shows that the degradation of Samata is caused by increasing mismanagement and too intensive looping. For validating the severity of overuse, we quantified the standing biomass of Samata trees and their mortality rates on 70 sample plots in the study region. Additionally, we did 111 interviews with livestock keepers in order to understand the socio-economic reasons for and dynamics of the perceived mismanagement.

Our data show that the use of trees leads to mortality rates of up to 22 %, which vary strongly with the trees' distance to villages and thus pressure of use. Interviews revealed that livestock keepers react to increasing Samata scarcity by privatizing this formerly open access common pool resource. Private Samata plantations showed considerably higher biomass yield per tree than open access stocks. This indicates that owners of private stocks carefully utilise their trees, while the open access situation on common stocks lacks coordinated management by the community and leads to degradation. On the other hand, this unruly privatisation process is a main trigger of overuse of the common pool stocks and leads to constant conflicts over the resource among the villagers.

Another important factor contributing to overuse is a local lack of knowledge on proper multiplication techniques for Samata. Field experiments on low input multiplication by cuttings under local conditions show good results for tree instalment and growth. Thus, local capacity building on Samata multiplication by cuttings can be a potential solution for mitigating the degradation of the fodder resource and thus reducing conflicts and enhancing local food security.

Keywords: Common pool resource, privatisation, resource degradation, succulent tree, vegetative propagation

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Ruminant production systems

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Threats and Opportunities for the Sustainable Use of the Indigenous Somba Cattle Breed in the Mixed Crop-Livestock System in North West Benin

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With an estimated number of 58,000 heads in 1986, the Somba breed represented 0.3 % of the national cattle population size but its number sharply decreased to about 17,000 in 2000. While it is generally accepted that this breed is threatened in its belt, very little is known about its current production systems and the main reasons for its decline. However, this information, together with the identification of its important functional traits, is necessary for the development of strategies for its conservation and sustainable use. The objective of this study was therefore to characterise the Somba breed in its production system context. For this purpose, 224 cattle farm-households were surveyed in the Boukombe district, the natural habitat of the breed in North West Benin. Information on the socioeconomic characteristics of the households and on herd management practices were recorded using a semi-structured questionnaire. In addition, fifteen body measurements related to shape and conformation traits were recorded from 102 adult cattle. Somba cattle have short horns (15.8 ± 10.88 cm) and a small body size with respectively 95.9 ± 5.76 cm and 146.8 ± 11.01 cm for height at withers and body length. Three types of Somba cattle breeders were distinguished: the owners-herders (54.0 %); the owners who entrusted their animals to specialised herders (40.2 %) and the herders who took on entrusted cattle (5.8 %). The average cattle herd sizes were 4.7 ± 3.70 and 58.6 ± 22.83 heads for owner-managed and entrusted herds respectively. The decision to keep Somba cattle was not based strictly on economic parameters. Offtakes were more associated with sociocultural purposes (75.5 %) than market. While crop farming was the main occupation and income source of their owners, the Somba cattle were used for ploughing during the rainy season. Main factors in the decline in the breed population were identified as the general decline in cattle farming and high mortalities (68 % of losses) rather than crossbreeding and/or replacement. Therefore, approach for safeguarding this breed should consist of simultaneously improving general herd management practices and involving farmers in breeding programs aiming at genetic improvement of health, fitness, survival and reproductive traits.

Keywords: Cattle genetic resource, characterisation, crop-livestock farming, *in situ* conservation

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Cattle Diseases in Dairy Herds in Tanzania - Farmers View and Laboratory Confirmation

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Cattle diseases remain a major constraint to increasing dairy productivity in Tanzania, by killing or keeping them sick and under-producing. Recent studies report overall mortality between 12 and 14 % in smallholder dairy cattle across different regions of Tanzania. Many of these diseases can also be transmitted to people, causing illness and/or even death. Existing information on the diseases affecting dairy cattle in Tanzania and their relative importance is limited and relies either on passive reporting by poorly resourced veterinary services or on localised surveys focused on a specific well known diseases. The causes of cattle diseases remain often unknown and differential diagnosis is not conducted leading to mistreatment or ineffective treatment. Addressing this concerns a survey was conducted among cattle farmers in two regions in Tanzania using participatory techniques to collect information on disease importance supported by laboratory investigations on commonly expected cattle pathogens but also those seldom looked for but known to be important in other regions. For this purpose blood samples were collected from cattle (n=402) reported by farmers to be sick and subjected to a range of tests (ELISA) including tick borne diseases, selected zoonoses (brucellosis, Q Fever), infectious bovine rhinotracheitis, bovine viral diarrhea (BVR) and bovine respiratory syncytial virus (BRSV) among other pathogens. Biological sampling was aligned with data collection on farm and diseases management. Results indicate that diseases are common for the region. Among those most prominent were East Cost fever and Anaplasmosis (32 % each). Also important zoonoses were found (e.g. Brucellosis, 11 %). High numbers of positive tested sera were also reported for pathogens commonly not tested for (e.g. IBRV). Preliminary results suggest discrepancies between laboratory results (tested positive sera) and farmer's perceptions on specific diseases. While for East Cost Fever farmer's perception on disease importance confirmed laboratory results (37 % versus 32 %) we found a discrepancy for brucellosis (1 % versus 11 %), a neglected zoonoses with the potential of causing chronic, long lasting diseases in humans. Implications of farming management practices on the presence/absence of certain pathogens are currently developed and part of ongoing dissemination efforts.

Keywords: Cattle, farmer's perception, pathogens, Tanzania

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Effects of Grazing Management and Watering Regimen on Sudan Desert Lambs Body Weights

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This study utilised mature Sudan desert ewes (*Ovis aries*) at a village in Sheikan province, North Kordofan State, within the semi-desert ecological zone of Sudan. Sixty ewes were randomly assigned to grazing and watering regimen combinations in a factorial arrangement of treatment using a randomised complete design. Grazing treatments were night grazing and day grazing whereas watering was either every other day or every three days. The ewes were naturally mated using two healthy rams that were randomly circulated among ewe groups to eliminate ram effect. The ewes were flushed (receiving a concentrate supplement for 45 days at mating time); and steamed-up (receiving the supplement for 45 days pre-lambing). The objectives were to investigate the effects of breeding ewes grazing management and watering regimen on lambs' weight at birth and lambs' growth. Lambs' birth weights were not significantly ($p > 0.05$) affected by both grazing management and watering regimen of their dams. However, lambs belonging to ewes on night grazing and every other day watering regimen recoded comparatively the highest birth weights while those on day grazing and every three days watering regimen had slightly the lowest weights. Respective lamb weights at birth for the two groups were 3.7 and 3.4 kg. Final weights were significantly ($p < 0.05$) influenced by grazing management where lambs belonging to ewes on night grazing had the highest weaning weights (32.6 kg) and those belonging to ewes on day grazing recorded the lowest weaning weights (28.5 kg). No significant grazing management X watering regimen were revealed. Nonetheless, lambs belonging to ewes on night grazing and every three days watering recorded the best weights compared to lambs belonging to ewes on the other treatment combinations. Both lambs belonging to ewes on day grazing and every other day watering and those on day grazing and every three days watering had the lowest weights throughout the 12 months trial period. It was indicated that grazing management of ewes greatly influenced the growth performance of their lambs. Further research work is needed to elucidate the lamb type of birth and lamb sex on lamb growth and performance.

Keywords: Grazing management, lamb birth weight, lamb growth, Sudan desert ewes, watering regimen

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Beef Production from Different Crops Associations for the American Tropics

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Forage grass-legume associations are an option to contribute to the solution of seasonality in the food supply of bovine industry not only for its contribution in the volume of forage, but in the diet quality and productivity of the whole system strengthening the sustainability of livestock production, a very important element for livestock in the American tropics.

A completely randomised design with four replications was used. The established grasses were *Brachiaria* hybrid cv. Mulato II, *Brachiaria brizantha* - Toledo, *Panicum maximum* cv. Mombaza and *Dichantum aristatum* (local control) as a monoculture; in the same way the following associations were sown: *Brachiaria* hybrid cv. Mulato II + *Canavalia brasiliensis*, *Brachiaria brizantha*- Toledo + *Canavalia brasiliensis*, *Panicum maximum* cv. Mombaza + *Canavalia brasiliensis*, for a total of seven treatments represented in 28 experimental plots on 8.6 hectares. Once the crop was established, it was grazed to determine weight gain in relation to the type of pasture and its productivity.

By using rotational grazing with 21 commercial zebu males (three per treatment), with a live weight of 340 kg, it was found that animals with higher individual weight gains were those that were grazed with *Brachiaria* hybrid cv. Mulato II + *C. brasiliensis*, with daily gains of 944 grams, 56 grams more than those who only consumed *Brachiaria* hybrid cv. Mulato II.

Regarding pasture productivity, the association with higher weight gains per area unit were Mombaza + *Canavalia brasiliensis*, Mulato II + *Canavalia brasiliesis* and *Panicum maximum* cv. Mombaza with 749, 641 and 557 kg meat ha^{-1} per year respectively, they also resisted the maximum charge capacity, in contrast to traditional pastures of *Dichanthium aristatum* with 193 kg meat ha^{-1} per year.

Keywords: Daily weight gain, forage mixes, tropical forages, tropical livestock

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Livestock Productivity, Resilience to Climate Change and Coping Strategies in Namibia: Commercial versus Parastatal Feedlot Farms

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As one of the driest countries in sub-Saharan Africa, the Namibian economy and people are vulnerable and sensitive to climate change. An increase of 2°C to 6°C is predicted for the year 2100 along with more variability in annual rainfall. Especially in the arid savannah areas livestock production plays a key role in the country's agricultural sector. The Namibian livestock sector comprises three major sub-groups: small scale farmers, commercial farmers, and parastatal feedlot farms. Despite its importance, it remains unclear which system may prove superior regarding climate resilience. The study assess and compares the productivity and resilience of the commercial and the parastatal feedlot farms to climate variability. Information on changes in total production, production costs, and other indicators are to be collected from the study area. The indicators are to consider various timespans to account for events of drought as well as for changes in prices. In addition, livestock producers will be interviewed to grasp their coping strategies during drought events as well as their reactions to changes in prices. The analyses will be based on the qualitative and quantitative primary data collected during interviews with parastatal farmers, an online survey for commercial farmers, and the existing literature on the perception of and adaptation strategies to climate change so as to provide a detailed insight into the livestock farming systems. The business objective of parastatal feedlot farms is a constant supply of cattle. Regarding the product output, the results of the literature review indicate that a lower sensitivity to climate variability can be expected within the feedlot sector. However, a higher volatility in production costs, and consequently profits, is predicted due to compensating fodder shortages with higher costs for purchasing fodder during droughts. Contrary results can be expected in the commercial sector: The occurrence of droughts lead to higher outputs followed by years of depression in marketed cattle; Costs of production are predicted to remain constant. Overall, both livestock systems face the challenges of more erratic rainfalls. While commercial farmers manage through changing their stocking numbers, feedlot farms deal with a tradeoff between constant production and capital input.

Keywords: Climate resilience, coping strategies, livestock productivity, Namibia

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Suitability of a Greenhouse Gas Emission Indicator in a Beef Cattle Improvement Programme

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There is a growing discussion on the use of environmental performance indices for beef cattle genetic improvement programmes, especially in Brazil, where general herd based improvement programs are expanding at fast pace. Current indicators in use for animal improvement are based on animal traits. Market demands are still focused on animal performance and not on production systems efficiency. There is a stated interest from the scientific community to develop economic and environmental indicators to be incorporated into cattle improvement programs. For commercial cattle husbandry, one important environmental indicator is greenhouse gas (GHG) emissions, which could have potential use as an index component in animal improvement programs. One of its advantages would be having relatively uniform assessment methods worldwide, even considering a broad range of production systems.

The proposed work uses a web-calculator specifically developed by Embrapa for scientifically estimating GHG emissions from different cattle systems (E-Missions). The calculator allows fast data processing for a large number of farms. A group of farms with different production intensity already participating in a cattle improvement programme in Brazil (Geneplus) is being selected and their data are collected and processed. From the results obtained from the GHG calculator, a genetic improvement index will be proposed to be tested. This index will be incorporated into a simulated analysis based on groups of beef cattle already evaluated by the Geneplus programme using the traditional method, which does not incorporate any environmental component. Differences in animal ranking in both evaluations will be explored and analysed to check the suitability and applicability of the proposed indicator. The null hypothesis of the work is that incorporating total GHG emissions as a trait into a beef cattle selection programme does not change the position of the top animals ranked by traditional breeding programmes.

Keywords: Beef cattle, genetic improvement, sustainability indicators

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Molecular Genotyping of some Camel Types and Subtypes from Sudan, Qatar, Chad and Somalia Using Microsatellite Technique

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This study aimed to genotype some camel types and subtypes from Sudan and from Qatar, to determine their genetic distances, as well as to compare these with camel genotypes from Somalia and Chad. Further, the relationship between the phenotypic characteristics and the genetic makeups were studied. Twenty-five polymorphic microsatellites out of fifty loci were used to genotype camel (*Camelus dromedarius*) types and subtypes from Sudan (Naylawi, Shanapla, Lahawi, Kinani, Rashaydi, Bani-Aamir, Annafi, Bishari Shallagyai and Bishari Arririt) and from Qatar (OmmaniHJ, OmmaniKH, Majaheem, Pakistani Sindi, Pakistani Punjabi and Pakistani). These were compared with one type from Somalia (Aarhou) and another from Chad (Spotted). The highest number of alleles were 23 in Locus CVRL 01 and the lowest number were 2 in YWLL 59. The observed heterozygosity (Hobs) was 0.950 and 0.049 for VOLP08 and YWLL09 respectively, while the expected heterozygosity (HExp) was 0.915 and 0.362 for Locus VOLP67 and YWLL58, respectively, and the HExp mean was 0.7378. Polymorphic Information Content (PIC) ranged between 0.907–0.345 in Locus VOLP67 and YWLL58 and the PIC mean was 0.7002. The genetic distance ranged between 0.545 – 0.098 for Shallagyai (Bishari subtype) – Pakistani Sindi subtype and between Annafi – Rashaydi respectively. The genetic distance between spotted and all types ranged between 0.223 with Arririt (Bishari subtype) and 0.463 with Punjabi (Pakistani subtype) found in Qatar, while all types with Aarhou ranged between 0.215 for Arririt and 0.469 with Punjabi (Pakistani subtype). The dendrogram showed that there was a relationship between the genetic makeup and geographical distributions and also between the genetic makeup and phenotypic characteristic. Individual assignment was calculated, 46.62 % correctly assigned and 46.87 % quality index. Hardy Weinberg Equivalent (HWE) was also calculated. It is concluded from this study that the microsatellite technique used was quite efficient in the genotypic identification of camel types and subtypes, individual assignment tests, and for parentage and paternity verification.

Keywords: Dromedary, microsatellite, Sudan

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The Effect of Management System on Camel Milk Yield, Composition and Reproductive Performance in Sudan

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This study was carried out in rain fed-cultivation areas of Central Sudan. The aim of this study was to evaluate the impact of farming system on she-camel milk yield, to assess the effect of seasonal variation on milk components, and to calculate calving intervals. Thirty six lactating she-camels and their calves were selected (Arabi breed): they were maintained under intensive, semi-intensive and traditional system. The animals were divided into three groups (12 for each group). The first group was managed under semi intensive system in which the animals were herded during night in closed pen and set free during mid-day and supplemented in the evening with 3 kg head per day of concentrate and 6 kg head per day roughages for dams. The second group was intensive system; animals were kept in the experimental farm during the day and offered 15 kg head per day roughages and supplemented with 3 kg head per day concentrate. The third group served as a control (traditional system), the animals were brought to grazing areas where they selected feed by themselves from the available plants, agricultural-residues and allowing no supplemented feeding. Data of milk yield and milk chemical composition was collected. Blood samples were collected for determination of progesterone concentration hormone by using radio immune-assay (RIA) kits. The study concluded that improved management (intensive and semi-intensive system) increased ($p \leq 0.05$) milk yield 3.2 times as compared to the traditional management systems. Milk composition was significantly different among the three production systems and during the seasons. The level of progesterone hormone in camels reared under intensive and semi-intensive increased during the eight months postpartum and reached a peak at 13^{th} and 14^{th} months postpartum. In contrast the progesterone concentration in the traditional system increased till the 12^{th} month post-partum. The results of the present study reflect clearly the significant contribution of the farming systems on productive and reproductive performances of dromedary camel. The long calving interval in the camel under traditional system is mainly due to the general lack of fodder and the poor nutritive value of the natural pastures, and water scarcity.

Keywords: Management systems, milk composition, progesterone, she-camel

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Improvement of Sheep Breeds Productivity through Artificial Insemination in the Jordan Rift Valley

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The project on improved extension for value-added agriculture in the Jordan River Rift Valley (EVAP) is a 3 year project (2011–2014) funded by Japan International Cooperation Agency (JICA), with artificial insemination (AI) as one of the main activities. The implementation of AI programme has been done by a professional team to study the conception rate, twinning rate, lamb birth weight, and 50 days lamb weight of sheep breeds in the Jordan rift valley. Data was obtained from sheep farms located in three districts (Jericho, Tubas, and Nablus). Variables for conception rate included in the model were location, ewe breed, and parity, and ram breed which was excluded from the model of twinning rate. Furthermore, lamb sex and liter size were added to the model for lamb birth weight and lamb 50 day weight. Among the effects, ewe breed and parity were significant ($p < 0.05$) on conception rate, whereas the locations as well as ram breed were not significant ($p > 0.05$). Twining rate was affected significantly ($p < 0.05$) by location and parity. However, the effect of location, ram breed, litter size, and lamb sex were not significant ($p > 0.05$) on lamb birth weight, while ram breed was the only variable that not significantly affected ($p > 0.05$) on lambs 50 day weight. Mean of conception rate, Twining rate, Birth weight (kg), and lambs 50 days (kg) were 62 % (57%-67 %), 1.49 (1.41–1.59), 3.67 (3.51–3.83), and 17.34 (16.43–18.25) respectively. It is concluded that artificial insemination has good results on conception rate and brings positive effect on the twinning rate thereby increasing farm profitability. However, it is important to carry out a research on the genetic effects of artificial insemination in order to improve traits of economic importance in sheep breeds in Palestine.

Keywords: Artificial insemination, conception rate, Jordan Rift Valley, Palestine, Sheep breeds

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Factors Influencing the Occurrence of Abnormal Lactation Curves in Iranian Buffaloes

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Rearing practices of buffaloes in Iran are under the rural system and in open areas. The total milk yield in 240, 270, or 305 days bases is often being used in genetic evaluation of buffaloes. High peak yields in normal lactation curves are correlated with high total milk yield. An ideal lactation curve has a high peak yield with moderate persistency. However, some curves do not have distinguished peak. Furthermore, another proportion of the curves are concave in shape. These curves, mostly characterised by the absence of the lactation peak, are called atypical lactation curves (ALCs), and are the subject of the present study. Logistic regression was used to assess the influences of some non-genetic factors on the occurrence of ALCs in Iranian buffaloes. The data set consisted of 24679 lactation records from 11478 buffaloes that calved during the years 1996 to 2012. As a reasonable statistical criterion, odds and odds ratio were used to evaluate the probable differences between the various levels of the factors. Genetic analysis of the ALC trait was also carried out using Bayesian approach to estimate heritability and repeatability parameters. The results revealed that almost 44 percent of the lactation curves were atypical. All factors, but ecotype factor had significant effects on the occurrence of ALCs. The frequency of ALCs increased until the 3^{rd} parity and decreased afterward, therefore the highest and the lowest values of the trait were observed in the 3^{rd} and 10^{th} parities, respectively. Unlike the parity effect, ageing of the buffaloes caused the odds values to be continually increasing. The incidence of the ALCs for buffaloes calved out of season (July to December) was more likely (almost 15 %) than those calved in season (January to June). The structure of the data also affected the trait significantly ($p < 0.05$), such that the lactations with 4 recorded test-days were 1.75 times more likely to have atypical curves than those with 8 recorded test-days. Heritability and repeatability of the occurrence of ALCs were estimated very low and were 0.020 and 0.036, respectively.

Keywords: Atypical lactation curves, Iranian buffaloes, logistic regression, threshold trait

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Vines of the Sweet Potato (*Ipomea batatas*): A Valuable Feed Supplement for Ruminants in Small Holder Systems

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Availability of suitable feed, and in particular sources of protein-rich food, is a major constraint to increasing the productivity of smallholders in sub-Saharan Africa it is difficult to justify diverting land from growing crops for human consumption. The roots of the sweet potato are a high energy cash crop, and the leaves and vines (SPV), usually treated as rubbish, are high in protein and have been identified as a valuable livestock feed. Additionally sweet potato has a prodigious dry matter yield (equivalent to 7.3 and 7.5 t ha^{-1} for vines and roots respectively) when fertilised and tilled and thus has the potential to make a major contribution to livestock feeding requirements, while providing a high yielding crop for human consumption or sale. Recently, SPV silage (SPVS) has been posited as a way to even out seasonal shortfalls in feed production for smallholders.

For the first time we conducted a feeding trial to assess simultaneous effects of SPVS on intake, live weight gain (LWG), daily methane production (DMP) and methane emissions intensity (MEI). We fed SPVS (DE: 12.8 MJ kg^{-1}; CP: 156 g kg^{-1}, DM) to growing Dorper wethers (n=20; LW:18 kg SEM:1.3 kg) at 5 inclusion levels (0, 20, 40, 60, 80 % as fed) while they consumed a basal diet of chopped maize stover (DE: 10.7 MJ kg^{-1}; CP: 46 g kg^{-1}, DM) for 70d.

Sheep consuming SPV silage included at 40 % (20 % DM basis) maintained LW, while those consuming diets at 60 and 80 % inclusion levels had significantly higher voluntary intakes ($p < 0.01$), LW gain ($p < 0.05$) and lower MEI ($p < 0.05$) than those consuming maize stover alone or SPVS at the 20 % inclusion rate.

We conclude that SPVS has the ability to significantly improve productivity and decrease MEI in animals fed low-quality basal diets, and should be offered optimally at 24–32 g kg^{-1} LW (as fed) to animals receiving only poor quality pasture or stovers.

Keywords: Enteric methane emissions, livestock, supplement, sweet potato

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Stockmen' Intention Toward Animal Welfare in Iran: A Matter of Productivity or Humanity

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Modern livestock farming has been impressively successful at increasing the performance of farm animals and decreasing production costs. However, this system has pushed the boundaries of environmentally friendly production, animal health, and welfare because it fails to fulfil animal needs. Organic farming is seen as response to these problems, and animal welfare is an essential element of it. For environmental and ethical reasons there is thus political and public interest in increasing the share of organic food production. The promotion of organic farming has therefore become an essential element of agricultural policy across the world. Societal expectations for more environmentally responsible livestock production practices are growing, of which good animal health and welfare are an important part. Moreover, a vast body of literature has examined and investigated various aspects of animal welfare.
Without any doubt, animal welfare has pivotal effects on the productivity of animaal. As such, recently, the role of stockmen's behaviour in animal welfare and productivity of dairy cattle has received more acknowledged by researchers. Therefore, understanding stockmen's intention and behaviour, and recognising the factors affected are of great importance. The aim of this study is thus to provide empirical data about intentions of Iranian stockmen toward animal welfare. This provided a knowledge base for the development of public policy measures that should aim to ultimately increase animal welfare schemes (as well as the health of animals and its products, and animal productivity and reproductive processes). The present study used the social cognitive theory, to predict farmers' intentions and behaviour regarding animal welfare. The study was designed as a cross-sectional survey. The population of interest consisted of stockmen in Sirjan district in Kerman province. The study sample consisted of 252 stockmen selected through a multistage, stratified random sample. It was found that others' behaviour and self-efficacy are significant predictors of intention regarding animal welfare. These two variables predicted 30 % of the variance in intention regarding animal welfare.

Keywords: Animal welfare, Iran, social cognitive theory

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Growth Ability and Carcass Characteristics of Purebred and Crossbred Lambs of Dhamari and Tehami Sheep Breeds in Yemen

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The objective of this study was to analyse and evaluate the effect of reciprocal crossing Dhamari and Tehami sheep breeds on pre-weaning growth and carcass traits of their purebred and crossbred offspring. The study was conducted at the Central Highlands Research Station (CHRS) at the Agricultural Research & Extension Authority (AREA) Dhamar - Yemen, 100 km south of the capital city, Sana'a. Data were analysed as a completely randomised design, using a general linear model (GLM) procedure of Statistical Analysis Software (SAS 2008) to determine effects of genotype of lambs, sex, litter size, ewe age and ewe weight at lambing and year breeding on growth ability and carcass characteristics.

Effect of lamb genotype, litter size and ewe weight at lambing on lamb weights at birth, weaning and pre-weaning average daily gain were highly significant ($p < 0.001$). Also significant was the effect of ewe age at lambing on weaning weight and pre-weaning average daily gain ($p < 0.05$). Additionally, the regression of lamb weaning weight on lamb birth weight was highly significant ($p < 0.001$). Fasting live weight, hot and cold carcass weights were significantly ($p < 0.001$) affected by genotype. Hot and cold dressing percentages were significantly affected by genotype ($p < 0.05$, $p < 0.01$, respectively). Effect of genotype on percentages of leg, prime quality cuts, moisture, crude protein and ash was significant ($p < 0.05$). Significant correlations were found between fasting live weight and cold carcass weight, and percentages of leg, loin, shoulder, breast, and flank, and area of loin-eye muscle and first quality cuts ($p < 0.001$). Positive and high correlations were also found between cold carcass weight and hot carcass weight and first quality cuts percentage. Results indicated that proper choice of indigenous sheep breeds and crossbreeding to take advantage of their biodiversity can significantly improve growth ability of lambs and increase meat production in Yemen.

Keywords: Carcass quality, crossbreeding, Dhamari, growth ability, sheep, Tehami

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Spontaneous Selective Consumption of Forage Plants of the Caatinga by Goats

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The Brazilian Northeast corresponds to 18 % of the country, with 75 % of this, classified as semi-arid and arid. Of the total area of the region, 19 % is suitable for agriculture, depends on rainfall, only 30 % have potential soil and water for irrigation and 78 % of the area has the ability to silvipastoral exploration. The Caatinga is one of the most important biomes in Brazil, with its importance in endemic plants of forage value. The present study aimed to observe the consumption of forage plants for native goats directly in Caatinga, being recorded species consumed, frequency of consumption, location to record coordinates, temperature at the time of consumption, altitude, and finally, most frequently consumed species into two distinct areas, 60 km distant from each other. The plants most commonly consumed in the region 01 -São José da Tapera were: Angicos (*Colubrina anadenanthera* (Vell.) Brenan), Catingueira (*Caesalpinia pyramidalis* Tui), Mororó (*Cheilantha bauhinia*), Dainty grass (*Gymnopogon mollis*) and in the region 02 - Santana do Ipanema were: Jurema Preta (*Mimosa tenuiflora* (Willd.) Poir), synonymous *Mimosa hostilis* (Mart.) Benth.), Malva Branca (*American waltheria* L.), Marmeleiro (*Croton sonderianus* Mull. Arg), Juazeiro (*Zizyphus joazeiro* Mart) and the Velame (*Croton heliotropiifolius* Kunt). The data collected made it possible to bring in the study area, a real sampling of consumed plants, taking into account the selectivity and the availability of plants for consumption by goats in the sampled regions. With this method the availability of fodder, the preference of animals, and the knowledge of pasture conditions were evident, making possible the researcher intervene in his essays and the producer in the management of his flock. This method can be adjusted to pasture production analysis and availability in the area by the method of direct observation of native species, occurring spontaneously and grazing on voluntary intake by goats. This work served as the initial analysis for development of other studies in animal nutrition, as a new method of observing animal consumption.

Keywords: Animal nutrition, native plants, semi-arid

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Genetic Variants of Candidate Genes Influencing Milk Yield, Composition and Somatic Cell Score in German Holstein Cows

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The aims of this study were to estimate the genotype and allele frequencies and genotype effects located in the Acyl-CoA: diacylglycerol acyltransferase 1 (DGAT1), Leptin (Lep/ob), Growth hormone receptor (GHR), Prolactin receptor (PRLR), and Kappa casein (CSN3) genes on milk yield, composition and somatic cell score (SCS) in German Holstein cows. The association analyses were based on data from 1380 German Holstein cows. The allele frequencies of the DGAT1 K232A were 44.2 % and 55.8 % for the Lysine and Alanine variant, respectively. The allele substitution effect for the Lysine variant was significantly increased the fat (0.30 %, $p < 0.0001$), protein (0.08 %, $p < 0.0001$) and casein contents (0.06 %, $p < 0.0001$) and fat yield (9.13 kg, $p < 0.0001$). In contrast, the effect was negative on milk yield (-372.77 kg, $p < 0.0001$), protein yield (-6.32 kg, $p < 0.0001$), and lactose yield (-0.05 kg, $p < 0.0001$). With respect to the Mbo1-RFLP in the Lep gene, the allele A was the major allele with a frequency of 90.3 %. The substitution effect of the minor allele B had a significant influence on fat yield (6.3 kg, $p < 0.05$). The frequency of the Phenylalanine allele of the GHR F279Y polymorphism was 83 %. The allele substitution effect of the minor Tyrosine variant was 320 kg ($p < 0.0001$), 0.02 kg ($p < 0.05$), 0.07 kg ($p < 0.0001$), and 0.03 % ($p < 0.05$) for milk, casein, and lactose yields, and lactose content, respectively. Negative effects were evident for fat (-0.12 %, $p < 0.0001$), protein (-0.09 %, $p < 0.0001$) and casein (-0.07 %, $p < 0.0001$) contents. The Tyrosine variant of GHR F279Y was associated with lower SCS ($p < 0.05$). For the PRLR S18N polymorphism, Serine was the major allele (76.7 %). The Asparagine variant had a significant ($p < 0.05$) effect on the casein content (0.02 %). For the CSN3 gene locus, the allele encoding the protein variant A was higher frequent (85.1 %) and the minor Allele B was associated with protein (0.03 %, $p < 0.05$) and casein contents (0.03 %, $p < 0.05$). This study demonstrated that power of candidate gene analyses. The gene effects are considered in genome wide genomic selection programs.

Keywords: Candidate genes, dairy cow, milk composition, milk yield, somatic cell score

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Dual-Purpose Cattle Production in Nicaragua: Which Breed Fits Best?

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The importance of milk and beef production in Latin America is high and increasing. In Nicaragua and neighbouring countries, smallholder dual-purpose (i.e., milk and beef) cattle production offers opportunities for poor cattle owners to improve their food and nutrition security, and increase their income. The milk and beef value chain employs thousands of people in production, processing and marketing. In order to improve production, many farmers currently practice crossbreeding, involving a large range of breed combinations, but without clear breeding strategies. To assess current farmers´ practices and develop appropriate breeding and related management recommendations, a research project that brings together the national agricultural university of Nicaragua (UNA), the International Livestock Research Institute (ILRI), the International Center for Tropical Agriculture (CIAT and BOKU-University is being implemented in two study sites in Central Nicaragua, Camoapa and Matiguás Municipalities. A gender-responsive baseline survey with questionnaires was performed with 289 households in Camoapa and 252 in Matiguás, using a random sampling procedure based on official census data. A "paperless" data collection format was adopted using the "Open Data Kit" (ODK) information technology platform.

Most households (>83 %) were male-headed in both municipalities. Mean age of the household head was higher in Camoapa (51.4±14 years) than in Matiguas (48.9±14 years).

Most of the cattle reared in the two municipalities were cross-breds (>98 %). The crosses comprised combinations between several breed-types. The most abundant breed-type in Matiguás was the Brahman, while in Camoapa there were more Brown Swiss and Holstein cross animals. At both locations also other breeds such as Creole, Girolando, Jersey, Nellore, Reyna and Simmental were found, whereas a large proportion of animals were crosses of unknown breed-types. Farmers stated different reasons for using various breeds in their herds such as availability of semen or bulls or different purposes for production. This is also reflected in the selection criteria of farmers. In comparison to Matiguás, cattle production in Camoapa is more intensive (higher number of animals per hectare, stronger tendency towards dairy production), this probably being an effect of a stronger presence of development organisations.

Keywords: Breeding strategies, dual-purpose cattle, Nicaragua

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Faecal Inoculum as Alternative Microbial Source for *in vitro* Rumen Fermentation Techniques

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In vitro techniques are simple method to determine feed value and most common source of microorganisms are fresh rumen liquor from fistulated animals. However, there is need to use alternative inoculum due to the costly management of fistulated animals, surgical procedure is an highly invasive technique which many countries has restricted its use accounting to animal's welfare issues. Hence, the objective of the present study was to evaluate the degradability of dry matter (DDM), crude protein (DCP) and neutral detergent fiber (DNDF) of three substrates on *in vitro* and *in situ* assays. Experiment was conducted at Laboratory of Animal Nutrition, CENA / USP - Brazil. Four adult fistulated Santa Ines animals were selected as inoculum donors of rumen liquor and fecal inoculum and animals were supplemented with 70:30 ratio of roughage: concentrate. Disappearance percentage of DM, CP and NDF were calculated in terms of weight difference between weighing before and after incubation *in situ* (rumen inoculum) and *in vitro* (fecal inoculum). The study was investigated in a completely randomised design for 24h and 48h incubation with a 3×2 factorial arrangement (feeds (100 % concentrate, (70:30) maintenance ration and 100 % Tifton hay) and two inoculants (rumen and fecal). Treatment means were compared by Tukey test at 5 % probability and correlation analysis was performed. There was interaction effect on substrate $\times$ inoculum for DDM ($p < 0.01$), DCP ($p < 0.01$) and DNDF ($p = 0.05$). On average, substrates incubated *in situ* resulted in greater potential degradation ($p < 0.05$) compared to *in vitro* incubation for DDM (63.36×40.67), DCP (67.78×44.63) and DNDF (56.06×31.99) with regardless of incubation time. Among the three substrates tested, concentrate had higher DDM values (88.16 and 57.36), DCP (85.38 and 52.04) and DNDF (88.07 and 60.39) followed by maintenance ration (57.30 and 39.10, 70.45 and 64.93; 54.12 and 34.43) and Tifton hay (44.62 and 25.55, 47.52 and 16.91, 27.98 and 1.14) incubated *in situ* or *in vitro* respectively. Our study concludes that although fecal inoculum showed lower degradability of feed constituents, it may be used as alternative microbial source for *in vitro* techniques.

Keywords: Alternative inoculum, degradation, faeces

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Natural Preference of Sheep for Saline Drinking Water in Relation to Ambient and Rumen Temperature

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Bangladesh is one of the frontline victims of global climate change. Among the impacts of climate change, increased salinity intrusion, particularly, in the southern coastal belts of the country endangers flora and fauna. This is also enforcing the local livestock population to adapt with increased water and soil salinity. This study investigates the tolerance of sheep for sodium chloride in drinking water. We explored whether sheep differentiate between fresh and saltine water, and their taste preferences with ambient temperature. Twelve sheep (Deutsches Schwarzkopf) aged between 1 to 8 years with an average body weight of 74.3 $\pm$ 10.1 kg were kept in individual experimental pens under controlled stable conditions. A two choice preference test technique was designed as the principal method. Each individual pen was equipped with two buckets and the positions of the fluids were reversed randomly in order to avoid a bias due to side preference. Consumed test solution was expressed as a percentage of total fluid taken from both containers. In addition, drinking behaviour was recorded by video. Throughout the experiment the sheep had access to hay and a salt lick ad libitum. As indirect measure of core body temperature, rumen temperature was recorded with a temperature logger. Food intake, respiratory rate, fleece length and body weight were measured regularly. Data on ambient temperature and relative humidity were recorded. The data collected for 2 weeks during the control phase (two buckets with fresh water only) revealed a tendency for sidedness (sheep consumed 4.58 % more water from the left than from the right side). Data of the choice test period will be analysed for the relationship between ambient temperature and preference for saline water.

Keywords: Adaptability, drinking water, salt tolerance, sheep

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Genetic Variation of Beta-Case in Gene in Sudanese Indigenous Cattle

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Sudanese indigenous cattle are part of East African *Bos indicus* cattle, have been gradually declining in numbers over the last years due to breed substitution, and crossbreeding. Therefore, conservation and improvement strategies are required to maintain these breeds, which are well adapted to the local environment. The aim of this work was to analyse milk protein genetic variation in the Sudanese indigenous cattle breeds.

The genetic variation at Beta-casein gene (CSN_2) was investigated in 220 animals belonging to five *Bos indicus* cattle breeds of Sudan (Butana, Kenana, White Nile, Erashy and Elgash). Allele specific primers were designed for five SNPs determine the CSN_2 variants A1, A2, B, I, J and L. Allele frequency, mean effective number of alleles and the magnitude of genetic divergence between populations as Nei's genetic distance (D) were calculated and the phylogenetic tree was constructed.

All breeds were found to be polymorphic for the studied gene. The CSN_2* A2 variant was found very frequently (>0.53) in all analysed breeds with highest frequency (0.77) in Kenana cattle. The second most frequent CSN_2 variant was CSN_2*L (0.12 to 0.22) followed by CSN_2*A1 (0.04 to 0.23). The mean absolute number of alleles was varied between breeds. The mean effective number of alleles per breed was similar for all breeds. The estimated D ranged from 0.003 to 0.023. The most distant breeds were Kenana and Elgash cattle (D 0.023). The results presented contribute to the genetic knowledge of indigenous cattle and can be used for proper definition and classification of the Sudanese cattle breeds as well as breeding, utilisation, and potential development of conservation strategies for these breeds.

Keywords: Beta casein, *Bos indicus*, cattle, milk protein genes

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Adaptation Strategies to Challenges in Small Ruminant Production in NE Brazil: Farmers' vs. Experts' Views

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The Northeast of Brazil is considered the poorest area of the country. In the semi-arid Itaparica region of Pernambuco, characterised by irregular precipitation, a long dry season and frequent droughts, goat and sheep production is a common livelihood strategy. This study explores farmers' challenges and their respective adaptation strategies and contrasts experts' perception concerning small ruminant production.
60 small ruminant keepers were interviewed using questionnaires with quantitative and qualitative questions. 10 open interviews were conducted with experts from agricultural institutions and cooperatives. Data were analysed with descriptive statistics.
Drought and subsequent forage shortage, particularly in the Caatinga rangeland, was perceived as the most impacting challenge by 68 % of small ruminant keepers. Low investment capacity was named as second most important constraint (12 %). Further challenges of lower importance were toxic plants, predators and robbery. As coping or adaptation strategy to drought and forage shortage, 49 % of farmers mentioned to buy additional feed, e.g. maize and soybean; 20 % cultivated grasses or other forages, or cut and carried fodder from the Caatinga and 13 % relied on a partitioned dry season forage reserve for grazing or browsing. Further 13 % did not apply any strategy against drought and 5 % provided water. 42 % of respondents wanted to enlarge or implement an irrigation system for forage production. 78 % of the farmers would like to receive (more) technical assistance.
Experts also regarded drought as a main limitation but emphasised the reluctance of farmers to adopt technologies, the missing extension and the missing financial capital of farmers in order to investment in new technologies as main challenges. Experts' most frequently mentioned adaptation strategy was to increase technical assistance in order to increase knowledge and innovativeness of farmers. Irrigation, forage production and conservation and use of adapted breeds were suggestions for adaptation strategies to drought. Further suggestions were improving local policies supporting farmers and facilitation of credits.
Results showed that farmers mainly applied coping strategies whereas experts only mentioned adaptation strategies. In contrast to farmers, experts emphasised strengthening the extension and financing system in order to increase farmers' adaptation capacity.

Keywords: Adaptation strategy, challenge, drought, Itaparica region, Pernambuco, small ruminant production

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Effect of Intercropping Clover with Wheat on Grain Yield and their Fodder Production on Dairy Goats Performance

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Legume intercropping of cereals is a commonly adopted practice when soil fertility is limited. This study evaluated the fodder production of early cuts of mono cropping Wheat (W), Egyptian clover (C), and intercropping both crops (CW) on final wheat grain yield, fodder dry matter yield, fodder nutritive value, and milk yield and its composition. The first cut at the level of 15 cm above ground at 69 days after sowing was to evaluate the systems in providing animal feed at an early production stage. The fodder was preserved as silage (clover silage (CS), wheat silage (WS) or wheat & clover mixture silage (CWS) and further tested in goat rations. After the early cut, all crops (C, W and CW), were left till final grain harvest. Sixteen lactating goats with a live body weight of 41.0 $\pm$ 1.3 kg were divided into four groups. Clover hay was completely replaced through one of the silages: i) concentrate feed mixture (CFM) with clover hay (control group, CH), ii) CFM with clover silage (CS), iii) CFM with wheat silage (WS) and iv) CFM with wheat & clover mixture silage (CWS).
Data collected indicated that intercropping significantly ($p < 0.01$) yielded more fodder than mono cropping (+27 %) but slightly depressed grain yields (-4 %) as compared to mono wheat cropping. The nutritive value of clover silage (CS) as crude protein (CP) was significantly ($p < 0.01$) higher (12.5 % DM) than CWS (10.6 % DM). NDF and DM degradability of CWS was significantly (P<0 0.05) higher (21.2 and 13.5 %) as compared to CS and WS. The lowest intake (DMI) was recorded for the CH group (422 g DM d^{-1}). The main results showed that goats fed ration with CWS recorded the highest ($p < 0.01$) average daily milk yield (1.23 kg d^{-1}). The lowest milk yield was recorded for group CH group (0.94 kg d^{-1}). In conclustion, intercropping legumes with cereals helps to improve fodder DM yield and increase the productivity of dairy goats. It further reduces the competition between human and animal food production.

Keywords: Average milk yield, clover, dry matter intake, grain yield, intercropping, milk composition, wheat

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Increasing Food Security through Evaluation of Prospects Cattle Stallions of the Breed Simmental and Simbrah

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In Mexico, agricultural and forestry production are the main land use activities, covering 57.3 % of the country. These land use activities in the state of Nuevo Leon cover 5.5 million hectares, representing 86% of the state are; 386.474 heads of cattle are kept in this state, ranking 20 for the country wide production of domestic beef. Additionally, in Nuevo León the per capita meat consumption is with 37 kg per year the highest in the country (national average 21 kg meat per capita). Simmental and Simbrah breeds might be an alternative to meet the state needs for beef meat. Therefore, studies are needed to corroborate the ability of these two breeds to adapt to the ecological and economic conditions of the country, especially in northern Mexico. The aim of this study was to evaluate different production traits of economic importance of the breeds Simmental and Simbrah under a suitable environment. Behavioural tests were used to evaluate the stallions (prospect to be a stallion). The study was performed during a 4 months observation period, in Linares, Nuevo León, Mexico. Measurements were made monthly. The variables evaluated were: daily gain for the period (ADG), daily gain for age (GDE), weight adjusted to 365 days, loin eye area, intramuscular fat percentage, back fat, genetic markers (smooth and marbling), body size and scrotal circumference. The results showed that the Simmental breed behaved better than the Simbrah, with respect to the variables increase in daily weight and increase in final weight. Likewise, it was noted that there were no statistically significant differences between the two breeds with respect to the variables weight adjusted to 365 days, area of the loin eye, percentage of intramuscular fat, fat, genetic markers (softness and “marmoleo”), body size and scrotal circumference.

Keywords: Genetic markers, race Simbrah, race Simmental, scrotal circumference, stallions

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Enteric Methane Emission and Nitrate Toxicity in Sheep Fed Encapsulated Nitrate

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Nitrate administration in diets for ruminants decreased methanogenesis and reduced methane intensity. However, it is well known the toxic effect of nitrate by nitrite accumulation, but a feeding adaptation strategy can reduce the nitrate poisoning. The purpose this study was to assess the effect of nitrate supplementation in ruminants on its toxicity and extent of methane mitigation. Six rumen cannulated lambs were distributed in a 6×6 Latin square, 2×3 factorial arrangement experiment. Factors were type of diet (20:80 and 80:20 concentrate : forage ratio) and inclusion of encapsulated nitrate (PNE; 0, 1.5, 3.0, and 4.5 % in dietary DM). Doses of nitrate corresponded to 0; 11.7 and 24.2 g NO_3 in dietary DM. Encapsulated nitrate replaced soybean meal to achieve isonitrogenous diets. The animals were acclimated gradually to nitrate stepped up from 0.5 % in the ration every 3 day until it reach 1.5 % and 3 % in the finisher ration respectively. We evaluated the toxicity of diets by following blood methemoglobin and measuring methane (CH_4) emission by open chamber technique. Treatment means were compared by Tukey test. Dry matter intake (DMI, $p = 0.48$) and methemoglobin ($p = 0.32$) were not affected by addition of PNE. Very low blood methemoglobin levels were observed 3 h after feeding, (3.21, 4.1 and 4.4) with increasing of nitrate level in diets. A 29 % reduction in estimated daily methane production ($p = 0.06$) was observed on diets with 80 % of concentrate with nitrate (27.5, 19.6 and 19.3 L CH_4 / day respectively for 0, 1.5 and 3 % PNE,) when compared with diets without nitrate. It is suggested that supplementary nitrate can be used to mitigate enteric methane emission with low risk by nitrite poisoning, if animals have a gradual acclimation of nitrate.

Keywords: Hydrogen sinks, methanogenesis, nitrite poisoning

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In-vitro and *in-vivo* Methane Production from Improved and Traditional Rations of Dairy Cows in India

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Enteric methane (CH_4) emissions arise from carbohydrate fermentation in the forestomachs of ruminants. Feeding dairy cows a balanced diet aims at increasing their productivity; however, it is less clear whether it may also reduce the CH_4 emissions per kg of ingested feed dry matter (DM). This study analysed differences in CH_4 emissions by cows fed traditional Indian dairy rations before (BRB) and after ration balancing (ARB) using both *in-vivo*- and *in-vitro*-techniques.

The CH_4 emitted by Holstein–Friesian crossbred cows (n=35) that first received a BRB and then a ARB diet in two subsequent experimental periods was measured by the sulphur hexafluoride tracer technique at the National Dairy Development Board (NDDB) in India. Additionally, 35 samples each of the two diet types were analysed using the Hohenheim gas test at NDDB and the University of Hohenheim (UHOH). The parameters measured in these *in-vitro*-trials were gas production (GP) (ml/mg truly degraded DM), CH_4 production (ml/g DM), partitioning factor (mg/ml), and short chain fatty acid (SCFA) concentrations (μmol/ml) in rumen fluid. Mean values were compared statistically using SAS 9.4.

Although only GP was lower in ARB than in BRB diets in in-vitro-trials at NDDB ($p < 0.01$), at UHOH GP ($p < 0.01$) and total SCFA concentrations ($p = 0.04$) were lower in ARB and the partitioning factor ($p = 0.02$) was higher in ARB than in BRB diets. Thus, the ARB diet improved feed DM degradability without adversely affecting rumen fermentation. Neither diet was associated with significant differences in *in-vitro*- and *in-vivo*-CH_4 production (ml/g DM), suggesting that CH_4 emissions per unit of feed intake are not reduced when animals are fed balanced diets. However, lower CH_4 emissions per kg of milk yield can be expected due to an increase in performance of animals fed more balanced diets. The correlation between *in-vitro*- and *in-vivo*-CH_4 production (ml/g DM) was weak. Thus, although the Hohenheim gas test is useful for screening many samples in a short time, it is of limited value for predicting CH_4 emissions from ruminants *in vivo*.

Keywords: Balanced diet, dairy cows, Hohenheim gas test, *in vivo* technique, methane

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Effect of Carbohydrate and Nitrogen Sources on Feed Intake, Nitrogen Balance, and Performance of Sheep

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The study aimed to evaluate the effect of different carbohydrate and nitrogen (N) supplements on feed intake, nutrient utilisation, and performance of sheep. Twelve male Dorper sheep with a body weight (BW) of 23 kg (standard deviation (SD) 2.20) were used. The experimental design was a 4 × 3 Youden square which consisted of four experimental diets and three 21-d-experimental periods (14 d adaptation and 7 d sample collection). Two carbohydrate sources (whey permeate, corn) and two N sources (protected urea, unprotected urea), which differed in their rate and extent of degradation in the rumen, were combined, resulting in four diets:
1) rapidly degradable carbohydrate with rapidly degradable N source (whey permeate-unprotected urea), 2) slowly degradable carbohydrate and slowly degradable N source (corn-protected urea), 3) rapidly degradable carbohydrate with slowly degradable N source (whey permeate-protected urea), and 4) slowly degradable carbohydrate with rapidly degradable N source (corn-unprotected urea).
Dry matter (DM) intake ($p = 0.75$), apparent total tract digestibility of DM ($p = 0.89$), and daily BW gain ($p = 0.98$) were not affected by dietary treatment. Mean daily DM intake (g/kg $BW^{0.75}$), total tract DM digestibility (%), and daily BW gain (g/kg $BW^{0.75}$) were 60.4 (SD 3.45), 60.1 (SD 3.17), and 2.0 (SD 6.34), respectively. However, N intake (g/d), urinary and fecal N excretions (% of N intake) and, to some extent, N retention (% of N intake), were affected by carbohydrate source, regardless of N source. Urinary N excretion was significantly reduced ($P < 0.01$), fecal N excretion was higher, and N retention had a tendency ($p = 0.09$) to increase when sheep were fed a rapidly degradable carbohydrate (whey permeate) compared with corn, regardless of N sources. This implies that sheep receiving whey-permeate-based diets utilised N more efficiently than those sheep receiving diets containing corn. Moreover, the decrease in N excretion with whey permeate may be of ecological significance by potentially reducing the excretion of N into the environment.

Keywords: Carbohydrate, nitrogen metabolism, protected urea, protein, sheep, whey permeate

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Effects of Quebracho Tannin Extract on *in-vitro*-Rumen Fermentation and Chemical Composition of Liquid-Associated Microbes

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Condensed tannins bind to proteins, thereby protecting them from rumen degradation and increasing the postruminal flow of dietary amino acids. In this study, the effects of a quebracho tannin extract (QTE) on *in-vitro*-rumen fermentation and chemical composition of liquid-associated microbial mass (LAM) were evaluated.

Three experimental substrates were tested:

1) Control: basal diet [in g/kg dry matter (DM)): grass silage (335), maize silage (315), extruded rapeseed (160), wheat (92.5), concentrate (92.5), and a mineral premix (4.0)]; 2) QTE15: control + QTE (15 g kg^{-1} DM); and 3) QTE30: control + QTE (30 g kg^{-1} DM).

Each substrate was incubated in three runs, with three replicates per run (n=9). Two grams of substrate were incubated in 300 ml of incubation medium (phosphate buffer and rumen fluid, 2:1 ratio) in a water bath at 39°C using an Ankom RF system. After 24 h, total content of the flasks was centrifuged at 500 g (4°C, 10 min) to separate feed particles. The supernatant was decanted and centrifuged at 20.000 g (4°C, 8 min) to separate LAM. This fraction was lyophilized, ground, and analysed for nitrogen, carbon, adenine, and guanine contents. Of the remaining supernatant 5 ml were collected for volatile fatty acids (VFA) and ammonia determination. The data were analysed by a general linear model with QTE level (0, 15, and 30 g kg^{-1} DM) as main effect and run as block effect. Polynomial contrasts were performed to find linear and quadratic effects.

Addition of QTE linearly decreased total VFA concentrations (mmol/ml), reflecting a lesser substrate degradation. Similarly, QTE linearly decreased the proportion of propionate, indicating an energetically less efficient fermentation. Proportions of valerate, iso-butyrate, and iso-valerate and ammonia concentrations also decreased with QTE addition, indicating a reduced protein degradation. The contents of adenine, guanine, nitrogen, and carbon of LAM were not affected by QTE level.

The QTE addition to ruminant diets may be beneficial in protecting feed protein from rumen degradation, but the rate and extent of carbohydrate degradation might be impaired as well. Chemical composition of microbial matter may be unaffected, but reductions in rumen microbial protein synthesis cannot be excluded.

Keywords: Chemical composition, *in vitro*, microbial fraction, purine bases, Quebracho tannin

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Economic and Water Footprint Evaluation Based on Intensity of Production for Dairy Farms in Bangladesh: Implications for Food Security

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Milk production in Bangladesh falls under pressure as a result of rising demand and simultaneously it has faced challenges to cope with high input and low output prices. Apart from this, water scarcity is an increasing problem which affects the environment, society and dairy production. Dairy farming needs to consider more efficiently both costs and water use (WU), therefore, the objective of this study was to assess the costs and water footprint (WF) of one kg energy corrected milk (ECM) on six typical case farms representing three different production systems with varying intensity. Further, a scenario analysis was carried out in order to identify potential ways to reduce costs and WF. The economic analysis was done by applying the TIPI-CAL 5.2 model. The WU impact assessment was assessed by Life Cycle Assessment-based WF method.

The average cost of milk production ranged from 0.23 to 0.33 USD kg^{-1} ECM. The higher the production intensity, the lower the costs per kg ECM were observed. The lower costs were due to lower opportunity costs of own factors of production and very limited fixed costs per kg milk. The feed cost had the highest contribution (an average 0.18 which accounts for 67 % of average costs 0.27 USD kg^{-1} ECM) to the total costs. The opposite results were observed when analysing the WF, the higher the intensity of production, the higher the WF kg^{-1} ECM. The single stand-alone WF (L H_2O e kg^{-1} ECM), integrating consumptive and degradative WU impacts, ranged from 11 to 45. The determinants for lower costs were the increased milk yield, feed efficiency, labour-land productivity, irrigation and purchased compound feed. A larger WF was due to a higher water stress index, purchased feed and irrigation. The scenario analysis showed that there was a potential tradeoff between economy of production and reduction of WF. However, results suggest that altering farming system towards high yielding cows and on-farm feed production in regions with lower water scarcity index might be an option to reduce costs and burden on water systems for sustainable dairy farming, thereby keeping the competitive advantages of the dairy industry and increasing food production for ensuring food security.

Keywords: Bangladesh, food security

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Sustainable Dairy Development in the Kenyan Highlands: Effect of Market Quality on Smallholder Farming Systems

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Smallholder dairy farming systems in the Kenyan highlands show diversity in production resources and outcomes. Farms are spatially distributed at varying distances to urban markets. It was hypothesised that production outcomes are affected by market quality which depends on distance to urban markets. To test the hypothesis, interviews and discussions were held with smallholder farmers and other stakeholders in three locations with differences in proximity to the urban market of Nakuru town. In urban locations (UL), markets had good accessibility and prices of inputs, e.g. concentrates and labour, were slightly higher while milk price was considerably higher than in mid rural locations (MRL) and extreme rural locations (ERL). Farm resources differed among locations, UL had the least land while MRL had most grazing land available. Livestock number did not differ significantly among locations. Input use, milk yields and economic benefits were also not different among locations. On the basis of the hypothesis, it was expected that market quality would be high in locations close to urban markets, with high prices for milk, labour, land and forage and relatively low prices for concentrate that would create high concentrate use and high milk production per cow. In UL, the observed high milk price was in line with the hypothesis while the high concentrate price, low concentrate use and low milk yield per cow were not. This low production intensity in UL was attributed to forage limitation (which was caused by land scarcity), high cost for purchasing of forages and concentrate, low cash availability and the livelihood functions of dairy. Therefore, proximity to urban markets alone did not result in increased milk yield per farm or per cow. Improving forage availability provides an opportunity for sustainable dairy development in urban Kenyan highlands.

Keywords: Kenyan highlands, market quality, production outcomes, smallholder dairy systems

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Non ruminant production systems

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Biosecurity Practices in Small Scale Pig Farms in Hung Yen and Nghe An, Vietnam

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With pork representing more than 70 % of meat consumption in Vietnam pig production is growing fast and plays an important role in the livestock production. Especially smallholder farms contribute substantial to the pork supply (approximately 80 %) because of consumer preferences, subsistence and commercial purposes. Despite of this considerable market share the overwhelming majority of smallholder pig farms lack of technologies, biosecurity and control measures in terms of diseases, hygiene and environment conditions. As being part of a wider research on improving smallholder pig value chains in Vietnam a longitudinal survey was conducted with the objectives to assess biosecurity practices and related farm management which will be used to identify suitable options for improved disease control. The survey was carried between March and December 2014 in the Hung Yen and Nghe An provinces of Vietnam. Thirty farms were selected randomly in each provinces as a sub-sample from a larger sampling frame (N=416) and visited in fortnightly intervals. On farm data by using a checklist and observations included information on farm management, biosecurity measures, working and feed storage conditions as well as diseases events. In general diseases control measures were found insufficient. The majority of farmers allowed visitors to access the farm without any restrictions (69.7 %) throughout the entire observation period. Disinfection mattresses were installed only in 42.7 % of visits, and even applied, often not maintained. The use of protective clothes and boots by workers was the exception (81.2 %). Pre-weaning piglets were usually not provided with litter (88.9 %) and/or heat sources (74.1 %), the latter being a particular constraint during the cold season. From an animal welfare perspective it was notable that only approximately half of farms provided permanent water access to their pigs (48 %). Poor management was also reported for feed handling and storage with clear signs of rodents or pests in feed (47.9 %) and visible signs of moisture (49.4 %). Observed gaps in farm management will be addressed in the upcoming intervention phase by developing and testing of packages guided by feasibility, cost benefit and farmers compliance.

Keywords: Biosecurity, farm management, pig, smallholder, Vietnam

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Nigella sativa Seeds Effects on Growth, Blood Parameters, Carcass Quality and Antibody Production in Quails

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Nigella sativa seeds (NSS) had been used by the ancient Egyptians and Greek physicians to treat headaches, asthma, allergies and improve immunity. NSS has shown many other pharmacological effects such as antibacterial, antitumor, anti-inflammatory, reliever and hypoglycemic. Pharmacological and therapeutic effects of this herb are so large that it is mentioned as a miraculous plant. NSS utilisation has displayed some effects on broiler performance layer performance and egg quality. For evaluating the effects of different levels of NSS in quail rations on performance, some blood parameters, carcass quality and antibody production to sheep red blood cells (SRBC), totally, 240 one-day old quails were allocated to one of 4 diet treatments (with 4 replicates of 15 quail chicks each) in 4 levels of NSS (basal diet with 0 % (control), 0.5 % (treatment 1), 1 % (treatment 2) and 1.5 % (treatment 3)) for 6 weeks. Body weights of broilers were measured weekly, feed intake was measured for different periods and FCR was calculated accordingly. At 42 days blood samples were collected for biochemical and hematological analysis. 2 birds per replicate were slaughtered for determination of carcass and organ weights at 28 and 42 days. Intramuscular injections of SRBC were performed at 14 and 28 days of age and blood samples were taken for measuring antibody titers 7 and 14 days after SRBC injections. Dietary treatments affected feed intake at 0–21 days, but did not in 21–42 days or 0–42 days. Cholesterol and triglyceride levels were statistically decreased by 1 % or 1.5 % of NSS ($p < 0.05$). HDL and RBC significantly increased in chicks given NSS. The levels of albumin, total protein, HDL, VLDL, Hb and PCV and the relative weight of internal organs and carcass were not significantly affected by the NSS. The relative weight of bursa and antibody titers to SRBC increased at 42-days. It is concluded that NSS had beneficial effects on weight gain, FCR and health of quail chicks.

Keywords: Antibody production, blood parameters, carcass quality, growth, *Nigella sativa* seeds, Quail

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The Effects of Garlic and Tea Supplementation on some Physico-Chemical Characteristics of Hen's Eggs

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This study was conducted to evaluate the effect of garlic and tea on the performance, egg traits and laying parameters of laying hens. Black leghorn hens, Yafa breed, aged 21 weeks were fed basal diet (commercial feed) supplemented with garlic at 1 and 2 % levels and tea at 1 and 2 % levels. Feeding was done for 4 weeks after a one week acclimatisation period on test and control feeds. The effects of supplementation on the number and weight of eggs layed, the weight of hens and the weight of egg yolk were determined. Also determined were the total triglycerides, HDL-, LDL-, and total cholesterol content of egg yolk. Feeding of hens for 4 weeks with test and control diets resulted in non-significant changes ($p > 0.05$) in the weights of birds, weight of eggs and egg yolk. 2 % garlic supplementation resulted in a non-significant increase in the number of eggs layed. All the garlic supplemented feeds resulted in significant reductions ($p < 0.05$) of total cholesterol, total triglyceride, LDL- and HDL-cholesterol. With exception of the 1 % tea supplemented diet, the other tea supplemented diet resulted in significant reductions in the cholesterols tested. 1 % tea supplementation had no significant effect on LDL-cholesterol concentration of egg yolk ($p > 0.05$). The combination of garlic and tea resulted in significant reductions of total- LDL- and HDL-cholesterol ($p < 0.05$) but not total triglycerides ($p > 0.05$). The control diets had in most cases non-significant effects on the lipid parameters tested. Anti-cholesterolemic agents found in garlic and in tea flavonoids could be responsible for the for the reduced cholesterol content of egg yolk from test layers. The results show that garlic and tea have great potential when low cholesterol egg is desired.

Keywords: Cholesterol, egg yolk, garlic, layers, tea

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Alternative Dietary Energy Sources in Grower-Pig Nutrition

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The scarcity and consequent high prices of conventional dietary energy feed ingredients such as maize has been attributed to the low non-ruminant animal production in most parts of Africa. The search for alternatives has therefore become imperative. The aim of this study was to evaluate the effects of different dietary energy sources namely; maize, palm kernel meal (PKM), brewer's dried grain (BDG) and wheat offal (WO) on growth performance and economics of producing grower pigs. Sixty-four (64) grower pigs (Large white $\times$ Landrace) were fed for 6 weeks. The grower-pigs were randomly assigned to four treatments diets (1, 2, 3, and 4) in a complete randomised design (CRD). Each treatment group contained four replicates with four grower-pigs per replicate. In diet I (control), maize served as the energy source, while in diets 2, 3 and 4 palm kernel meal, brewers dried grain and wheat offal served as alternative dietary energy sources respectively. Data on performance characteristics for feed intake and feed conversion ratio were not significantly ($p > 0.05$) influenced by the dietary treatments. Weekly weight gain showed significant ($p < 0.05$) differences with mean values of 4.4 kg, 5.0 kg, 4.1 kg and 4.4 kg for treatments 1, 2, 3, and 4 respectively. Average total weight gain/pig showed significant ($p > 0.05$) differences as influenced by the dietary treatments. The values ranged from 24.4 kg in the BDG diet to 30.2 kg in PKM diet. The cost benefit analysis revealed that the highest cost of feed per kg (N) was recorded in the control maize diet with N75.5. The cheapest was in PKM diet with N55.7. The income (N/pig) was highest in diet 2 (PKM) followed by the wheat offal, maize and BDG diets (N9,966.0; N8,844.0; N8,778.0 and 8,052.0) respectively. The net profit (N/pig) was highest in the PKM diet followed by diet 4(wheat offal), 3 (BDG) and I (maize) with their correspondent monetary values as N5,186.94; N3,949.24; N2,992.8 and N2, 422.4 respectively. In conclusion, it was evident that palm kernel meal (PKM) could be used to replace maize wholly in diets of grower-pigs without any negative effect on growth and health performances of the pigs.

Keywords: Brewer's dried grain, dietary energy, grower pigs, maize, palm kernel meal, wheat offal

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Evaluation of the Potential Inclusion of *Dichrostachys cinerea* Pods in Pig Diets in Cuba

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Dichrostachys cinerea (L.) Wight & Arn. is an invasive leguminous shrub which has occupied a significant proportion of Cuba's agricultural land over the past decades, thus becoming a primary threat to national food security. As a result of the difficulty to rid this pesky plant through traditional methods, a twofold alternative approach has been considered: to promote improved control of its spread by integrating it into sustainable production systems while making profitable use of its potential products. *D. cinerea* pods contain acceptable amounts of protein, which could be of a benefit for Cuba's smallholder pig sector, which is mainly constrained by the lack of locally-produced protein concentrates and the added difficulties to import them from abroad. Consequently, this work aims to evaluate the potential of including *D. cinerea* pods into pig diets in Cuba. Results will be presented from a study, where different methodologies were applied. Firstly, nutrient composition was determined by proximate analyses. Secondly, an on-farm feeding trial over a 60-day period has been put into practice, including substitution of *D. cinerea* pods for commercial feed at 0 %, 15 % and 30 % levels. Different parameters were evaluated among the three tested groups: net weight gain, daily weight gain, parasites in feces and blood parameters. In addition, an *in-vivo* digestibility trial is being carried out by applying the difference method against a feed source of a known digestibility value. This has been followed by another *in-vitro* digestibility trial for organic matter at the ileal level, using the enzymatic method. Finally, an economical assessment on the potential commercial value of *D. cinerea* as feed for pigs has been made.

Keywords: Cinerea, Cuba, *Dichrostachys*, feeding, mimosa, pig

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Increasing Smallholder Pig Farmers' Adaptive Capacity: Low-Cost Balanced Diets for East African Pigs Using Livestock and Plant Co-Products

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By acquiring livestock poor farmers can ascend out of poverty. Pigs require minimal inputs and raising them is often within disadvantaged members of society's means. In East Africa, 2.2 million pigs are raised by resource-poor, subsistence farmers most with under 2 hectares of cropland. They typically raise 1–4 pigs to pay for school, medical costs, food, and seeds, but pig productivity is low. Lack of feed, seasonal feed shortages and unbalanced diets contribute to slow growth, resulting in compromised earnings from pig-raising.

We estimated East African pig feedstuff nutrient composition through nutrient analysis and from literature. Seasonal availability was identified by local experts. Performance results from local-breed pig feeding trials were used to adjust the NRC (2012) nutrient requirement model for growing-finishing pigs. Local pigs' nutrient requirements under typical management conditions (intestinal parasites present and free-ranging) were estimated. A least-cost diet formulation programme was used to generate diets minimising cost and human/pig competition for food, maximising agricultural co-products and forages use, considering seasonal availability, and satisfying minimal requirements for digestible energy 2960 kcal kg^{-1} of dry matter [DM]), calcium, standardised total tract digestible phosphorous, standardised ileal digestible crude protein and lysine (0.28, 0.13, 8.5, and 0.58 % of DM respectively)

Feedstuffs availability differed between November-February; June-August; and March-May plus September-October. Estimated growth performance potential of local pigs is less when free-ranging, or intestinal parasite infected, than when restrained and non-infected (80; 217; and 259 g per day respectively) A typical least-cost diet for June-August (all as % of DM) is: maize flour 20.6; cassava leaf 20.0; sweet potato vine 19.2; ripe avocado 15.0; *Bidens pilosa* 7.9; limestone 7.7; molasses 5.0; cattle blood 3.9; *Amaranthus spinosus* 0.3; table salt 0.24; premix 0.10. Sun-dried fish (*Rastrineobola argentea*) and grist mill waste are available all year as substitutes for seasonably available ingredients e.g avocado and sweet potato vine.

Use of such diets will enable continuous pig feeding during all seasons, thereby increasing farmer resilience. Their use will improve pig performance resulting in increased farmer income, enabling poverty alleviation, improved food security, human health and nutrition, and investment in other livelihood ventures to further increase resilience.

Keywords: Adaptive capacity, diet, locally available feeding stuffs, nutrient requirements, pigs, subsaharan Africa, subsistence farmers

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Physiological Response of Laying Birds Fed Honey and Vitamin C in Drinking Water

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The continuous challenge of climate and its impact on livestock with the resultant threats in food security has necessitated the need to mitigate the effects of stress resulting thereof on the physiological response of layers. This study was designed to investigate the effect of honey and vitamin C fed to layers in drinking water, on the physiological response, growth performance, egg quality characteristics, hematology, serum biochemistry and cost benefit of the birds. One hundred and twenty Shika brown layers were randomly divided into four treatment groups of 30 layers, each replicated three times with 10 birds per replicate, in a randomised complete block design (RCBD). The groups were fed four diets containing 0 ml (only water), 200 mg litre^{-1} (vitamin C.), 10 ml honey and 20 ml honey representing treatments 1, 2, 3 and 4, respectively for 84 days during the wet and dry seasons. The measurements taken include body weights, external and internal egg characteristics, daily temperature and relative humidity of the pen, heart and respiratory rate, daily rectal temperature and blood samples. Layers on T1 recorded the highest mean values of 114.6 beats per minutes (bpm) and 39 bpm for HR and RR, respectively. Layers on T4 was superior to those on T1 with regard to body weight (1827 g) and hen day production (80.9 %) as against 1717 g and 53.3 % for T1, respectively. The hematological profile viz; hemoglobin (Hb), PVC, RBC was significantly ($p < 0.05$) influenced by the treatments. Layers on T4 recorded the highest PCV (31.0 %), Hb (8.33 g l^{-1} and RBC (2.53/l) than T1, PCV (25.63 %), Hb (6.23 g l^{-1} and RBC (2.1l). The result on serum biochemistry showed that there were significant ($p < 0.05$) differences among treatment means in respect to total proteins (4.01 g dl^{-1}), urea (7.46 mg dl^{-1}), calcium (10.96 m dl^{-1}), cholesterol (148 g dl^{-1}), potassium (6.60 mmol $^{-1}$dl) and glucose (212 mg dl^{-1}) in favour of T4. It is therefore concluded that inclusion of honey at 20 % level of inclusion did not show any deleterious effect and could be used to promote growth performance, elicit positive physiological responses on layers to stress condition and improve their egg characteristics.

Keywords: Hematology, honey, physiological response, layers, vitamin C

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Performance, Egg Qualities and Blood Profile of Laying Hens Fed Mould Contaminated Diets Supplemented with Three Mycotoxin Adsorbents

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A study was conducted to investigate the effect of activated charcoal (AC) and two commercial mycotoxin adsorbents (CA1 and CA2) on performance, egg qualities and blood profile of layers fed on mould-contaminated feed. There were eight dietary treatments, diets 1 to 4 contained uninfected maize supplemented with: no adsorbent (NA), AC, CA1 or CA2. Diets 5 to 8 contained infected maize with the supplementation as stated for diets 1 to 4 in a 2×4 factorial arrangement, (two types of maize: uninfected and infected and four types of supplements: NA, AC, CA1 and CA2). There were five different fungi isolated from infected maize grains. The fungi were identified as *F. oxysporum*, *Rhizopus* stolonifer, *Aspergillus flavus*, *A. fumigatus* and *A. parasiticus*. The activities of the fungi depleted the organic component protein and lipid contents and the caloric value of the maize grains by 23 %, 51 % and 4.5 % respectively, while compensating in terms of high inorganic elements such as total ash, Ca, K and Mg. The mould-contaminated diets significantly ($p < 0.05$) decreased body weight gain (BWG) and hen day production (HDP) while egg qualities and feed intake were not significantly ($p > 0.05$) affected. There were considerable reduction ($p < 0.05$) in haematological indices (RBC, Hb, and mean corpuscular measurements: MCV, MCH and MCHC) in birds subjected to contaminated diets. There were higher ($p < 0.05$) retention of urea and creatinine in the blood of birds on contaminated diets. Similar pattern were observed for liver enzymes, ALT and AST. The addition of the three adsorbents in contaminated diets improved BWG and HDP, but only AC compared closely ($p > 0.05$) with birds on uninfected diets. AC showed superiority in counteracting the effect of fungi metabolites on haematological and serum composition of the experimental birds. The results indicated that fungi metabolites in contaminated feed retard growth, egg production, conversion efficiency of the birds and some blood constituents whereas the addition of AC, CA1 or CA2 prevents the adverse effects of mycotoxins to varying extents, with activated charcoal being the most effective adsorbent treatment in this study.

Keywords: Blood profile, egg qualities, laying chickens, mycotoxin adsorbent, performance

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Effects of Supplemental Enzymes on Metabolisable Energy Values of Wheat Bran and Performance of Broilers

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Inclusion of substantial quantity of cereal by-products, such as wheat bran, in broiler diets could be an imperative technical option for achieving sustainable animal production. However, the utilisation of wheat bran in poultry nutrition has been limited due to its high content of non-starch polysaccharides, low metabolisable energy (ME) and high unavailable phytate phosphorus. Indeed, supplementation of exogenous enzymes have proven as potent tools for considerable use of high-fibre feedstuffs in poultry diets. Different types of enzyme products are available in the global market with varied cost implications and efficacy on animal performance. This study investigated the effect of multi-carbohydrase (Roxazyme G2®), multi-enzyme (Natuzyme®) and single-carbohydrase (Nutrase Xyla®) on the ME values of wheat bran as well as the performance and nutrient retention of broilers fed wheat bran-based diet. 216 mixed-sex one-day-old broiler chicks were fed either the basal diet or test diet (20 % of the basal diet replaced with wheat bran) without or with the commercial enzymes in a 2×4 factorial design. Performance data were collected throughout the 42-day trial period and nutrient retention trial was conducted on day 21 of the experiment. The enzymes significantly improved ($p < 0.001$) the ME values of wheat bran but Nutrase Xyla® had the highest increase in apparent ME, nitrogen-corrected apparent ME and true ME of wheat bran. Neither enzyme supplementations of the basal diet nor test diet had significant effect ($p > 0.05$) on the feed intake, weight gain and feed conversion ratio of broilers. Enzyme supplementations of both basal and test diets were economically insignificant ($p > 0.05$) but were rewarding on a numerical basis. Compared to the basal diet, addition of Roxazyme G2® to the test diet had the best economic gain with 27.36 % reduction in feed cost per kg live weight of broilers. Enzyme supplementations significantly increase ($p < 0.001$) the fat and phosphorus retention of broilers on both basal and test diets. Broilers fed the test diet supplemented with Roxazyme G2® and Natuzyme® had the highest phosphorus and fat retention, respectively. Overall, addition of enzymes, particularly those containing carbohydrase, to 20 % wheat bran-based diet could be a sustainable alternative in broiler nutrition.

Keywords: Economic benefit, enzymes, nutrient retention, poultry nutrition, sustainable animal production

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Performance and Antibiotic Residues in Organs and Meat of Broiler Chickens Fed Supplements of Three Phytogenic Plants

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A biological experiment was conducted to study the effect of *Chromoleana odorata*, *Azadirachta indica* and *Spondias mombin* as alternative to antibiotic growth promoter on broiler production, performance and antibiotics residue with eight weeks old broiler chicks which were randomly allotted to six dietary treatment groups in a completely randomised design (CRD). Each treatment group contained 44 birds and further divided into four replicate groups of 11 birds each. Fresh *Chromoleana odorata*, *Azadirachta indica* and *Spondias mombin* leaves were plucked, the leaves were removed from the stalk, allowed to wilt at room temperature by air drying and milled before adding and formulated with the feed at the rate of 0.5 % for treatment 3 to 6. Treatment 1 (negative control) in which birds were not giving any vaccination or prophylactics. Treatment 2 (positive control) birds were given normal prophylactics (that is antibiotics and drugs) and normal vaccination schedule was used. Results showed that use of antibiotics in raising broilers show a level of antibiotic residue in the meat tissue and organ as compared to the control treatment T1 (negative control) and other dietary treatments that were fed with three different phytogenic plants (Treatment 3 – 6). Also the result of performance characteristics in starter broiler showed that the phytogenic plant as feed additives in poultry diet were inconsistent whereby highest mean values were recorded in final weight (431.5 g), feed intake (27.9 g) and weight gain (14.0 g). While other parameters like feed conversion ratio and mortality were not significantly ($p > 0.05$) influenced by the experimental diets. But in finisher phase of broiler, all parameters were significantly ($p < 0.05$) influenced and highest mean value was recorded. It is now concluded that phytogenic plants as feed additives in broiler ration is recommended to be used as an alternative to the use of antibiotics, vaccines and other prophylactics for the control of antibiotic residue.

Keywords: Antibiotic residues, broiler chickens, meat, organs, performance, phytogenic plants

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Effects of Probiotics on the Utilisation of Fiber Feedstuffs by Weaner Pigs in the Humid Tropics

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This study was carried out for 70 days to investigate the effects of probiotics on the utilisation of three fiber feedstuffs (Brewers' dried grain (BDG), Wheat Offal (WO) and Palm Kernel Cake (PKC) by weaner pigs for growth, apparent nutrient digestibility and economics of production.

Eighteen weaner pigs (Large White $\times$ Hampshire) of average weight of 6.17 ± 0.44 kg were randomly distributed into 6 experimental diets of 3 animals per diet with each animal serving as a replicate. Diets 1, 3 and 5 contained 25 % each of BDG, WO and PKC respectively while a commercial probiotics (Re3) was added at recommended rate of 2.5mlkg^{-1} of feed into diets 2, 4 and 6 which had the same formulation as 1, 3 and 5. The bacteria and fungi in the probiotics include *Lactobacillus* spp., *Bacillus* spp. and *Saccharomyces* spp. The fixed ingredients which constituted 75 % in each of the 6 experimental diets in this study were made up of 45 % maize, 15 % groundnut cake, 10 % soybean meal, 2 % fish meal, 2.25 % bone meal, 0.5 % salt and 0.25 % vitamins/minerals premix. The design was completely randomised design. The animals were fed 5 % of their body weight on daily basis and water was supplied ad libitum.

The result from growth performance showed an increase ($p > 0.05$) in final weight and average daily gain of animals on PKC and BDG supplemented with probiotics while those on WO had a reduced final body weight and average daily gain. The average daily gain was lowest in diet 1 (160 g day^{-1}) and highest in diet 3 (238 g day^{-1}). The feed conversion ratio was best in WO based diet without probiotics (2.14). The apparent nutrient digestibility showed that probiotics had a significant ($p > 0.05$) positive effect on the dry matter, crude protein, crude fiber, ash content and ether extract digestibility. The feed cost per kg gain was highest in diet 1 and lowest in diet 3.

In conclusion, the inclusion of probiotics had positive effects on PKC and BDG based diets on growth and apparent nutrient digestibility. Also the feed cost/kg gain was better with PKC and BDG based diets supplemented with probiotics.

Keywords: Apparent nutrient digestibility, economics of production, fiber feedstuffs, growth, probiotics, weaner pigs

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Effect of Dietary Camel Grass (*Cymbopogon schoenanthus*) on Performance, Parameters and Carcass Characteristics of Broiler Chicks

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The experiment was conducted to evaluate the response of broiler chicks to dietary dried camel grass (*Cymbopogop schoenanthus*) as phytogenic antioxidant and growth promoter to improve poultry meat quality. A total of 160 one day old, unisex of breed Arbro-acre was randomly divided into four equal groups 10 birds per replicate. Four experimental diets were formulated to meet nutrient requirements of broiler chicks. The basal diets contained sorghum and groundnut seeds cake and were supplemented with different levels of camel grass (0 %, 0.25 %, 0.50 % and 0.75 %). A completely randomised design was used to execute the experiment. Feed and water were provided all the time. Feed intake and body weight were weekly recorded, and weight gain and feed conversion ratio (FCR) were calculated, the experiment lasted for 6 weeks. Two randomly selected birds from each replicate were weighed and slaughtered to determine carcass weight and weight of some internal organs (liver, heart and abdominal fat). Blood samples were collected and serum was obtained for determination glucose, cholesterol and triglycerides. The results showed that dietary treatment had significant ($p < 0.05$) effect on feed intake, weight gain, carcass weight and dressing percentage. The highest values were found for birds fed 0.75 % camel grass. The treatments had no significant effect ($p < 0.05$) on FCR, liver and heart relative weight (%), and subjective meat quality attributes. Treated diets increased serum cholesterol and glucose percentage, and decreased abdominal fat. The economic evaluation showed that all camel grass dietary levels were economically feasible, but the value profitability ratio of 1.3 found for 0.75 % camel grass was the highest.

Keywords: Broiler chicks, cholesterol, glucose

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Effect of Dietary Inclusion of Earthworm Meal Replacing Super-Concentrate on Broiler Performance and Carcass Characteristics

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The objective of the study was to measure the effect of dietary substitution of imported super-concentrate (ISC) by different levels of earthworm meal (EWM) on broiler performance. A total of 144 unsexed one-day broiler chicks (Ross 308) were distributed to 12 pens that were randomly assigned to four treatments. Each treatment was replicated three times (12 birds per pen). In a completely randomised design, the dietary treatments consisted of 0, 1.5, 3.5 and 5 % of EWM replacing the ISC as animal protein source by 0, 30, 70 and 100 %, respectively. The experimental diets were formulated iso-nitrogenous and iso-energetic to meet or exceed the requirements of broilers. At day 42, two birds per replicate were slaughtered for determination of carcass and organs weights. The results showed that EWM contained 38.87 % protein, 3.71 % fat, 43.5 % ash, 0.93 % calcium, 0.5 % phosphorus, 0.68 % methionine, 5.56 % lysine (dry matter) and 7.99 MJ kg^{-1} metabolisable energy. Feed consumption, weight gain and feed conversion ratio were significantly ($p \leq 0.01$) affected by dietary treatments. The birds fed on control and 3.5 % diets consumed greatest and less feed, respectively. The birds fed on control, 3.5 and 5 % diets gained the largest weights, while the lightest one was observed with 1.5 % treatment. The same pattern of weight gain results was recorded with feed conversion ratio. Control and 3.5 % treatments scored the heaviest carcass weights ($p \leq 0.01$). The breast weights of birds fed on control diet were the best ($p \leq 0.01$) among all treatments. However, the control and 1.5 % treatments had the lowest weights of the drumstick. The weights of thigh and abdominal fat were greater for control followed by 3.5 % treatment. Liver weights increased as the dietary EWM inclusion increased. Moreover, the birds fed on control diet had largest liver weights. The intestinal length records and the weights of proventriculus and gizzard were unaffected by dietary treatments ($p \geq 0.05$). The study indicated that for most parameters investigated good results were obtained when 3.5 % of EWM was included in broiler diet replacing ISC by 70 %. So, dietary inclusion of EWM by 3.5 % could be used as an alternative protein source for broiler diets.

Keywords: Animal source protein, broiler, carcass characteristics, eartworm meal

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Application of Physical Body Morphometric Parameters in the Evaluation of Sudanese Local Rabbits Breed

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Physical morphometric body parameters (body length, height at withers, heart girth, abdominal girth, nose to shoulder length, ear length, tail length, foreleg length, hide leg length, thigh girth, and live body weight of 142 Sudanese local rabbits were subjected to general linear model (univariate) analysis of variance and simple least squares regression analysis. The aims of this research were to (1) disclose the main sources of variability among live physical body morphometric parameters, (2) quantify the age and sex differences in live physical body morphometric parameters, (3) deduce the interrelationships among live physical body morphometric parameters and live body weight of different ages and sexes, and (4) predict live body weight from live physical body morphometric parameters. Live body morphometrical parameters appeared to be affected by both age and sex factors. Simple person's correlation coefficients between live body morphometric parameters and live body weight were revealed positive and highly significant ($p \leq 0.05$). Respective predictive simple linear regression analysis equations from live body morphometric parameters with coefficients of determination R^2 (0.90, 0.87, 0.72, 0.74, 0.65 and 0.74) respectively for both sexes (male and female at three, four and five months of age) were derived. Of all live body morphometric parameters studied, heart girth, height at withers, body length and abdominal girth were shown to be the most important predictors for live body weight of Sudanese local rabbit breeds, in addition to being used as selection criterion for genetic improvement of body weight. It is plausible that simple regression equations can be used for live body weight prediction. However, predicted live body weight based on derived simple equations come up with close results to the actual measured live body weight and these equations are acceptable to rabbit breeders due to its simplicity, time-saving and cost-efficiency.

Keywords: Physical morphometric parameters, correlations, regression analysis, Sudanese local rabbits

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Sustainable production systems

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Exploring Yield Gaps in Smallholder Oil Palm Production Systems in Eastern Sumatra, Indonesia

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Oil palm (*Elaeis guineensis*) has become the most produced and traded oil crop throughout the world. During the last two decades the area under oil palm has increased more than two-fold and the production of crude palm oil (CPO) has increased more than four-fold. Its expansion has, however, raised serious environmental and social concerns. Increasing yields on existing plantations is a potential pathway to reduce the undesired ecological impacts of oil palm expansion and to enhance the social benefits of oil palm production. Although oil palm production is still dominated by private sector companies, smallholders are increasingly engaging in its cultivation. In Indonesia, smallholders are expected to outnumber the private sector in both production and area under cultivation in the near future. Despite their growing importance in the oil palm sector, studies on smallholders' agronomic performance are scarce. Based on crop modelling analysis and quantitative household survey data from Sumatra, Indonesia, this paper quantifies smallholder yield gaps relative to exploitable yield levels and analyses smallholders' production constraints. We find that oil palm smallholdings offer a tremendous potential for future yield increases, because they obtain only 56 % of the cumulative exploitable yields over a 20 year plantation life cycle. Important determinants of yield gaps are management practices such as fertiliser dosage and length of harvesting intervals. Furthermore, supported smallholders operating under contract arrangements are found to achieve higher yields compared to independent smallholders. Results suggest that smallholders are constrained by limited knowledge about best management practices and by imperfect access to input markets. Some policy implications are discussed.

Keywords: Crop modelling, Indonesia, oil palm smallholders, yield gaps

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Impact of Organic versus Inorganic Approaches on Sustainable Intensification and Advance Food Security in Tomato (cv. Solan lalima) under Mid-Hill Conditions of Himachal Pradesh

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The present studies conducted during the years (2011–13) give an overview of the impact of organic and inorganic agriculture systems on soil health, productivity and food nutritional values. The organic treatments [T_1-T_6 (organic treatments) - T_7 (control)] integrated the use of organic manures (FYM (200 q ha^{-1}) and VC (50 q ha^{-1}), biofertilisers (*Azotobacter*, *Azospirillum* and PSB 4 kg ha^{-1} each), Biocontrol agents (*Trichoderma viridae* (4 kg ha^{-1}), *Trichoderma herzianum* and *Pseudomonas flourescens* 10 g l^{-1} water each), barrier and cover crops, pheromone and yellow sticky traps, green manuring and crop rotation etc, whereas the conventional treatment (control) implemented the use of chemical fertilisers (FYM 250 q ha^{-1} + chemical fertilisers (CAN 650 kg ha^{-1}, urea) 650 kg ha^{-1} + pesticides (40–50 no. of sprays). The results confirmed the presence of higher soil NPK status (413.1 kg ha^{-1}, 26.33 kg ha^{-1} and 285.4 kg ha^{-1}) and OC (0.99 %). The GCMS results showed lesser pesticide residues (8.3 %) in tomatoes produced under organic treatments as compared to conventional system (43.3 %). The study recorded higher TSS (5.37 Brix), fruit firmness (10.11psi) and pericarp thickness (3.29 mm) with higher levels of Vit C (37.3 mg/100g), phenolics (42.1 %) and antioxidant activity (12.6 %) as compared to control (conventional system). The lycopene and beta-carotene extracted by SPE (Solid Phase Extraction) column and further purified by HPLC reported higher fractions in organically grown tomatoes (28.8 % lycopene and 13.41 % beta carotene respectively) than the conventional ones (14 % lycopene and 4.8 % beta carotene respectively). It was interesting to note that organically grown tomatoes have longer crop durations as compared to conventionally grown tomatoes. The overall productivity (665 kg ha^{-1}) was also recorded higher than the conventionally grown ones (649.5 kg ha^{-1}). It can be concluded from the present studies that by adopting appropriate organic production technologies productivity levels comparable to those under conventional practices can be achieved in tomato with better quality produce, improved soil health and nutrient status.

Keywords: Cultivation systems, food nutrition, GCMS, HPLC, quality produce, soil health, tomato

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The Yield Effects of Organic Farming: A Case Study of Black Pepper in India

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Global debates on sustainable agriculture have brought certified alternative farming systems like organic agriculture to the forefront. In the recent decades, organic certification schemes have captured the willingness to buy of the environmentally conscious and ecologically motivated consumer; threatening to break out of its current niche markets.

Yet, the principal objection towards certified systems like organic agriculture is low yields. Such conclusions are often drawn by simply comparing organic and conventional crop yields. But this is subject to severe methodological limitations due to issues of selection bias, endogeneity and absence of a valid counterfactual. A justifiable counterfactual group is needed to ascertain the yield of organic farmers if they were conventional and *vice-versa*.

In this context, we study Indian agriculture which has the leading number of organic producers in the world. The domestic black pepper scarcity and soil fertility problems pushed many smallholder farmers to shift to alternative agricultural systems like certified organic farming to increase production. Some of these organic farmers were also fair trade certified. But, previous studies were only restricted to organic and not extended to fair trade systems. Hence, we explore this choice in the framework of the ability of certification schemes to increase pepper production. We use data collected from 277 smallholder black pepper farm households in Idukki district, Kerala, India. We estimate a multinomial endogenous switching regression equation along with a counterfactual analysis to ascertain the effects of organic and fair trade certification on production. We also methodologically expand the multinomial counterfactual model to include heterogeneity effects.

Results show that organic farmers are the most productive and that conventional farmers will increase yield by 113 % if they adopt certified organic black pepper farming. Base heterogeneity effects reveal that organic farmers have unobservable characteristics that make them better farmer even under a counterfactual setting. Transitional heterogeneity effects are negative implying that conventional farmers will benefit the most if the venture into certified organic black pepper farming. We also find that a joint organic and fair trade certification is vital for those farmers who were less high-yielding before they ventured into certified systems.

Keywords: Fair trade, heterogeneity effects, impact evaluation, India, multinomial endogenous switching regression, organic farming

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Rice Productivity and Technical Efficiency: A Meta-Frontier Analysis of Rice Farms in Northern Ghana

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Among the cereals produced in Ghana, rice presents the best opportunity to rapidly increase food production. This is because current yields are far below potential due to low productivity on most rice farms. And despite several policy interventions, rice productivity is still low and self-sufficiency ratio stands at 30 %. This study examines the productivity, and technical efficiency differentials among a cross section of 808 rice producing households, consisting of 333 and 475 rice farmers in the forest-savannah transition and savannah agro-ecological zones of Northern Ghana respectively. The study applies the stochastic frontier approach to assess the productivity of inputs used, technical efficiency, and the determinants of technical inefficiency. It further uses the stochastic meta-frontier approach to measure the technology gap ratio. The results reveal that all the input variables positively contribute to rice productivity except the quantity of seed which reduces rice output in both zones. Rice farms located in the savannah agro-ecological zone are characterised by constant returns to scale whilst their counterparts in the forest-savannah transition zone exhibit decreasing returns to scale. Estimates of the stochastic frontier analysis reveal that the mean technical efficiency for farms located in the forest-savannah transition and the savannah agro-ecological zones are 0.50 and 0.39 respectively. The stochastic meta-frontier estimates show that the mean technical efficiency relative to the meta-frontier are 0.42 and 0.30 for rice farms located in the forest-savannah transition and the savannah zones respectively. The study therefore concludes that rice farms located in the forest-savannah transition zone are technically more efficient than their counterparts in the savannah zone. The estimated determinants of technical inefficiency show that enhancing farmers' access to seeds of improved rice varieties and proper land security arrangements can improve technical efficiency. Households with access to education and off-farm income are also encouraged to invest their resources, cash and knowledge, in farm activities as a way of contributing to the efficiency of agricultural production systems. These are issues that future policies and programs may have to consider in the quest to improve farm-level performance.

Keywords: Meta-frontier, productivity, stochastic frontier, technical efficiency, technology gap

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Role of Organic Agriculture in Natural Resources Management and Food Safety: Case Study in Vietnam

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The objective of this study was to investigate the role played by organic farming system in protecting nature resources, especially land and water, and enhancing food safety for population in Hanoi the capital city of Vietnam. Vietnam, as one of the most populous countries in Southeast Asia, depends economically mainly on agriculture. Hence, to improve crop yields and therefore ensure food security and economic development, Vietnam promoted the use of chemical fertilisers and pesticides. Increasing the use of agrochemicals in agriculture without proper management had negative effects on the environment and human health issues. Food safety is an important component of food security, which is currently of critical world-wide concern, particularly in Vietnam. Therefore, the adoption of organic agriculture was tried in order to prevent food safety threats and improve environmental pollution. This research was carried out in 2013 in Hanoi, Vietnam. In total 300 respondents (organic and non-organic customers) were interviewed for information about their intention to buy organic vegetables. Three group discussions with 34 farmers, 3 responsible people from organic organisation and 5 organic sellers were conducted to collect the ideas about actual situation of organic vegetable production in Hanoi region and the obstacles for the establishment of organic agriculture in this location. Qualitative and quantitative methods of analysis were used. Our main findings suggest that consumers tended to purchase organic vegetabled because of their concern about food safety; after buying organic products their perception about environmental protection was raised. Organic farming system still could not cover the demand of the consumers. Although the organic system significantly improved the food safety situation, farmers had trouble implementing organic agriculture mainly cdue to lack of finance. We suggest that state support should play an important role in developing organic farming systems.

Keywords: Environment pollution, food safety, organic farming system, Vietnam

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Evaluation of Yield and Economic Benefit of On-Farm Maize-Rice Bean Relay Cropping without Residue Burning

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Maize production in Thailand has been introduced to the highlands, where residues of crop and weeds are burned to prepare land for the next crop causing air pollution. This study evaluated the yield and economic benefit from maize - legume relay cropping system to reduce burning in the highlands of Pang Dang Nai and Long Khod Royal Project Extension area in Chiangmai province, Thailand. The treatment conducted with no burning of maize-rice bean was compared with burning maize monoculture in 3 farmer fields/locations during the wet season of 2012 to 2014. The grain yield of maize from maize-mono in these two areas of study was 3.3 and 2.4 Mg ha^{-1} respectively, which were 18 and 33 % respectively higher than the maize-rice bean relays. In addition, yield of legume was 1.3 and 1.4 Mg ha^{-1} in maize-rice bean in Pang Dang Nai and Long Khod respectively. While the residue in maize-mono was lost due to burning, there remained 5.5 Mg ha^{-1} and 6.4 Mg ha^{-1} of residue in the maize and legume field from no-burning maize-rice bean. There was a contribution of total N retained on the fields of 79.7 and 91.5 kg ha^{-1} in Pang Dang Nai and Long Khod, respectively. Moreover, economic benefit analysis found that total cost in maize-mono (farmers' practice) was lower in comparison with maize – rice bean of US$ 129.2 ha^{-1} and US$ 192.8 ha^{-1}, respectively. Total gross margin was highest in maize – rice bean in comparison with maize mono in farmers' practice with US$ 744.4 ha^{-1} and US$ 662.8 ha^{-1}, respectively. In conclusion, the maize-rice bean relay cropping system is promising as a means to reduce burning in the highlands while increasing maize yield and income for farmers. Other benefits which were not taken into account included the reduction of nutrient losses, sedimentation, and air pollution.

Keywords: Burning, maize, relay cropping, residues, rice bean

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Evaluation of Sustainable Agricultural and Horticultural Land Use in in Rural Area of Northern Vietnam

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With the growth of the population in particular in developing countries as Vietnam, a significant growth of the food demand can be observed. Therefore, the intensity of the land use and their productivity should be improved. A sustainable land use strategy needs a multicriterial evaluation of the current situation in order to develop and compare different scenarios. In northern Vietnam the province Phu Tho was studied in this regard and in particular two communities of this province, Trung Vuong with 119 and Tan Duc with 115 respondents, regarding their current land use. Three different methods for decision analysis and evaluation of the sustainability of land use were compared, the method of empirical social research, the SWOT analysis and the analytic hierarchy process (AHP). In frame of the AHP 15 sub-criteria were investigated, based on three main-criteria related to economy, ecology and socials aspects. This method was applied with the stakeholders in the province as well with the land users in the community. Regarding the evaluation of the main-criteria in both groups of respondents, the same ranking was observed: first economy, then ecology and sociology. As a result of the evaluation of the sub-criteria by the land users, in the first analytical complex (main-criteria) the highest priority had 'relation revenues/expenses', the lowest 'infrastructure', whereas in the second analytical complex 'overuse of pesticides and fertilisers' had the highest priority, but 'soil quality' was not valued as problematic, in the third analytical complex highest priority for the farmer had the 'social and medical care' and the 'motivation of the farmers', as the lowest problem were valued the job opportunity.

Keywords: Analytic hierarchy process (AHP), development rural area, land use evaluation, multicriteria analyses, sustainability

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Effect of Pre-Crop on Growth and Yield of Potato in Kenya

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The pre-crop is a crucial component of competitiveness of grain legumes and yield benefits to subsequent crops depending on fertilisation and the type of pre-crop. A field experiment was conducted between 2013 and 2014 at KALRO, Njoro, in Kenya, to evaluate the benefits of legumes in crop rotation on potato yields. The site lies within the semi-humid, lower highland zone three (LH3) also classified as wheat/maize/barley zone (AEZ LH3) with a bi-modal rainfall pattern of 275 mm in the short rains and 425 mm in the long rains (total 960 mm) with mean maximum/minimum temperatures of 24°C/8°C, respectively. The soils are well drained, deep to very deep, dark reddish brown, friable and smeary, silt clay, with humic topsoil classified as mollic Andosols. The experiment was laid out in a split split-split plot-design with four factors including water harvesting (two levels), crop rotation (four levels) and soil fertility management (SFM) (four levels). Water harvesting (wh) was assigned as the main treatment, crop rotation as the sub-plot while soil fertility management as the sub-sub plot and sub-sub-sub plot was inter-crop (IC). It was evident that potato grown in the long rains (lr) after the legume (*Lablab purpureus* (L.) Sweet) in the short rains (sr) attained the budding stage, 2 days, significantly ($P < 0.05$) earlier, took longer to reach physiological maturity (4 days) and produced a higher tuber yield (24 %) than when grown after wheat (*Triticum aestivum* L.). Legume as a pre-crop had a profound effect on physiological traits which resulted in increased period between crop emergence and budding. Similarly, the period between emergence and physiological maturity also increased significantly, subsequently resulting in increased tuber yields. This therefore agrees with the fact that legume as a pre-crop contributes more positively to yield components and tuber yield of potato than when cereals are planted as pre-crops.

Keywords: Lablab, Njoro, potato, pre-crop

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Potential of Agronomic Management Options on Rice Productivity in Valley Swamps of Uganda

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With year-round water availability and relatively fertile soils, the so far largely unused wetlands of East Africa are expected to contribute substantially to regional food security in future. We comparatively evaluated different cropping systems (single rice vs. rice-maize rotations), different fertiliser strategies (mineral vs. organic) and crop and land management strategies (open vs. bunded fields; weeding frequency and green manure crops) in a randomised complete block design for two seasons and three toposequence positions of an inland valley swamp at Namulonge, Central Uganda.

Both the crop production potential and the effectiveness of technical options are likely to vary with the position in the valley (fringe, mid-section, centre). We assessed biomass and yield parameters and nutrient uptake by rice. Performance parameters differed between toposequence positions and production systems. On average, farmer´s practice (unbunded field, one hand weeding and no mineral fertiliser applied) resulted in average grain yield of 3.1 t ha^{-1}. Clean-weeding combined with field bunds increased rice yields to 4.3 t ha^{-1}. Optimal crop management with high external inputs (N:P:K at 120:60:60 kg ha^{-1}) provided an attainable yield of up to 7.1 t ha^{-1}, which is about 75 % of the potential yield for this region. Combined application of green and chicken manure provided an N input of 120 kg N ha^{-1} and gave yields up to 5.4 t ha^{-1}. The application of green manure such as lablab corresponding to 60 kg N ha^{-1} achieved higher aboveground biomass and grain yield compared with equal amounts of mineral fertiliser applied. Soil and crop nutrient analysis is still ongoing, however first results indicate that treatments with mineral fertiliser had a higher nutrient uptake in the first two month after transplanting than organic and non-fertilised plots. Regarding location in the valley, yield parameters indicated that rice can perform better in the fringe than in the centre and mid-section, possibly due to a high initial soil fertility.

The findings of our research reflect yield potential in the region and we will discuss the need for site-specific targeting of options, their extrapolation and implications for the regional food security.

Keywords: Green manure, *Oryza sativa*, yield gaps

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'Game Changers' Towards Greater Nutritional Diversity in Cereal-Based Smallholder Farming Systems, Ethiopia

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About ten percent of the Ethiopian population still struggle to meet their basic needs for safe and nutritious food in years of low yields. In 2014, about 2.7 million people in Ethiopia faced a severe lack of food resources. An increasing cereal production is needed to achieve national food security. The success of this mission lies in the hands of Ethiopian smallholder farmers who contribute about 98 % of the national cereal production.

Besides teff, maize and sorghum, wheat is one of the most important cereal crops in Ethiopia in terms of farm area and household consumption. The increased wheat production in the Ethiopian highlands has improved national food security and local farm incomes. The dominance of wheat however has decreased the regional nutritional diversity of the landscape and led to the disappearance of local grazing grounds as well as forest resources, constituting a major pressure for the traditionally cattle dominated farming systems. New technologies such as combined harvesters for barley and teff, small scale irrigation for vegetable production and new processing and storage methods to prevent post-harvest losses might function as 'game changers' enabling an increase in crop and nutritional diversity as well as overall productivity of individual farms and of the landscape.

This study analyses and explores features, dynamics and potentials of smallholder farming systems in the wheat-belt of Ethiopia. The aim is to understand how these farms are operated, what challenges they face and what opportunities exist to improve their performance, e.g. in terms of crop yields, on-farm nutritional diversity, income, labour and soil fertility. A farm typology was developed to choose representative farms for detailed farming systems analysis in the whole farm model FarmDESIGN. The study reveals substantial differences among farm types in their 'room to maneuver', not only due to their resource endowment but mainly as a result of differing growing and harvesting conditions. The above mentioned 'game changers' such as innovative combined harvesters, small scale irrigation and improved post-harvest storage appear to be potent drivers of change towards greater food security and nutritional diversity.

Keywords: Drivers of change, farm typology, farming systems analysis, trade-off analysis, whole farm model FarmDESIGN

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Challenging Endeavours to Grow Sugarbeet in Sudan: Strengths, Weaknesses and Definition of Problems

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Attempts to grow sugarbeet in Sudan have continued unabated since 1999. These efforts were then increased by Gezira State, Sudan, since 2012. Considerable areas were planted with promising results. Moreover, 2.1 and 8.4 hectares were planted with sugarbeet within Guneid Sugar Scheme for two seasons, harvested and crushed together with sugarcane in Guneid cane mill giving successful and encouraging results. Further, researches were conducted in many irrigated areas in the country addressing several aspects of the crop. An example of this research, was an experiment conducted in Guneid Research Center in 2010/11 which gave high yield and good quality crop. Its treatments included 13 cultivars (Strube and KWS, Germany, and Syngenta, Switzerland), 4 sowing dates: 14th and 28th October, 13th and 29th November, and 3 harvesting ages: 5, 5.5 and 6 months. The results showed that root yield ranged from 80 to 90 t ha^{-1}, sucrose ranged from 16 to 18 % and the sugar yield ranged from 10 to 14 t ha^{-1}. Speaking of the strengths, the crop is planted by planters. Germination has to be satisfactory since no supplying gaps will be effective. No major diseases are recorded. The major insect pest is the leaf cutter *Spodoptera exigua* which is properly controlled by insecticides. Harvesters are not yet introduced. However, the major problem facing sugarbeet will be the very short harvest time if it is planted as is done now from October to December. When the crop ages 5.5 to 6 months, harvest time will be from mid-March to mid-May, which will miss the effective period of sugar accumulation (winter months) by about two months. Earlier planting of sugarbeet in July to September is more suitable and harvest time will be from mid-January to late April. However, this timing is faced by rains during this period which will hinder land preparation, machine planting, because the soil is heavy cracking clay. Moreover, weeds and insects will be a nuisance. Therefore, for the success of the crop, the problem of reconciliating the planting time with harvest time that gives the maximum sugar production must be judiciously tackled.

Keywords: Brix, cultivars, germination, insects, sowing date, sugarbeet, weeds

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Food and Biofuel: A Possible Dialogue? An Overview about Brazilian Ethanol Context

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Since the concern with Kyoto Protocol targets, the energy matrix and the strategies for sustainable economic development have been the centre of discussions of experts and global authorities. This new scenario has led ethanol into agendas and policies, especially in developed countries, like the United States (U.S.) and members of the European Union (EU). The ethanol importation is one of the strategies to achieve this goal and Brazil has a representative role in this scenario. However, the Brazilian ethanol exportation is decreasing in Europe. There are allegations about social and environmental dumping because of historical conditions of precarious work in the sugar cane fields and about the no adoption of conservation practices in production. Another important issue that also appears is the competition between food and biofuels, since Brazil has a strategic role in food production. Some Brazilian policies were published to avoid it, as The Sugarcane Zoning, where the orientations concern the use of mechanised crop, for instance, without the labour degradation found in burnt harvested sugarcane fields. Nevertheless, there are no policies or tools that consider the sustainability evaluation, with the social, economic, environmental and institutional dimensions in an integrated model.

Keywords: Biofuels, Kyoto protocol

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Classification of Urban and Peri-Urban Livestock Farm Types in Ouagadougou and Tamale

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Livestock activities constitute an important part of urban and peri-urban agriculture (UPA). They are however constrained by increasing competition for resources, especially land and fodder, and hence increasing costs. Farmers try to withstand these pressures by intensifying their production. Against this background, SP3 of the UrbanFood^{Plus} project aims at the quantification of resource use and calculation of resource use efficiencies in UPA livestock systems in Ouagadougou (OUA), Burkina Faso and Tamale (TAM), Ghana. Research started in 2014 with a characterisation of UPA livestock systems, using exhaustive semi-structured interviews with 181 (OUA) and 187 (TAM) livestock keepers. The data was subjected to categorical principle component analysis followed by two-step cluster analysis and descriptive statistics on the resulting farm types. Most farms could be assigned into one of 6 (OUA) and 5 (TAM) livestock farm types. In OUA, most farms operate in peri-urban areas and in TAM in the build-up city zone. Livestock management varies between farm types, because of the different livestock species kept and due to different investments in housing structures and supplement feeds. Higher input use could be observed for the commercial dairy production and commercial pig farming that are both more common in OUA than in TAM. Grazing (ruminants) and scavenging (monogastric animals) is important in both cities, but access to pastures is restricted for those livestock farmers who are located in the centre of the city. Selling livestock is more frequent in OUA than in TAM, where live animal sales across species average 1–2 TLU per farm and year as compared to 5 TLU in OUA. Similarly, daily milk sales average 9 liters (SD 7.8, n=36) on semi-commercial and 47 liters (SD 62.8, n=20) on commercial dairy farms in OUA, but only 5 liters (SD 4.4, n=27) in TAM. Further research will quantify inputs into and outputs from livestock units and determine their quality. Existing models will be parameterised and validated with the collected data to identify strategies of optimised resource use. These will be test-implemented in order to assess their effectiveness, costs and practicability.

Keywords: BMBF-GlobE, milk production, pig farming, resource use efficiency, urban agriculture, UrbanFood^{Plus}, West Africa

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Developing Healthy Vegetable Seedling Systems for Vegetable Smallholders in East Africa

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Healthy planting material is a critical, basic agronomic requirement and a key principle component of good agricultural practice (GAP), towards maximising productivity and reducing production losses from pests and diseases. In East Africa, the health of vegetable seedlings remains a key challenge. Smallholder vegetable farmers regularly sow their seed into nurseries in or close to the field area and are therefore aware of the benefits off using transplanted seedlings. However, farmer nurseries are rarely sanitised or protected to prevent infection of the seedlings with pests and diseases. Consequently, this practice regularly results in the immediate infection of germinating seedlings with soil-borne pests and diseases and thereafter with airborne or vector-borne diseases. This includes plant parasitic nematodes, especially root knot nematodes. The use of infested seedlings consequently leads to low production potential, and reduces host suppression of pests and disease as the season progresses, which indirectly results in high use and reliance of synthetic pesticides. The promotion of improved, healthy vegetable (tomato and pepper) seedlings, using sustainable seedling systems has been the objective of a GIZ/BMZ supported project at IITA. Healthy seedlings were distributed to farmers to compare their performance against normal practice. This resulted in better healthier crop production. Further improvement of seedlings by enhancing them with microbial antagonists, further increased their benefits to farmers, reducing pest and disease incidence and increasing yields. To create sustainable delivery systems, pilot seedling units have demonstrated a high demand from farmers, and provide a suitable mechanism for maintaining supply. The results are discussed.

Keywords: Peri-urban, seedling health, smallholder, sub-Saharan Africa, sustainable

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Impact of Population on Wildlife Domestication and Production: An Economic Consideration

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The rainforest regions of Nigeria are widely recognised as biodiversity hotspots of global significance. Understanding both the economic benefits and costs of conserving ecosystems will help to allocate scarce money most efficiently. This paper focuses on the technical feasibility of small-scale grasscutter farming. The idea of domestication on one hand and production of wildlife on the other hand is, therefore, seeking to bridge the gap between population increase and livestock production as a means of securing the long-term viability of the forest, in a way which is well-integrated with other aspects of the rural economy. Feasibility reports on grasscutter farming ventures indicate that the long-term profitability is comparable to that of poultry farming and cattle ranching. However, the high cost of initial inputs (cages, breeding stocks), the slow returns and the limited technical expertise has hampered the adoption of backyard grasscutter farming by rural households and the development of large-scale commercial ventures. Grasscutter farming may be designed for women and youth empowerment organisations, NGOs, institutions; and even those in private or paid employment seeking extra income from domestic resources lying fallow. In addition, armed forces and civil service personnel preparing for retirement, Federal, State and Local Government personnel are often involved in extension services of grasscutter farming. Commercial or cottage, profitable grasscutter production and marketing will involve production plan, site selection, selection of breeding stock and sources. Rearing grasscutters in backyard space is one of the best ways to make wealth and meet want because domestication alone is not enough to produce widely shared prosperity. Grasscutters are not the most prolific of rodent species but the high demand, attractive market price and the small amount of investment required makes grasscutter farming a suitable mini livestock activity for income generation in many parts of Nigeria. Grasscutter farming, if pursued with the benefit of the right information and knowledge now available, is a very viable commercial venture. Grasscutters are mainly herbivorous, requiring neither imported food components of food nor expensive medical expenses if strict hygiene is maintained. They are easy and cheap to raise.

Keywords: Domestication, grasscutter, population, wildlife

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An Integrated Assessment of Potential Legume Cover Crops for the Sustainable Intensification of Smallholder Agriculture in the Dry Corridor of Central America

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Smallholder agriculture in the dry corridor of Central America faces soil degradation, feed gaps and low agricultural productivity. The promotion of agricultural innovations to support a sustainable intensification of family agriculture in Central America demands more integral assessments of their benefits. Tropical legume cover crops can be multipurpose including improving soil health, increasing crop yields, controlling pest and weeds, feeding livestock and producing food. Their potential for upscaling depends on the stability and adaptability of aboveground biomass accumulation (ABA) across different environments. This study aimed to conduct an integral assessment of promising legume cover crops combining multi-environmental trials, participatory approaches, analysis of ABA and decomposition rates of five tropical cover crops. *Canavalia brasiliensis*, *C. ensiformis* (jack beans), *Cajanus cajan* (pigeon pea), *Vigna unguiculata* (cowpea) and *Vigna radiata* (mung bean) were evaluated in thirteen environments in El Salvador (2), Honduras (4) and Nicaragua (7) using a randomised complete block design with four replications in each site. In each country a participatory evaluation was conducted with 20–25 farmers to assess the performance of these legumes based on their perception of local indicators. Analyses of variance of ABA after 45 days of sowing were conducted to differentiate the effects of the species (G), environment (E) and their interaction (G×E). Finally, a decomposition experiment was conducted during 60 days in one site to assess the decomposition rate of each of the legumes. The results showed that farmers preferred *C. ensiformis*, *V. unguiculata* and *C. brasiliensis* because of their higher biomass production, weed control, tolerance to pests, root system and rate of decomposition. *C. ensiformis* and *V. unguiculata* were the most stable in terms of a higher ABA in all the environments (1880 and 1509 kg ha^{-1}, respectively) and showed the fastest decomposition rates. However, the integrated assessment suggested that *V. unguiculata* and *C. brasiliensis* are promising cover crops in these agricultural systems compare to other promising legume species. More integral assessments of key agricultural components can contribute to develop cropping systems that are more targeted to farmers' needs for a more sustainable intensification of smallholder agriculture in the region.

Keywords: Cover crops, litter decomposition, multi-environment trial, sub-humid areas, sustainable intensification

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The Impacts of Changing Paradigms for Coffee Production in an Integrated Modelling Framework

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Coffee production is shaped by its high climate sensitivity and the dominance of North-South trade for demand. Projections of future trends make deep changes of the paradigms of coffee production likely: On the supply side climate change will negatively affect major coffee producing countries like Brazil; increasing population and global income have been postulated to drive up demand.

Here, we integrate these paradigm shifts in the modelling framework Globiom to *ex-ante* analyse the impacts on the coffee sector. Three methodological gaps had to be addressed here. First, a global model of the impacts of climate change was used to estimate spatially explicit shifts on yield potential. A spatially disaggregated dataset of coffee production statistics was generated to calibrate Globiom and last, a demand scenario that projects increasing demand depending on population and GDP increases was developed.

We here show that by the 2050ies climate change may reduce the area available for coffee production by half and could reduce global yield potential by 20 % on remaining area compared to historic climate. Total demand was projected to be increased 2.5-fold. However, market effects resulted in prices up to 58 % higher than with historic climate, and a reduction of production by 5 million tons per year. Thus, climate change impacts may be equivalent to the size of the baseyear 2000 market volume. In addition, an increasing share of production will be met by low-quality Robusta coffee, rather than high-quality Arabica. We conclude that despite the drastic climate change impacts on the sensitive coffee shrub because of market effects there will be coffee on the table in 2050. But this coffee will be of lower quality, will cost more and it will still be the lab rat of sustainable enterprises because its production will still be shaped by poverty risk and environmental problems.

Keywords: Climate change, coffee, partial equilibrium

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Farm Sustainability Assessment: The Case of Small Scale Organic Apple Production in Ningxia Province, PR China

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The high dependence on small-scale orchard systems in China makes organic apple production challenging in terms of sustainability impacts and fruit quality. This case study examines the ecological, social and economic performance of organic apple farms under an export-oriented organic apple project in the Ganchengzi village, Ningxia province situated in North West China. An advisory tool called RISE 2.0 (Response-Inducing Sustainability Evaluation) was adopted to assess farm sustainability of selected 10 organic apple orchards and their associated farms. The RISE 2.0 analysis results show high variations in farm biodiversity and economic viability between the analyzed farms, with major ecological deficits in the indicators Nutrient flows and Biodiversity & Plant protection; other critical indicators were Water Use, Energy & Climate and Farm Management. However, the farmers performed well in the indicators Working Condition and Quality of Life. The findings show that organic apple growers participated in the project had more confidence than conventional farmers in the region because of the 15 % price premium which they are entitled for selling table fruits in the domestic market, as well as more comprehensive extension service and farm inputs provided by the exporting company. To enhance economic sustainability of the organic apple production project, it is recommended that the company can strengthen farmers? emotional ownership and economic incentives by providing higher price premiums for their organic apples. In such a way, organic farmers may have more willingness to prioritize inputs to improve ecological sustainability of the small scale apple orchards.

Keywords: Apple Juice concentrate, certified organic agriculture, China, fair trade, farm sustainability assessment, impact, Ningxia, RISE 2.0, small-scale orchards

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Biochar-Based Biofertilisers: An Emerging Technology for Sustainable Crop Production

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In recent decades, ecological problems increased in many regions of the world and these conditions are likely to contribute to decreased food security and increasing health risks. The low technological development, improper agricultural methods and policies are major hindrances against agricultural development in many developing economies. Climate change may lead to even more degraded landscapes in many non-irrigated regions since it is accompanied by less rainfall and higher temperatures. These facts represent a serious threat to sustainable food production and to our natural resources. Owing to population growth and increasing food demand, intensive and environment-friendly agricultural techniques such as application of bio-fertilisers have become a promising model for many countries in the world. Biofertilisers contribute environmental benefits and help to conserve resources for crop cultivation, especially for poor farmers. The reduction of chemical fertilisers by using biological fertilisers is one of the effective steps in sustainable agriculture. The application of biochar to soil is considered to mitigate climate change by increasing carbon storage in soils but also to improve fertility of degraded soils, improve plant growth and development, increase fertiliser efficiency, and suppress soil pathogens. Biochar-type materials have been also suggested as inoculant carriers and will remain stable in the soil and thus may positively influence abundance of the inoculant organisms such as rhizobia, or plant growth promoting rhizobacteria. Efforts to better understand the role of biochar-based biofertilisers in nutrient uptake and plant response to environmental stress are more compelling now, since a continuous use of high amounts of chemical inputs are generating environmental problems and not sustainability. This paper discusses prospects of biochar-based biofertilisers for better agricultural productivity and increased food security, especially possible roles in better plant nutrient uptake, reduced use of chemical fertilisers, enhanced or induced systemic plants' tolerance to adverse environmental stresses, such as salt and drought stress.

Keywords: Abiotic stress, biochar, biofertilisers, crop production, sustainability

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Economic Assessment of Common Bean Variety BRS Estilo in Brazil

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This study aimed to economically evaluate BRS Estilo, a variety of common bean (*Phaseolus vulgaris* L.), of 'carioca' commercial type, developed by EMBRAPA Rice and Beans and its partners. This technology was suitable for the first cropping season in the states of Goiás, Sao Paulo, Paraná, Santa Catarina, Rio Grande do Sul and Pernambuco; for the third cropping season in the states of Goiás, Mato Grosso and Tocantins; and second cropping season in the states of Goiás, Paraná, Santa Catarina, Rondonia, Mato Grosso and Mato Grosso do Sul. The economic analysis was referring to earlier technology – the variety Perola – which was commercially released in 1994 for the same coverage area. We evaluated four successive years of BRS Estilo, i.e. the crop 2010/2011, 2011/2012, 2012/2013 and 2013/2014. In the above region, there have been considerable increases in the factor prices, mainly inputs, which resulted in the increase in the average product cost. Prices received by bean producers also varied and ranged from R$ 95.40 to 205.17 per 60 kg bag. This variation did not compromise the bean business, which is economically viable and guaranteed in the production chain. The common bean producers, by adopting the common bean cultivar BRS Estilo, yielded on average in the first and second cropping seasons, and had a cost of R$ 2,414.38 to produce 33 bags of 60 kg per hectare. The winter crop, produced 53 bags of 60 kg per hectare with costs of R$ 3,876.84. The average financial return on investment was 112 % for the winter crop, and 105 % for the first and second cropping season. The BRS Estilo variety contribution over the whole period, to the bean agribusiness in Brazil was R$ 239,431,760.83 (US$ 106.00 million). The transfer process of the BRS Estilo to the productive sector represents 7.5 % of the total cost for the development of the technology since the year 2000. In addition to the economic benefit provided by the adoption of this technology, it has also generated more jobs and increased product supply on the market.

Keywords: Common bean, economic impact, production costs, profitability

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Use and Management of Ado-Odo Wetlands, Ogun State, Nigeria for Agricultural Production

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The wetlands of Ado-Odo area of Ogun State, southwest Nigeria contain critical ecosystems that have been a life-line in agriculture-dependent economies. Available evidence, however, shows that they are grossly underutilised, compared with their potential for agricultural production and the socio-economic benefits that could be derived from them.

This study examined how the Ado-Odo wetlands are being used and identified their natural and anthropogenic limitations. Primary data were gathered through direct measurement, personal interviews and questionnaire design and administration. Issues of interest were size of area cultivated, crop type and yield, and economic returns from agricultural and other activities undertaken on the wetlands as well as challenges encountered by wetland users.

Crops cultivated were vegetables, maize, rice, sugarcane, plantain and banana. Period of cultivation varied from 3 to 9 months annually on areas that varied from 3 to 5 ha. Seasonal economic returns were between N80,000 and N100,000 per farmer depending on the crop cultivated. Fishing and craft-making yielded N65,000 to N182,000 and N61,000 to N87,000, respectively.

Challenges to more beneficial use of the wetlands included fragmented farm holdings, low application of adaptable technology to wetland cultivation, lack of appropriate policy and guidelines from government, and absence of incentives such as farming inputs at subsidised rate.

The study suggested measures to turn the situation around. These measures include putting relevant guidelines in place, provision of infrastructure such as roads and storage facilities, undertaking focused study to further identify issues that can engender sustainable wetland use and on-the-farm training of primary users of the Ado-Odo wetlands, i.e., farmers, fishermen and craftsmen.

Keywords: Adaptable technology, infrastructural development, capacity building, sustainable wetland management

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Optimisation of Seedball Technology for Pearl Millet (*Pennisetum glaucum*) Production in the Sahel

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In the Sahel, pearl millet (*Pennisetum glaucum*) production is severely constrained as a result of the combined effects of erratic rainfall, poor soil fertility and resource scarcity on the seedlings' survival, most especially at the on-set of the farming season. This increases the bottleneck of labour acquisition for replanting and the production cost, and also keeps the female farmers away from partaking in the farming. However, the farmers practice dry planting, but this leads to crop failures due to the first low rain amounts (<10mm), seed predation and seed wastages at sowing as a result of inserting a vast and an unknown seed amounts in the planting pockets. The application of irrigation, mineral fertiliser and seed treatments as solutions to these problems require skills and are expensive, thus, cannot be afforded by the small scale farmers. In this study, we try to optimise 'seedball technology" in the context of small holder farmers. Seedball technology is a cheap and simple seed-pelleting technique that improves seedlings' survival using locally available resources (clay + sand + seed + water), with wood ash or NPK-mineral fertiliser as the nutrient additives, in a gravimetric mixture. The technology has an added advantage of controlling seed wastages and predation by using a known amount of seeds and seed encapsulation within the seedballs respectively. We conducted climate-chamber pot experiments (<40 days, 30°C temperature, 48.5 % humidity, sandy soil), using the different combinations of the local materials in a block-design of six replicates to optimise the mechanical (size) and chemical (nutrient concentration) effects of the seedball on the seedlings' emergence, nutrient contents (N, P, K, Ca and Mg) and physiology (shoot and root biomass) of pearl millet. We found significant differences in the root and shoot biomass, root and shoot length development, and nutrient contents. Seedballs of 1.5–2.0 cm diameter size, at 2–3 cm sowing depth have no negative effects on the seedlings' emergence. Ammonium and greater than 3 cm sowing depth inhibit seedlings emergence in seedballs. Seedballs have the potentials to relax the bottleneck of crop failures in the Sahel, and encourage more female farmers in pearl millet production.

Keywords: Local materials, pearl millet seedlings, seedball technology, seedballs, seedling establishment

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Agronomic Assessment of Cold Tolerant Chickpea Genotypes in Fall Sowing at Mashhad Conditions

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In order to evaluate agronomic characteristics of chickpea (*Cicer arietinum* L.) cold tolerant genotypes in fall sowing, a field trial was carried out in 2002–2003, 2003–2004 and 2004–2005 at the experimental field of College of Agriculture, Ferdowsi University of Mashhad. This study was performed under rainfed conditions with only two times irrigation at planting stage and 20 days after planting. In the first year (2002–2003), 46 chickpea genotypes (30 cold tolerant accessions resulted from previous studies at Mashhad and some genotypes from ICARDA and Canada) were planted based on Randomised Complete Block Design with three replications. In the first year, cold injury caused complete loss, so, in the next two years, by adding 106 other accessions, totally, 152 chickpea genotypes with 4 checks were evaluated based on the Augmented Preliminarily Design. In each year, genotypes were categorized according to their seed yields to some groups, and some statistical indices such as mean, standard deviation and range were calculated for each group. There were significant differences ($p \leq 0.05$) among genotypes on yield, yield components and plant height. In the second year (2003–2004), the range of seed yield among the first group with the highest yields (39.5 % of all genotypes) was from 251 to 622 g m^{-2}, while in the third year (2004–2005), this range among the first group with the highest yields (20% of all genotypes) was from 254 to 442 g m^{-2}. Finally, 20 chickpea genotypes with the highest yields for each year were selected and introduced the next studies. Considering the importance of field investigations, these results are important to continue research and development programs on the subject of chickpea cold tolerance.

Keywords: Augmented preliminarily design, plant height, rainfed, yield and yield components

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Agroforestry

Invited Paper

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Agroforestry Options for Sustaining Food and Biomass Production and Adapting to Climate Change

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The trend of crop yield and cultivated areas in SSA, suggests that agricultural expansion is the main strategy used by farmers to sustain food production. This practice, however, accelerates natural resources degradation. For instance, 27 % of deforestation in eastern and southern Africa is linked to agricultural expansion through wood extraction for accessing woodfuel. This demonstrates that food and biomass energy supply systems are closely linked. Thus, technologies integrating food and biomass production systems are critical for sustainable intensification of agriculture in SSA to enhance food security while minimising natural resources degradation. We analyse opportunities for meeting household's food and wood demands and increasing the adaptive capacity of smallholder farmers to climate change in SSA through agroforestry. Soil fertility depletion is one of the major driving forces for agricultural expansion, but integrating fertiliser trees on-farm can improves soil fertility and crop yields. High dense (10,000 trees per ha) stands of leguminous shrubs (e.g. *Tephrosia* spp. and *Gliricidia* spp) planted in 1–2 year rotations with crops, has been noted to improve soil fertility and reduce fertiliser costs by 50 % without compromising maize yields. Consequently, there is ongoing work in Malawi to integrate agroforestry with the input subsidy programme as a strategy to scale out proven agroforestry practices and reduce investment risk to farmers. Longer fallows (up to 5 years) of trees have also been noted to build N and P to levels similar to recommended rates and doubling or tripling crops yields relative to unfertilised monoculture. Besides, improving crops production, agroforestry can reduce harvesting pressure on native forests through on-farm wood supply. For instance, clearing 2000–8000 ha of forest annually could be avoided in Tanzania if farmers would adopt woodlots to meet their household's woodfuel demands. Agroforestry practitioners in Kenya and Tanzania have been noted to be more adaptive to climate change (by 25 %) than non-agroforestry practitioners because of diversified products and ecosystem services from agroforestry. Consequently, agroforestry is increasingly being recognised as a climate-smart production system which through provisions of sustainable ecological and socio-economic benefits helps to increase resilience of farming systems and the adaptive capacity of farmers to impacts of climate change.

Keywords: Bioenergy, food and energy security, land degradation, resilience and sub-Saharan Africa

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Baobab (*Adansonia digitata* L.) in Kenya – A Valuable Genetic Resource in a Changing Environment

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Baobab (*Adansonia digitata* L.), an autotetraploid species of the Malvaceae, represents one of the most important indigenous fruit tree species in drylands of sub-Saharan Africa. Despite its significance for food and nutrition security of local communities, the baobab is being threatened by increasing climate and land-use changes, especially by agricultural intensification. Also the species' persistence depends on genetic resources available in its populations. The knowledge of intra-specific morphological variation is increasing while investigations on the genetic diversity of the baobab are rare, especially in the East African centre of its distribution. This study aimed at examining the genetic diversity patterns of *A. digitata* in Kenya, where a high morphological variability suggests a significant genetic diversity. Leaf and bark material of 180 randomly selected baobab trees from six regions in Kenya (East and Coast Province) were collected and analysed in the laboratory with ten nuclear microsatellite markers (SSR) to characterise the genetic diversity patterns. The results indicate that genetic structure correlates with the geographical distribution. At a larger biogeographic scale, investigated populations can be integrated in the East African centre of distribution by examining their haplotypes resulted from chloroplast microsatellite markers. However, single gene pools in Kenya are possibly influenced by gene flow among the Kenyan regions also explained by human-induced seed distribution. The results of genetic investigation will be combined with morphological diversity patterns based on tree and leaf characteristics. The combination of these variation patterns will allow for identification and characterisation of locally adapted types, which may be enabled to persist the increasing threats of climate and environmental changes. The knowledge of local gene pools based on combined diversity patterns are a prerequisite for conservation programs, and the development of sustainable management strategies, especially domestication activities.

Keywords: *Adansonia digitata*, baobab, East Africa, genetic diversity, Kenya, microsatellite markers, polyploidy, population structure

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Agroforestry Systems for Improved Food Production and the Restoration of Other Ecosystems Services in the Dry Corridor in Nicaragua

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The provision of food and other key ecosystem services in the rural landscapes of the dry corridor in Central America are increasingly at risk as a result of unsustainable management practices, high potential of soil degradation and a changing climate. A promising farming strategy to restore the provision of ecosystem services is the use of agroforestry systems (AFS) that combines crops/pastures and trees to improve the functioning of agroecosystems (e.g. biomass production, soil and water retention, biodiversity). It remains difficult to adopt AFS in the field because they can generate trade-offs between ecosystem services, as well as between limiting resources including labour, water and nutrients at plot and farm levels. The objective of this study was to design, implement and monitor with farmers and other partner the impact of AFS on food production and the provision of other key ecosystems services in two sites in the dry corridor of Nicaragua. On-going research shows that combining AFS with crops and pastures can maintain or even improve food (20 % more for bean production) and livestock production (30 % more milk production), while maintaining landscape tree biodiversity, C sequestration (between 5–20 t ha^{-1}) and soil retention. The magnitude of these results depends on the degree of agricultural intensification of farming systems related to their agroecology and market integration. Close interaction with farmers and other partners in the implementation and monitoring of more sustainable farming systems is essential for building common knowledge on social-ecological systems, as well as for facilitating the adoption and adaptation of technologies by farmers. A major challenge remains concerning how farmers could benefit from ecosystem services that have advantages for a larger population in emerging economies, where payment for ecosystems services is rare.

Keywords: Biodiversity, livestock production, smallholder farming, soil degradation, sub-humid tropics

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Labour Demand in Five Different Cocoa Production Systems in Bolivia

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Cocoa cropping systems vary from full-sun monocrops to highly diversified agroforestry systems, which combine the cocoa production with by-crop such as bananas or plantains and trees with different functions. Additionally, these systems can be organically or conventionally managed. Although labour demand is one of the main activities contributing to the total production costs of the plantations and it may highly differ between production systems, there are still scarce data and information available.

In this study we present the labour demands of five different production systems in a newly established cocoa plantation in Alto Beni, Bolivia. The trial was established in 2008 within the framework of the SysCom programme (www.systems-comparison.fibl.org) and comprises monoculture and agroforestry systems under organic and conventional management and one successional agroforestry system with organic management, each one replicated four times. From 2009 to 2013, the establishment phase of the plantation, the time spent in all the farming activities, mainly weeding, pruning, harvesting and fertilising was recorded separately for each plot.

Overall, total labour demand was higher in the successional and agroforestry systems compared with the monocultures, mainly due to the time devoted to the management of the multifunctional trees and by crops. However, no significant differences were found between organic and conventional management under both agroforestry and monoculture systems. On the contrary, the time needed for pruning the cocoa trees was higher in the monocultures. Similarly, the time spent in cocoa harvesting was also higher in the monocultures, especially under conventional management, which well correspond to the yield obtained. Weeding was high time demanding the first years of the plantation but decreased with the time. However, no differences between the monoculture and agroforestry systems and between the organic and conventional management were found.

An economic analysis of the gross margins for each system at plot level, including the input costs (herbicides, fertilisers, etc.) and the associated cost for their preparation (e.g. compost preparation), and the income generated from the harvested produces (cocoa, banana, plantain and other by-crops out of the highly diversified system) is under evaluation.

Keywords: Agroforestry, monoculture, organic farming, profitability, working time

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Developing Capacities to Sutainably Manage Tropical Forests in the Peruvian Amazon – Communal Land-Use Planning and the Focal Model

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Protected areas in the biodiverse Peruvian Amazonian region, are increasingly threatened by human expansion and land-use changes. In order to confront this development, the internationally financed NGO CIMA supports pilot communities in the buffer zone of the natural park "Cordillera Azul" with the development of micro-land use plans, community norms, technical assistance and the organisation of community projects, such as reforestation. Besides, other NGOs and governmental programmes also operate in the region offering payments for the conservation of community forests. By looking at pilot communities in the sectors Chazuta and Shamboyacu, this project analysed the effectiveness of this capacity building at improving sustainable land-use management and limiting deforestation. Based on a mixed-method approach using information from document analyses, qualitative interviews and satellite image analysis three levels of effectiveness were assessed: political output, social outcome and ecological impact.

As political output we assessed the extent to which institutions in the communities are developed, approved and part of local resource management. Based on Elinor Oström's eight criteria for resource use management, the implementation of those instruments in regulating the use of territory and the conversion of forest area is evaluated as social outcome. Due to trust towards the NGO and leadership within the community, many of the analysed communities had significantly advanced with the establishment of those political tools in their community and connected them to habits such as conservation of forests on mountain ranges and around water sheds. The institutionalisation of those community rules helped stabilising the community's land-use as well as the reduction of conflicts within and among the communities. The analysis of satellite images confirmed that those advances led to reduced deforestation and land-use change, particularly in areas that communities designated for conservation. Crucial for the effectiveness in reducing ecological impacts of the resource management was the generation of a sense of ownership among the communities. Economic incentives and regulatory mechanisms only worked, if the mechanisms were proactively incorporated into the community practises.

Keywords: Biodiversity, buffer zone, capacity building, deforestation, institutional development, land-use planning, protected area

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Fruit Tree Diversity and its Contribution to Food Security of Smallholder Farm Households in Western Kenya

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Cultivation of fruit trees on farms can contribute to household food security especially during non-cropping seasons and at times when crops have failed. Fruit tree cultivation also diversifies the income generation options of smallholder farmers and provides micronutrient-rich foods for increased dietary diversity. However, there is insufficient data on diversity of fruit trees on farms and their contribution to food security in Kenya. Understanding these relationships was the aim of the present study. In a stratified random sampling design, a total of 296 farming households were selected, covering four agro-ecological zones (AEZs) in western Kenya and three groups of respondents; one group exposed to a programme promoting fruit cultivation ('FRUIT'), one group exposed to a hygiene programme ('WASH') and one group not exposed to any programme ('CONTROL'). Socio-economic and farm and fruit tree diversity data was collected through interviews.

Of the 32 fruit tree species and 8,376 tree individuals mentioned by respondents, only 9 and 180 were of indigenous origin, respectively. Most frequently mentioned species were the exotics *Mangifera indica*, *Persea americana* and *Psidium guajava*, occurring on 80, 77 and 62 % of the farms, respectively. Median number of fruit species per farm was 4.0 (range 0–10) and median tree abundance 13 individuals (range 0–1,091). All the fruit tree diversity and richness variables showed significant differences across the selected AEZs ($p < 0.001$). The 'CONTROL' groups had significantly lower number of indigenous tree individuals ($p = 0.039$). Male headed households had more exotic individuals than female headed households ($p = 0.030$). About 90 % of households had experienced food scarcity with peaks in April and May. Mean household hunger scale was 5.1 (range 0–15) and mean number of food insecure months 3.6 (range 1–12). Multivariate regression analysis showed that household hunger scale was mainly influenced by the household's poverty index, ethnicity and farm size, but not by on-farm fruit tree richness or abundance.

Interventions should be designed and implemented in the study region to address the currently relatively low level of fruit tree cultivation on farms and to provide fruit tree species, particularly indigenous ones, ready for harvest during the most food-insecure months to vulnerable households.

Keywords: Food scarcity, fruit tree cultivation, household hunger scale, indigenous fruit trees

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The Baobab (*Adansonia digitata* L.) in Southern Kenya — A Study on Status, Distribution, and Use

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Baobab (*Adansonia digitata* L.) is a multipurpose, drought resistant, fruit-bearing, wild savannah tree endemic to drylands of sub-Saharan Africa. Due to its multipurpose properties and its high levels of nutrients in the leaves and fruits, the baobab has a great potential to improve household food and nutrition security through direct consumption and providing alternate income. A recent increase in the demand of baobab fruit pulp on national and international scales has sparked concern over health and utilisation level of wild baobab populations including those in Kenya, for which little data exists. Therefore the main aim of this study was to investigate the population status, distribution and use of baobab in a defined area in southern Kenya.

A stratified systematic transect survey was performed along the road from Voi to Taveta to document baobab distribution. Occurrence, health status and diameter at breast height (DBH) of baobab trees were documented in 49 transects of 1.5 km^2 size each. Household surveys and focus group discussions (FGDs) were used to evaluate use and traditions related to baobab, and baobab distribution in the area.

The baobab population in the research area was found to grow in two main clusters (mean tree density 0.541 baobabs per ha with regenerative populations and 36.5 % small trees (DBH<1 m). Of these, 21 % showed 'stunted growth' caused most probably by pests and/or livestock. The area in between the two clusters, including parts of the Tsavo National Park, had only a few large baobabs (mean density 0.004 baobabs per ha) with no rejuvenation. However, no significant changes in densities over time were mentioned during FGDs. Twenty-seven different uses of six parts of baobab trees were mentioned by the respondent, who highlighted the importance of fruits for family nutrition during food scarce times, while most other uses have become outdated or substituted. The resource was largely under-utilised, but local communities had great interest in new baobab products or improved marketing channels. Baobab in the research area provides a source of alternate income and nutrients for the local communities, but could be exploited to a larger extent to further improve local livelihoods in Kenyan drylands.

Keywords: *Adansonia digitata*, baobab, population structure, rejuvenation, traditional knowledge

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Evaluation of Yield Gap and Production Factors in Cocoa Systems Along a Climatic Gradient in Ghana

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Factors limiting cocoa production include infestation of pests and diseases, low soil fertility, poor management practices, excessive shade and above all climate change. Sustainable intensification through climate smart agriculture has been identified as the way forward. In this context, soil conservation and knowledge of agroforestry could ensure sustainability and resilience to climate change while increasing yields. The cocoa growing region of Ghana is predicted to experience increased temperatures, resulting in higher evapotranspiration rates, as well as more erratic rainfall patterns and longer dry seasons, causing heat and water stress. Despite an increase of cocoa productivity over the last decade in Ghana, the estimated national average of 400 kg $ha^{-1}yr^{-1}$ is still low compared to yields from other countries.

The present study aimed at assessing the cocoa yield gap in three sites along a latitudinal (rainfall) gradient in the cocoa belt of Ghana. Surveys were carried out with 50 farmers per location. Farmers were interviewed about their management practices, and farms were subsequently visited for inventories on cocoa and shade trees, soil and foliar sampling, and an assessment of pests and diseases.

Cocoa yield gap per location is estimated by means of a boundary line analysis. Contribution of production factors (such as soil fertility, agricultural management, pests and diseases) to yield losses are expressed as percentage of attainable yields. The results will then be put in the context of climate change. Considering the potential impact of climate change on cocoa production in Ghana, and the unpredictability of yield outcomes of adaptation measures that farmers are facing today, such a study can guide in setting priorities for location specific adaptation strategies.

Keywords: Climate change, cocoa, intensification, productivity, soil fertility, sustainability, yield gap

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Shade-Tree Diversification in Cacao Agro-Forests: A More Sustainable Model?

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Sulawesi is still home to some of Indonesia's remaining tropical forests, but this is quickly changing due to the expansion of logging activities, cash-crop cultivation, and the degradation of converted areas via unsustainable management practices. Indonesia is one of the world's leading producers of cocoa, and in Southeast Sulawesi, cocoa is currently the principal crop. Declining yields in existing plantations, which can be attributed to high pest and disease incidence, climate change, depleted soils, and ageing trees, might lead to increased deforestation if established systems cannot support sustained or even increased production. It is thus imperative to improve the sustainability of existing cocoa cultivation systems in the region. Diverse cocoa agro-forests are considered to contribute to general ecosystem health. However, while the beneficial effects of trees in cocoa systems are widely stated, data on the magnitude of these effects, and how they ultimately translate into effects on yields, is scarce and often controversial.

In our study, we assessed the impacts of smallholder management decisions on soil fertility across a shade-tree diversity gradient. We quantified the effects of shade-tree diversity, plot age, and fertilisation intensity on ecosystem functioning by measuring yields, soil nutrient pools, soil aggregation, pH and water holding capacity (WHC), and microbial community structure and diversity.

We found no significant effect of shade-tree diversity or fertilisation levels on soil carbon/nitrogen pools, pH and WHC, or yields. Increased shade-tree presence negatively impacted total soil phosphorus pools. We observed significantly higher soil aggregation and SOM content in macro-aggregate fractions, as well as higher microbial diversity and total biomass, in secondary forests as compared to managed cocoa-based systems. Total microbial biomass was significantly higher in older plots.

These initial results suggest that in Sulawesi, shade-tree diversification may not have the clear benefits for soil fertility and yields generally associated with diverse agroforestry systems. Still, trees may have beneficial effects on other ecosystem services such as biodiversity conservation or pest and disease control. Further research is needed to investigate this. It is also likely that other factors such as pest occurrence or microclimate may have more direct effects on yields and productivity.

Keywords: Cocoa, Indonesia, shade-tree diversification, smallholder agroforestry, soil fertility

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Modelling Crop Growth, Soil Fertility and Water Retention under Agroforestry and Slash-and-Burn Systems in Nicaragua

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Soil degradation due to soil organic matter (SOM) depletion and erosion is frequently observed in tropical areas under agricultural intensification, typically affecting the poorest. Restoring those landscapes and enhancing sustainable food production should be a research goal.

Smallholder farmers in drought-prone northwestern Nicaragua highly depend on soil fertility and water regulation capability to produce sufficient subsistence crops. Practicing slash & burn agriculture (s&b) with common bean cropped after maize, loss of SOM results in poorly structured and unprotected soils. Farmers experience topsoil and nutrient loss via water erosion under maize in the early and water shortage for bean development in late rainy season. The Quesungual slash and mulch agroforestry system (QSMAS) as an alternative to conventional s&b consists of a maize-bean rotation under thinned secondary forest without burning and ploughing. Trees are heavily pruned and mulch covers the soil and augments SOM.

QSMAS is thus assumed to be superior to conventional cropping in terms of yields and soil protection. The research goal of this study was to evaluate the agroforestry system and identify key processes limiting or enhancing plant growth. WaNuLCAS, a plant growth model for crop-tree interactions at plot scale, is used for verification and to test improvement options for Quesungual set-up and management (tree species, planting density, pruning and animal browsing). Existing data on soil physical and chemical parameters on three QSMAS and s&b plots, respectively, in Somotillo, Nicaragua, were combined with own measurements soil moisture, photosynthetically active radiation (PAR), canopy light interception, crop growth, mulch quantity and quality .

First modelling results without trees show nutrient availability to be limiting for maize and bean. Under agroforestry, competition for water becomes limiting to crops at higher tree densities, which appears to be supported by measured soil moisture dynamics under three different tree densities. Although results for tree mulch quantities show higher amounts with higher tree density, beneficial mulch effects for soil water retention seem to be overcompensated by additional tree water demand. Furthermore, with tree canopies intercepting 50 to 70 % of PAR, light competition may counteract beneficial effects of enhanced litter production at high planting densities.

Keywords: Crop-tree interactions, maize-bean, quesungual agroforestry, SOM dynamics, WaNuLCAS

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Basis on Rhizoculture: Management of "Underground Agroforestry Systems" to Improve their Climate Change Resilience

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Agroforestry has traditionally been focused on the most economically valuable elements of plants. However, Horizon 2020 Societal Challenge analyses indicate that new nature-based solutions that include the multiple functions of ecosystems are needed for the transition towards a circular economic eco-innovation system to change production and consumption patterns towards a green society. In agroforestry, a better understanding of soil and organism interactions with host plants would allow an intensification on the development and activity of their roots leading to increased resistance of plants to climate change and soil C sequestration and to decreased fertilisation dependence. The development of this multidisciplinary body of knowledge could be called "rhizoculture". The present work propose a review and a research project to develop a new "rhizoculture" approach in Agroforestry connecting the root, rhizosphere, agroforestry uses, fertilisier managements and landscape planning, all supported by four research approaches: (1) agrotechnological support to root development, (2) biological and biogeochemical support to "soft" fertilisation and rhizosphere management, and (3) soil organism management by soil organic matter control (by extensive livestock and biomass uses) and other tools, (4) landscape planning using territorial analysis tools, as i.e., Openforis Collect Earth. Seeking to change production and consumption patterns towards a sustainable, green economy and society, the benefits associated to this type of research on rhizoculture may increase the biodiversity and C stock in the soil, moreover, the development of the roots in agroforestry systems would increase the plant´s ability to cope with environmental and climatic changes. This approach would also improve the health and performance of plants and decrease the high costs and pollution associated to fertilisers and phytochemicals.

Keywords: Biodiversity, fertiliser management, resilience to climate change, rhizosphere, root management, soil biodiversity, soil C stock, soil carbon

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Systems and Managements Related Differences in Phenology of 12 Cocoa (*Theobroma cacao* L.) Cultivars

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Cocoa production systems can vary from a mono-cropping (MC) full sun plantation to a highly diversified successional agroforestry (SAFS). Mono-cropping is still the most common one but recently agroforestry (AF) systems have raised more interest because of their expected long-term resilience. Nevertheless, information about the influence of cropping systems and management methods such as organic versus conventional in cocoa production and phenology in South America is missing.
This study is based on the SysCom program's framework located in Alto Beni (Bolivia), where three cropping system (MC, AF and SAFS) are compared. Additionally, MC and AF systems are conventionally and organically managed. A total of 12 cultivars including local clones, foreign clones (from the Imperial College Selections and Trinidad Selections) and hybrids are planted in each system. The aim of the present study is to identify differences between systems, management methods, cultivars and the respective interactions on cocoa phenology. Data on flushing and number of flowers, small, medium and big fruits and cherelles are being recorded every 15 days from March 2015. The trial was designed according to a split-plot design with four replicates. Principal component analysis (PCA) and cluster analysis were performed on the cultivar level. Additionally, the collected data will be statistically analysed with a generalised mixed model (Poisson distribution) to test the effect of the different cultivars, systems and their interactions on the phenological traits.
Preliminary results of the PCA and cluster analysis do not show a clear grouping pattern between the three types of genotypes analysed. This suggests that there are differences between cultivars but they are not consistent within the three groups. Preliminary descriptive results of the collected traits show differences between single cultivars and systems, but not between managements (organic vs. conventional). Some of the traits seem to be more system dependent than others. For instance, the number of cherelles seems to be higher in the SAFS than in the other systems. Additionally, interactions between systems and cultivars are expected to be present. This would be positive in terms of potentiality for selection of cultivars adapted to each different system.

Keywords: Agroforestry, Bolivia, cherelle wilt, monoculture, organic farming

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A Preliminary Investigation on Locally-Based Identification and Use Determinants of Multipurpose Tree (MPT) Species in the Yayu Forest Coffee Biosphere Reserve, South West Ethiopia

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Currently, more than half of Ethiopian farmers are not capable to produce or purchase enough food to cover their own demands. Production systems of small farmers are traditional: human and animal labour-based, use of low inputs and rain fed. Under such scenario, agroforestry practices have shown to be cost-effective means to enhance small householders' food security, through by-products generating income, and conserve the environment. The study area, the Yayu Forest Coffee Biosphere Reserve, registered by UNESCO as a center of origin and diversity for *Coffea arabica* and sanctuary of several other plants and animal species, is well known for hosting long-lasting traditional practices for the effective utilisation of the forest resources on which rural households depend greatly. As part of a study aimed on understanding the nexus between agroforestry and food and nutrition security, the existing multipurpose tree (MPT) species in the study area were identified, their uses listed, and the characteristics of their adoption determined. Methods combined botanical transects (n=16) and semi-structured interviews with key informants (n=40). Sampling subsets considered of eight categories, systematically defined as function of the distance to markets and the biosphere reserve. Univariate and multivariate statistical analyses were applied to compute the relative influences of the two factors on the use of MPTs. A total of 43 edible MPT species were identified in the study area, among these 17 exotic and 26 native. Main uses include food, fodder, fuel, and honeybee production. About 22 MPT species (50% of the total species encountered) are potentially merchantable. The proximity to the biosphere's core area is significantly correlated with the presence of trees important for production of honey ($p < 0.05$). Several exotic species show a strong correlation with the proximity to the market ($r = 0.760$ and $p < 0.01$). In general, the proximity to the market has been found as major determinant of the variability and use of MPT species.

Keywords: Coffee-tree system, food security, mountain forest, edible trees, Yayu

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Comparison of Methods to Assess Dry Bean Yield of Different Cocoa Cultivars

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To estimate the cocoa dry bean weight from the fresh weight a standard dry bean factor (DBF) ranging from 32 % to 40 % is usually applied. This factor, i.e. the relation between the dry bean weight (fermented and dried) and the fresh weight at pod opening, is used by cooperatives and factories that buy the fresh beans of the farmers. However, this factor is subjected to seasonal fluctuations and can be highly influenced by rainfall. Therefore, for instance, higher values are expected during the dry season compared with the rainy season.

The objective of this study was to evaluate the accuracy of the use of a standard fix DBF value compared with the use of actual DBF values periodically collected over the season for assessing the performance of 12 cocoa cultivars (clones and hybrids). We hypothesised that using the same DBF for different cultivars that may have the production peak at different times of the season can lead to over- or underestimations of the yield performance.

The study was performed in a long-term cocoa trial in Alto Beni, Bolivia, which comprises full-sun monocultures, agroforestry and successional agroforestry productions systems. In 2014, for each harvest date, cultivar and production system, a subsample of the fresh beans was collected, put in a mesh bag and weighted. After the fermentation and drying process, the subsamples were weighted again and the DBF was then calculated at 8 % water content of the beans. The total performance of each cultivar at the end of the harvest season was estimated using the actual DBF for each cultivar, system and harvest date, and the results were compared with the performance estimated using the DBF values averaged across systems, harvest dates and varieties and also with the fixed DBF of 35 %.

The results only showed minor differences in the overall performance of each cultivar when comparing the different methods used. However, for all the cultivars, using the 35 % fix value gave the poorest estimation compared with any of the other DBF tested, mainly due to underestimation of the performance of the early maturing cultivars.

Keywords: Agroforestry, Bolivia, cultivar performance, fresh bean weight, monoculture

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Interactive Effects of Altitude and Management on Coffee Agro-Ecosystems Along a Transect on Mount Elgon, Uganda

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Coffee intensification and its environmental impact has been documented extensively in the last two decades, particularly in South and Central America. Coffee systems of East Africa on the other hand are still under researched, despite their socio-economic and environmental importance in the region. Arabica coffee systems predominate on many East African mountains and constitute a mayor land-use type bordering the remaining tropical montane forest cover. Depending on how coffee is managed it can retain substantial biodiversity and provide many other essential ecosystem services particularly relevant for vulnerable montane slopes. The multifunctional role of shade trees contributes in sustaining coffee production and improving farmers' livelihoods, if managed appropriately.

In this study we assessed the range of Arabica coffee systems along an altitudinal gradient on Mount Elgon, Uganda. A typology of coffee systems was derived based on an extensive field work on 150 coffee plots related to vegetation structure. Productivity, management intensity, labour intensity, severity of pest and disease incidence, soil health, and tree species diversity were compared between the systems and along the altitudinal gradient. Determinants of adoption of different coffee systems were investigated.

The results serve as a basis for studying the trade-offs inherent in and between the systems regarding a diverse set of ecosystem services. Furthermore, the altitudinal range enables to explore the diverse effects of temperature (and precipitation) on coffee productivity and other ecosystem services among the identified systems and its interactive effects. This is particularly relevant to study the possible impacts of climate change and the relevant measures for adaptation.

Keywords: Altitudinal transect, coffee agro-ecosystems, ecosystem services, system comparison, trade-offs

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Characterisation and Spatial Distribution of Shade Trees and Bananas in Arabica Coffee Systems of Eastern Uganda

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Coffee plays an important role for the Ugandan economy and is mainly cultivated by smallholder farmers. Yields are generally only 30 % of potential yields for the region and one of the reasons is that local farmers are often not able to provide the inputs that are required to achieve high yields. Moreover, Arabica production in Uganda is increasingly going to be negatively affected by climatic changes. Especially lower altitudes will suffer from reduced rainfall and increased temperature, and might become marginally suitable for Arabica coffee.

The present study aimed to (1) characterise the plots of smallholder Arabica coffee farmers in Eastern Uganda with regard to the spatial distribution and canopy extension of shade trees and bananas (*Musa* spp.), and (2) to assess their influence on coffee yield and vigour, in order to give recommendations to farmers regarding climate change adaptation strategies.

Smallholder coffee plots in the Mount Elgon region of Eastern Uganda were monitored at three altitudinal levels (1000–1400, 1400–1800, 1800–2200 m asl). A detailed mapping of the plots was conducted with GPS technology, which allowed to create maps showing the location of shade trees, bananas and coffee. The maps further give information about the canopy spread and DBH of shade trees, as well as the leaf area of bananas. In addition coffee trees assigned to three shade categories were rated for their vigour, and productivity data previously obtained on the same plots was included in the analysis. We then examined the influence of tree and banana distribution, species diversity and canopy characteristics on the vigour and production of coffee.

Our results point to a high variability in the design of coffee systems in the region, and help to disentangle differences in coffee performance between and within plots. Our study allows a more detailed understanding of the main effects of shade trees and bananas on coffee production and of the conditions under which shade is most beneficial.

Keywords: Climate change, coffee, shade, spatial distribution, Uganda

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Contribution of Internal Nutrient Cycling in a Successional Agroforestry in Tomé-Açu, Pará, Brazil

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The Agroforestry System of Tomé-Açu, Brazil (SAFTA) mimics natural succession with commercial species and enables farmers to use their fields for a long period. However, the mechanism of SAFTA, especially on the effects of crop-plant succession on the nutrient and carbon (C) flows, has not yet been well documented. Thus, the objective of this study was to reveal the change and its mechanism in C flow during succession, and clarify the ecological advantages and conditions of SAFTA.

Three different successional stages of SAFTA were selected of the fields planted in 2008 (6 years old; 6YO), in 2002 (12YO) and in 1980 (34YO). The C flow was analysed by measuring the C contents in aboveground biomass, soil, litter and harvest (fruit plus residue), and the carbon dioxide (CO_2) emission from soil. For reference, the C contents in soil and litter and soil respiration were monitored in a nearby secondary forest. The measurements were conducted from September 2012 through July 2014.

The yield of cacao fruit was highest in 12YO and contained 3.3 kg-C tree^{-1}, followed by 34YO and 6YO with 1.9 and 1.5 kg-C tree^{-1}, respectively. Litter was highest in secondary forest with 8.2 Mg C ha^{-1} year^{-1}. The litter of 6YO, 12YO and 34YO increased with the age, and were 4.6, 5.6 and 7.1 Mg C ha^{-1} year^{-1}, respectively. Soil respiration rate in the chamber with litter in secondary forest was 176 mg CO_2-C m^{-2} h^{-1}, those for 6YO, 12YO and 34YO were 77, 104 and 113 mg CO_2-C m^{-2} h^{-1}, respectively. The C balance in 6YO, 12YO, 34YO were 4.1, 4.5, 3.9 ton C ha^{-1} y^{-1}, respectively.

Our results demonstrated that the amount of litter fall and soil C increased as the SAFTA stages progressed, indicating a higher internal nutrient cycling according to the agroforestry age.

Keywords: Agroforestry, carbon balance, internal nutrient cycle

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The Role of Coffee Agroforestry in the Conservation of Tree Diversity and Community Composition in Native Forests

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Agroforestry is considered a promising alternative to conventional agriculture that can both conserve biodiversity and support local livelihoods. Coffee agroforestry may be particularly important for sustaining trees of conservation concern and late-successional stage, but this possibility remains unclear. Here, I examined whether coffee agroforestry systems can serve as conservation reservoirs of tree species native to nearby forests. I compared tree diversity, composition and structure between coffee agroforests and forests in La Sepultura Biosphere Reserve in Chiapas, Mexico. I found that, although at the landscape level the full set of coffee agroforests appears to conserve comparable tree species richness to nearby native forests, the species composition that is being conserved is different. Coffee agroforests had a lower proportion of trees of conservation concern, a higher proportion of pioneer trees, were dominated by Inga spp., harbored lower tree species diversity at the plot level, and were composed of different tree species compared to native forests. I suggest that conservation practitioners and policy makers seeking to promote coffee agroforestry as a conservation strategy should consider how such agroforestry systems differ in species diversity and composition from the native forests of conservation interest. Further, promoting different coffee agroforest management strategies, such as discouraging the replacement of diverse agroforest canopies with single species dominated canopies, would help improve the conservation value of coffee agroforests through more sustainable practices.

Keywords: Agroecology, agroforestry, biodiversity, conservation, tree diversity

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Farmers' Local Knowledge of Shade Tree Species in Cocoa Agroforestry of Western Ghana

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Cocoa (*Theobroma cocoa* L.) is one of the most important perennial cash crops for the economy of Ghana. Growing as an understory tree, it needs high annual rainfall and temperatures between 18°C to 32°C. Due to its climatic requirements cocoa cultivation is highly vulnerable to climate change, which may cause reduction in production. Predictions for Ghana show that some regions will become less suitable for cocoa cultivation.

The present study assessed farmers' perception of shade trees species, which are not only an essential part of cocoa farming, but also play a key role for climate change mitigation.

In the region of Asankragua in Western Ghana, 45 cocoa farmers were chosen randomly and interviewed about their general opinion on shade trees. Moreover, they also responded to a detailed questionnaire covering major advantages and disadvantages of shade tree species, including ten pre-selected species as well as the eight most common species on their respective farms.

In total 105 tree species were found to be associated as shade trees on cocoa farms. Both female and male farmers' generally perceived shade trees as beneficial for cocoa farming. However, some shade tree species were regarded as harmful (e.g. *Cola nitida*), as it is attracting mistletoe amongst other things. Other species were highly appreciated, because they provide fruits or timber as supplementary income (e.g. *Persea americana*, *Petersianthus marcocarpus*) despite having negative impacts, such as causing black pod (*Phytophtora palmivora* and *megakarya*) and harboring rodents. Female cocoa farmers were found to have fewer shade trees on their farms compared to male farmers (on average 21 vs. 38 trees ha^{-1}). Anyhow, a slightly higher percentage of male respondents (67 %) than females (53 %) wished to increase the number of trees on their farms. This points towards the estimation that female farmers expect additional trees as less beneficial. Further research should make use of the detailed knowledge of farmers, especially regarding attributes and characteristics of uncommon shade tree species. Nevertheless, best practices for cocoa farming, including agroforestry, still need to be promoted, especially among female farmers.

Keywords: Cocoa agroforestry, local knowledge, shade tree species, western Ghana

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Maintaining Carbon Stocks and Tree Diversity in Agroforestry Systems in the Sub-Humid Pacific Region in Nicaragua

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The seasonally dry tropical forest (SDTF) of Mesoamerica has been highly transformed by deforestation, burning, agriculture expansion and extensive livestock production, causing extensive habitat destruction and fragmentation resulting in soil degradation, biodiversity loss and an overall reduction of other ecosystem services. Silvopastoral systems (SPS) and Quesungual slash-and-mulch agroforestry system (QSMAS) have been promoted to restore key ecosystem services. A study was implemented to: i) quantify the potential impact of different land-use systems in tree diversity and C regulation; and ii) understand potential trade-offs of these two ecosystem services in a SDTF in northern Nicaragua in five major land-uses : SPS, QSMAS, naturalized pastures (NP), slash and burn traditional cropping system (TCS) and secondary forest (SF). In 144 plots (0.1 ha each), we estimated tree composition (dbh >2.5 cm), species richness, diversity (Shannon) and carbon stocks (fractioned in aboveground, litter, dead wood, soil at 20 cm depth). We recorded 2655 trees belonging to 110 species and 45 families. Land-uses differed significantly in terms of abundance, diversity, and floristic composition of tree species. SF was the most diverse land-use, followed by QSMAS and SPS. SF and QSMAS were more similar in composition compared to the others land-uses, Regarding above-ground biomass, SF measured 88 Mg ha^{-1} and QSMAS 33 Mg ha^{-1}, whereas 3 Mg ha^{-1} in TCS. Soil organic C pools were similar between land-uses, with more variability in SF. Total C pools ranged between 102 in SF, 60 in QSMAS, 54 in SPS, 46 in NP and 39 Mg C ha^{-1} in TCS. Soil C accounted from 54 % to 80 % of the total C in SF and QSMAS, whereas up to 96 % in TCS as expected. Results confirmed that QSMAS and SPS can improve both tree diversity conservation and C storage. These synergies can be further enhanced by co-designing with farmers linking better tree diversity and potential use to ensure rural households. The adaptation of these systems could also include farmer incentive mechanisms to restore the multi-functionality of farming systems and rural landscapes in SDTF of Central America.

Keywords: Biodiversity conservation, seasonal dry tropical forest, smallholder agriculture, sub-humid region

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Participatory Forest Management in the Congo Basin — Ways for Climate Change Adaptation and Sustainable Development

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The Congo Basin belongs to some of the most complex and most interesting terrestrial ecosystems in the world and is considered to be one of the world's biodiversity hotspots. Human and animal populations living in or nearby the forests are dependent on its ecosystem services for their daily livelihood needs. Unfortunately, the man-made degradation of the Congo Basin forests persists and thus threatens the provision of food, water, medicinal plants as well as important cultural, regulating and supporting ecosystem services. In addition to land-use changes, climate change is dramatically increasing the vulnerability of the forest ecosystem and all dependent species including the local human population.

Thus, new solutions need to be found that combine a sustainable forest management practice, while ensuring climate change adaptation at the local level to increase resilience of the Congo Basin socio-environmental system. For this, Participatory Forest Management (PFM) has been analysed using a multi-criteria assessment of different climate change adaptation indicators. The indicators chosen combined socio-economic, cultural, political and environmental factors to provide a holistic and interdisciplinary perspective.

The analysis showed that PFM can offer a management practice that ensures and enhances the satisfaction of livelihood needs such as the provision of food and water, while promoting sustainable development of health infrastructure and education services. At the same time, PFM increases climate change resilience of the forest ecosystem and subsequently also the local population. Additionally, the analysis showed that certain factors (e.g. enhanced food security) promote the effectiveness of climate change adaptation, while other factors (e.g. lack of transparency) increase the constraints for proper PFM implementation. At the end, these factors need to be considered to reduce effectively the vulnerability of local population and the Congo Basin ecosystem and thus need to be integrated into the post-2015 political development agenda.

Keywords: Adaptation, Africa, climate change, Congo Basin, participatory forest management, participatory resource management, post-2015 agenda, resilience, sustainable development, tropical forests, vulnerability

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Constraints of Sustainable Forest Management: A Case of Nuba Mountains Region

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Sudan like other developing countries has weak strategies, policies and legal frameworks that support the sustainability of natural resource. The criteria of forest resource management were largely carried out informally through local community leaders prior to the colonial era. Recently, governments intervened and withdrew the managing control from villagers and followed new approaches to manage this resource. This study was an attempt to investigate the efficiency of the official forest management system in enhancing sustainable management of forest resource in the Sudan. A field survey visit based on structured interviews in 22 villages covered three types of tenure systems; reserved forests, community forest and natural woodlands. Total sample size was 300 households distributed among units of Rashad locality in Nuba Mountains according to the Principle of Population Proportional to size (PPS). The data were analysed using Statistical Package for Social Sciences (SPSS) software. The forest reserves in the study areas constitute a basic source of a variety of environmental goods and services most needed by villagers in addition to provide them with critical subsistence, income generation and job opportunity. However, the largest part of benefits were obtained through illegal access, leading to negative impact on forest resources. Moreover, 82.9 % from the respondents had no relationship with Sudan Forests National Corporation (FNC), meanwhile only 17.1 % had this relationship implying: access to extension services, licenses, establishing relationships, training on awaraness, and rights and properties. On the other hand and despite the small area and limited contribution of community forests, farmers possessed a huge experience in the establishment of plantations and their management. Therefore, opposite the expectations of the government multiple use management policy proved to be ineffective in the absence of coordination between all stakeholders. To enhance any development strategy, forest authorities should actively involve local inhabitants and to support these through helping them understan the perceptions, aspirations as well as to give due consideration to their basic needs and integrate indigenous knowledge when developing forest management strategies and plans.

Keywords: Forest management, land use, Nuba Mountains, policy, tenure systems

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Research, education and innovation: The global food security programme of BMBF

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Research, Education and Innovation: The Africa Strategy an Example for the International Perspective of the German Federal Ministry of Education and Research (BMBF)

PETER WEBERS

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International collaboration is a cross-cutting and substantial part of the research policy in Germany. The presentation will give an insight on it's best example: the Africa Strategy of the BMBF.

The German research funding agenda in many aspects has an international structure. The national framework conditions for Germany's research and innovation system corresponds to BMBF's Internationalisation strategy and especially to the collaboration with Africa and the MENA region.

For Germany's international research cooperation the basis was laid out in the Federal Goverment's strategy for the internationalisation of science and research, adopted in 2008. An example of BMBF's regional activities is the strategy for cooperation in science, research and innovation with Africa. This was adopted in summer 2014 after a consultation process with the African partners.

In autumn 2014, the BMBF published the Action Plan for International Cooperation.The main goal is to connect national, European and international activities more closely in order to exploit synergies.The action plan paves the way for Germany's higher education institutions and research institutions to act internationally, for their benefit as well as for the benefit of their international partners.

Keywords: International collaboration, research networks

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BiomassWeb: Improving Food Security in Africa through Increased System Productivity of Biomass-Based Value Webs

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With the shift of governments towards a bioeconomy, global demand for food, feed, fuel and fiber crops has increased pressure on the agricultural sector and food production worldwide. Concepts to increase food security while attending growing demands for non-food biomass are still in their infant stages. BiomassWeb develops concepts to increase food security in sub-Saharan Africa by focusing on innovations in the agricultural sector and in biomass-based value webs.

BiomassWeb addresses all pillars of food security: 1) food availability through enhanced productivity; 2) food access through income generation from non-food biomass production, processing and trading; 3) use of food through increased nutritional quality; and 4) food stability through more efficient land-use systems. System complexity is captured by the methodological framework of biomass-based value webs, i.e., interlinked value chains in which food and non-food biomass are produced, processed and traded.

The 5-year BiomassWeb research programme comprises 22 work packages organised into 7 research clusters. Research activities identify potential productivity and efficiency gains in the biomass sector through an increased integration of all value web components and the utilisation of currently wasted biomass. For strategic points within the value webs, the project identifies modular innovation opportunities in production and processing technologies and institutional and governance structures. The project output consists of scientific knowledge generation and capacity development regarding: (1) Specific recommendations for crops, especially for cassava, maize, banana/plantain/enset and bamboo, and countries (Ethiopia, Ghana, Nigeria); (2) a framework of methods and tools to address future biomass challenges and a group of regional biomass resource experts trained in applying and expanding the tools; and (3) a pan-African network (Biomass Net) of biomass experts and actors in sub-Saharan Africa's biomass sector as a stakeholder platform for biomass-related discussions and activities for the next decades. Stakeholder engagement and interaction ensure the adoptability and dissemination of project results and contribute to preparing the African bioeconomy for the rising biomass demand.

BiomassWeb builds on a network of German and African universities, research institutions, and international agricultural research organisations, in particular the Forum for Agricultural Research in Africa (FARA) with strong expertise of transforming research into action.

Keywords: Bio-economy, biomass-based value-web, food - non-food competition, system productivity

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Diversifying Food Systems – Horticultural Innovations and Learning for Improved Nutrition and Livelihoods in East Africa (HORTINLEA)

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Food security and poverty remain aggravating challenges in East Africa despite decades of development work and research. Enhancing food security having complex dimensions of food availability, food accessibility, food stability and food utilisation, requires an integrated approach that transcends disciplinary boundaries and aims at solving real world problems not merely at contributing scientific knowledge. Horticulture, in particular African Indigenous Vegetables (AIV) provide a comparatively advantageous entry point as they offer largely untapped potentials in terms of workplaces and income opportunities, the delivery of vital micronutrients for combatting malnutrition and, last but not least, a raised diversity of agricultural production systems. However, top down research approaches generating only knowledge from selected disciplines have reportedly failed to provide smallholder farmers with affordable, practical and readily available solutions to their problems; adoption rates of scientific inventions are low. Interdisciplinary knowledge generation must be embedded in an effective innovation system extending to all stakeholders to bring about change. The HORTINLEA research framework holistically analyses the food system and AIV value chains of Kenya and bordering regions of Tanzania and Ethiopia using an integrative, interdisciplinary framework adapted from natural, social and communication science, ecology, gender studies and development economics, developed by more than one hundred young and senior researchers from Kenya and Germany within our international research project. In this presentation the general logical framework, project structure, challenges and opportunities will be discussed.

Keywords: African indigenous vegetables, dissemination, food security, horticulture, HORTINLEA, interdisciplinary

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Wetlands in East Africa: Reconciling Future Use with Environmental Protection

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Food production in many areas in East Africa shows stagnating or declining trends, with demographic growth, land degradation and climate variability being the main culprits. Wetlands, on the other hand, have year-round water availability and generally high resource base quality and present potential production hotspots. They cover 20 Mio ha in the four target countries (Kenya, Rwanda, Tanzania and Uganda) with only a small proportion currently being used. We surmise that these wetlands may become the food basket of the region. However, an increased food production from wetlands will only be achieved sustainably if intensified land use can be reconciled with the conservation of biodiversity and the maintenance of ecosystem services. Since September 2013, a German – African consortium assesses wetlands' contribution to food security and the sustainability of current and future uses.

We have classified major wetlands by developing a wetland typology. In and around four representative target wetlands, we have catalogued the prevailing biodiversity and defined indicators of change. Changes in resource base quality attributes are being assessed along climatic and social gradient. The spatial-temporal dynamics of matter fluxes and their underlying processes are studied, and the economics of various ecosystem services are being quantified. Technical options for enhancing production, their ecological trade-offs as well as their social-cultural implications are compared along hydrological gradients at two super test sites. Models and various assessment tools are being developed and employed for cross-disciplinary and cross-scale integration. In this context, also the positive (food security and nutritional diversity) as well as the negative (water-borne diseases) human health implications are considered, and we develop regional projections under different global change scenarios.

The integration of actors from development and policy into the research process and a strong component of capacity building by training ensure the application of the findings both within the region studied and beyond.

Keywords: Floodplain, Kenya, modelling, Tanzania, Uganda

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GlobE – RELOAD: An Approach to Facilitate Food Security in Sub-Saharan Africa

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In the face of 850 million people being undernourished and a growing global population which is predicted to reach 10 billion by 2050 the German ministry of education and research has started a call for research projects enhancing food security especially in African developing countries.
Post Harvest Losses (PHL) with a global extent of about one third of the harvested products (annually 1.3 billion tons) contribute essentially to the devastating nutritious situation in many developing countries.
RELOAD (Reduction of Post Harvest Losses and Value Addition in East African Food Value Chains) is a project based on German-African research cooperation. Four academic institutions and one private company from Germany together with six African universities from Ethiopia, Kenya and Uganda, African national agricultural research institutes, small and medium enterprises and the International Centre of Insect Physiology and Ecology (ICIPE, Nairobi) make up a network for research about solutions to the problems arising from PHL.
RELOAD consists of seven sub-projects, four of which are related to important commodities with significant losses in each of the respective East African countries. These include staple foods, roots and tubers in Ethiopia, milk and meat products in Kenya and fruits and vegetables in Uganda. Three subprojects are product- and country-comprehensive, covering economic, technical and social aspects. The research results will be disseminated and implemented using SMEs and stakeholder groups as vectors and multiplicators.
Besides optimising supply chain performance and developing low-cost and grid independent technological solutions for storage and preservation it is especially aimed at developing innovative processed food products that provide for a balanced diet (e.g. maize or plantain flours blended with pulses or pumpkin flours) and other convenience food items that respond to the demand of a growing urban middle class in the concerned countries.
Based on this approach and setup valid research results are generated that can be transferred to other regions and contribute to a considerable reduction of PHL in a sustainable manner.

Keywords: Food security, post harvest losses

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Trans-SEC - Innovating Strategies to Safeguard Food Security Using Technology and Knowledge Transfer – Current Status

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Food security is one of the most pressing constraints in the Sub-Saharan Africa. Site-specific upgrading strategies (UPS) can improve the food situation; however, it is necessary to understand the local and region-specific food systems. The collaborative research project Trans-SEC is targeted to enhance the Food Security for the most vulnerable rural population in Tanzania. It is composed by 12 institutions from Germany, Tanzania, and 2 International Research Institutions.. Trans-SEC focuses on entire Food Value Chains (FVC) and its nexus elements and integrates the specific cultural, political, social, ecological and economic environments. Another key aspect is the broad stakeholder's involvement.

Trans-SEC has four case study sites (CSS) in two contrasting regions (semi-arid, sub-humid). The focal crops are maize and sesame (in the sub-humid region) and millet and sunflower (in the semi-arid region), also including intercropped commodities such as pigeon pea and groundnuts or other crops if adding high value to the food system.

Trans-SEC so far has achieved several core outcomes:

1) a baseline survey of 150 households in the four CSS and two more villages (as control) and

2) a complete typology of the FVC of the CSS;

3) a stakeholders mapping along the FVC was completed for the four CSS.

4) Thirteen UPS for testing selected using participatory methods

7) UPS implementation groups, which are monitored.

8) business plans and innovation funds have been set up for UPS implementation

Besides the implementation of the UPS, the next steps include the monitoring and analyses for all five FVC components, the evaluation and (ex-post) impact assessment of UPS, and dissemination.

Keywords: Food security, food value chains, Tanzania, upgrading strategies

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UrbanFood^{plus} – African-German Partnership to Enhance Resource Use Efficiency in Urban and Peri-Urban Agriculture for Improved Food Security in West African Cities

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Food security in West Africa not only depends on productivity increases in marginal rural areas, but also on enhanced use of intensively farmed agricultural "niche" lands such as the urban and peri-urban spaces. They are characterised by easy market access and input availability which allows self-reinforcing processes of agricultural intensification. However, too little is known about resource use efficiencies, matter flows and negative externalities in these systems. Starting from general assessments (*status quo* analyses), the African-German UrbanFood^{Plus} (UFP) network develops and tests site-specific, farmer-tailored innovations. These directly address the above mentioned knowledge gaps in the four West African cities of Ouagadougou (Burkina Faso), Tamale (Ghana), Bamako (Mali), and Bamenda (Cameroon).

At all locations farmers attempt to cope with increasing land pressure by cultivating along electrical power lines, on public property, and on undeveloped private land.

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While a large proportion of the major food crops origin from the countryside, leafy vegetables and milk are mainly produced in the cities and peri-urban areas. Determined by water availability cultivation patterns strongly vary across the year. In Tamale staple crop production is vital in the rainy season while commercial vegetable production dominates during the dry months. Livestock production systems are highly diverse in both cities while dairy and commercial pig farming predominates in Ouagadougou.
Urban agriculture is also characterised by high nutrient input rates through organic and inorganic fertilisers and reliance on irrigation. Biochar produced from corn cobs, rice husk, and saw dust was characterised and used for direct land application, filtering of irrigation water, and for co-composting. Biochar improved crop growth in both cities (up to 50 %) and can be used as an effective filter material for waste water (2.5-3 log10 units reduction in pathogens in a two stage system). A market model was established using secondary time series data (production and consumption) of the past 30 years. This will allow a site-specific economic evaluation of the impact of productivity enhancing technologies.

Keywords: Food security, irrigation, nutrient fluxes, soil fertility, urbanisation

Land use management - IITA and sustainable intensification, the role of ISFM

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Is Integrated Soil Fertility Management a Viable Pathway Towards the Sustainable Intensification of Smallholder Farming Systems in Sub-Saharan Africa?

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Sub-Saharan Africa needs to produce more food, feed, and fiber to support its growing population and intensification of smallholder agriculture is a crucial component of any strategy towards this goal. Where intensification is desirable, Sustainable Intensification (SI) denotes a commonly accepted goal to achieve this but does not specify a priori how it should be approached. Three principles are usually considered for SI: (i) production of more food, feed, fuel and/or fiber per unit of land, labour, and/or capital used, (ii) preservation of important ecosystem services, including those governed by healthy soils, and (iii) resilience to shocks and stresses, including climate change.

Integrated Soil Fertility Management (ISFM) aims at increasing crop productivity and the agronomy efficiency of applied inputs but targeting appropriate combinations of improved varieties, fertiliser, organic resources, and other soil amendments, the latter as required based on site-specific constraints limiting crop productivity ISFM also targets scarcely available production resources within heterogeneous farming systems, thereby taking into account within-farm soil fertility gradients which are common feature of smallholder farming systems in densely populated, resource-limited farming landscapes. Examples are given on the performance of ISFM interventions with maize-legume and cassava-legume systems within heterogeneous farming environments.

Since ISFM is not addressing the provisioning of soil-based ecosystem services operating beyond an individual plot or farm, to achieve SI, other investments will be required that require interventions beyond individual farms, often based on collective action. It is argued that such interventions, in absence of incentives such as payment for ecosystem services schemes, will be of interest to smallholder farming communities once the productivity question is addressed.

Besides improving productivity while conserving/enhancing the natural resource base, SI also aims at increasing resilience to climate shocks and change. Adaptation to climate change at farm level often includes many of the elements that are key to ISFM, such as adoption of new crop varieties, adoption of mixed crop-livestock farming systems, optimised intercrop systems including trees and shrubs, and soil and water conservation practices. The 'climate-smart' nature of ISFM is briefly discussed.

Keywords: Capital, feed, fiber, fuel, healthy soils, labour, land, more food, resilience, soil and water conservation

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Enhancing Legume Productivity for Sustainable Intensification of Maize-Legume Farming Systems in Sub-Saharan Africa

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Increasing food production in the sub-Saharan Africa countries requires sustainable intensification in order to address the chronic problems of food insecurity, under- and malnutrition and to increase the incomes of rural households. The International Institute of Tropical Agriculture (IITA) and Wageningen University, through the N_2Africa and COMPRO projects, are advancing grain legume technologies using the Integrated Soil Fertility Management framework to achieve sustainable intensification of maize-legume farming systems in sub-Saharan Africa. Field activities focus on enhancing biological nitrogen fixation and yields of grain legumes through identification and promotion of effective agricultural commercial products such as inoculants (I) and phosphorus (P) fertilisers, seeds of improved varieties and good agricultural practices appropriate to various agro-ecologies and cultural contexts. Other activities include institutionalisation of regulatory procedures to guarantee quality of inputs and to create sustainable supply chains of these inputs. Field evidence shows that rhizobia inoculation can yield benefits worth US$50–75 for an investment of only US$3–5 but with small amounts of P fertiliser to ensure acceptable soybean yields. Yields of groundnut, cowpea and common bean are often doubled with small amounts of P. However, making the most of the benefits offered by 'improved' gain legume varieties requires careful attention to crop management including rhizobial inoculant, balanced fertilisation, timely planting weeding and pest management. Also results indicated that, besides N, P and K, other nutrients e.g. Mg, S and micronutrient limit legume yields in most African soils warranting formulation of area specific legume fertiliser blends. In terms of benefits, farming households with sufficient land and labour benefit most from value chain, market led approaches. Poorer, often female-headed households benefit from the opportunities that grain legumes offer to intensify production and process nutritious food on small farms. A direct and causal developmental impact is clearly demonstrated between the increases in production and N_2-fixation of grain legumes and food and nutritional security and participation in markets. However, agriculture in sub-African Africa faces several challenges sustainable intensification requires coordination of different research products and investments among different stakeholders along a product value chain.

Keywords: Intensification, legumes, N-fixation

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Increasing Cassava Productivity in the Context of Sustainable Intensification

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Cassava is one of IITA's major mandate crops, which traditionally received high attention by the institute's breeding programs for high yield potential and pest & disease tolerance/resistance. More recently, with the "cassava transformation" cassava has emerged as or is becoming a cash crop for many farmers in Sub-Saharan Africa. This trend is reinforced as cassava is used in food (high quality cassava flour) and industrial processing (starch, sweetener, glue) and also continues to be a staple food for growing urban populations. Thus, avenues of sustainable intensification for cassava production of high agronomic efficiency are key to several cassava related programs and projects. Central is the concept of integrated soil fertility management, which has been validated for cassava in Central Africa by the "Consortium for the Improvement of Agriculture based Livelihoods in Central Africa" (CIALCA). The approach encompasses the stepwise application of improved germplasm, fertiliser, legume inter-cropping and locally adapted optimised cassava husbandry including spacing, planting time and weeding. A planting pattern of 0.5m $\times$ 2 m cassava intercropped with 4 rows of short duration legumes, optionally followed by 2 rows of second legume, between cassava rows appears not to reduce cassava yield but increases land productivity. Establishing the response of cassava to fertiliser composition, amount and application timing, as well as interaction with manure is an integral part of cassava agronomy research in the programme "Support to Agricultural Research for Development of Strategic Crops" (SARD-SC). In collaboration with the International Plant Nutrition Institute (IPNI), fertiliser response data are used to develop the first site specific cassava nutrient manager, which will replace "blanket recommendations" with an OPEN ACCESS decision support system that considers farmers' conditions, yield targets and investment capacity. Agronomic efficiency in cassava is severely compromised when weeds are not efficiently controlled. Weed management consumes about 40 % to 50 % of the total labour in cassava production. The effect of management options such as tillage, fertiliser application, intercropping, cassava plant density and growth type, on weed suppression and cassava yield is a major research component of the 'Sustainable Weed management in Cassava Systems' project together with the screening of herbicides to reduce drudgery specifically of women and children.. Varietal choice, tillage and plant density are suitable options to attain higher root yields and suppress weeds. The next step is combining component technologies and developing efficient approaches to take cassava agronomy to scale across the major producer countries in Sub-Saharan Africa.

Keywords: Agronomy, decision support tools, fertiliser, improved germplasm, legume intercropping, locally adapted optimised cassava husbandry, weed control

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Climate-Smart Intensification of Coffee and Cocoa Smallholder Systems in Africa

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Coffee and cocoa demand on the world market continues to expand annually by 2–3 %. Over 5 million African smallholder families depend on these cash crops for their livelihoods. However, cocoa and coffee yields are low (10–30 % of potential) and highly variable with limited use of external nutrient inputs. Research shows that poor soil fertility is largely responsible for those low yields, together with pests and diseases and poor management practices. Over the past decades, supply growth largely depended on the expansion of the crop into natural/fallow land. Consequently, cocoa has been a key driver of deforestation and less than 15 % of the original forest cover in West Africa remains. The industry is increasingly concerned about future supply, particularly now that climate change further threatens the current production zones. Climate-smart intensification is required to ensure both smallholder livelihoods and the industry's need. Over the past decades, full-sun production systems have been promoted by public authorities and industry actors. Whereas these systems are often perceived to have the highest production potential, they do expose farmers to risks

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of climate variability and reduced sustainability. Novel integrated soil fertility management (ISFM) options are designed, combining (i) targeted fertiliser applications based on foliar and soil nutrient diagnostic tools, (ii) no-till mulched systems and (iii) inter-cropping with shade crops (e.g. bananas) and (leguminous) trees. Such systems improve both production quantity and resilience. Additional fruit and fire-wood diversifies farm income and food security. Increased carbon storage above- and below-ground (10–60 t/ha) further contribute to climate change mitigation. Producing more on the same area due to sustainable intensification could have avoided 21,000 km^2 of deforestation and forest degradation in West Africa, equivalent to nearly 1.4 billion t of CO_2 emissions. Expanding sustainable intensification efforts to the Congo basin is needed to (i) reduce poverty, (ii) respond to industry demand, and (iii) 'compensate' for production area loss in West Africa. This requires (i) novel partnerships between agricultural and forest conservation actors and (ii) commitment from the industry to invest in sustainable supply chains, both from an economic, human and environmental perspective. Certification labels can further accelerate this.

Keywords: CO_2 emissions, Congo basin, deforestation, external nutrient inputs, poor soil fertility, West Africa

Using Cropping System Models and Geospatial Tools to Bring Agronomy to Scale in the Savannahs of Nigeria

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Crop yields in sub-Saharan Africa are generally low and vary significantly from one location to another due to a myriad of reasons including poor soil fertility, moisture stress, pests and diseases, and inappropriate agronomic practices. There is usually a huge gap between the yield attainable within any specific climate-soil zone and the actual yield realised by the average smallholder farmer. In order to close the gap, the underlying reasons for the low yields must be clearly understood. Cropping system models, if properly calibrated and validated, could assist in providing a better understanding of the reasons for the gaps. The use of such tools could assist decision-making at various stages including site selection, evaluation of various management options, and extrapolation and scaling-out of results obtained in trial sites. In the last three years, Bayero University has worked with IITA and other national and international research Centers to calibrate and validate the CERES-maize model for use as a decision support tool in the Savannahs of Nigeria. Experiments were conducted in 2013 and 2014 to generate genotype-specific parameters for calibrating the model, and on-station and on-farm trial data were used for model validation. Areas within the Savannahs of Nigeria were divided into climate-soil zones in which various production scenarios (variety $\times$ planting time $\times$ N application rates) were modeled. The outputs produced include yield maps and yield gap graphs, which will assist extension workers, researchers and policy makers in making decisions on alternative crop and soil management interventions and ex-ante evaluations of various production scenarios. However, the usefulness and the possible scaling-out of such results depends on the reliability and resolution of the input data used in validating the model and in characterising and delineating the climate-soil zones. The work currently being conducted on Maize (TAMASA) and Cassava will provide more data and a better understanding of the response of the two crops to various genotype $\times$ environment $\times$ management combinations. The findings from this work will have to be validated under realistic conditions. In order to find suitable areas for future validation trials, geo-spatial methodologies like similarity analysis and classification procedures are applied. Identifying and mapping areas with similar characteristics to existing trial sites helps to scale out the results while areas with significant environmental differences should be avoided for direct dissemination.

Keywords: CERES-maize model, moisture stress, pests and diseases, poor soil fertility, yield gaps

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Aflasafe: Safe Crops, Better Health and Higher Income

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Aspergillus flavus and *A. parasiticus* are saprophytic moulds that are often associated with pre- and post-harvest yield losses of food and feed crops. The fungi reside in soil and infect crops in the field. Upon infection, the fungi produce highly toxic secondary metabolites – aflatoxins — which render contaminated crops unsafe for consumption. Presently, up to 65 % of maize and groundnuts that are produced and consumed in sub-Saharan Africa are aflatoxin contaminated. Consequently, aflatoxin exposure is very high, with $>$ 95 % of children below 5 years containing the toxin in their body. Aflatoxins cause liver cancer, suppress the immune system, stunt children and sometimes kill. In animals, it decreases productivity and profitability. Commodities containing unacceptable aflatoxin levels are either forced into low-value markets or destroyed. To minimise aflatoxin contamination in maize and groundnuts, IITA and its partners have developed a biocontrol product known as Aflasafe. Aflasafe is an environmentally friendly granular formulation of native non-toxic strains of *A. flavus* that are coated on sterile sorghum grains. Aflasafe application in the field displaces toxin producing *Aspergillus* strains, thereby reducing aflatoxins. Farmers in Nigeria, Kenya, and Senegal for instance continue to treat tens of thousands of hectares of maize and groundnut fields annually and have consistently achieved 80 % to 99 % reduction in aflatoxin contamination. Moreover, one annual application of aflasafe provides multiple-year and multiple-crop benefits. The product is cost effective providing high returns on investment and health benefits. Although aflasafe deployment provides a valuable tool for promoting trade, enhancing healthier farm families, increasing income and livestock productivity and profitability, its uptake and scaling up in various African countries is hindered by lack of manufacturing plants, capacity and permits. At the moment, the product is registered in Nigeria and Kenya and only one aflasafe manufacturing facility exists in the whole of Africa. This makes the manufacture and distribution of country specific biocontrol products to West, East and Southern African countries costly and unsustainable. In order to encourage aflasafe use and commercialisation through private, public, or public-private partnerships, modular aflasafe manufacturing plants for local production, manufacturing, marketing, and distribution licenses and mechanisms of providing stewardship and technical backstopping need to be in place.

Keywords: *A. parasiticus*, aflatoxin, *Aspergillus flavus*, contamination, non-toxic strain

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Leveraging Agriculture to Improve Nutrition and Health

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Agriculture and nutrition are part of a virtuous cycle. Not only does increasing agricultural productivity have the potential to improve rural families' nutrition, but healthier and better-nourished smallholder farmers are more productive, earn more income, and contribute to further economic growth. To address under nutrition using agriculture, in collaboration with our partners, we conduct food consumption and nutrition population surveys to identify commonly consumed foods, preparation methods and portions and determine nutrient intakes of women of childbearing age and preschool children. Studies on nutrient retention are conducted to establish the impact of processing while dietary diversification is achieved through conducting research on product development; improving nutritional quality of traditional food products (food-to-food fortification); increasing availability and access to nutritious and safe food and income through research on processing, packaging and storage targeting small and medium scale entrepreneurs. Our research on food quality includes relating physico-chemical characteristics and functional properties with product sensory characteristics and consumer preference. Lessons learned show that there is a steep increase in the incidence of wasting between 6 and 12 months, which corresponds with to the introduction of complementary foods; across the agro-ecological zones, the largest proportion of malnourished children is in the dry savannah compared to moist savannah and humid forest; the onset of the three forms of malnutrition (stunting, wasting, and underweight) appears to occur most often between 6 and 24 months of age. The amount and types of foods consumed by women of child bearing age and preschool children lacks diversity as it is based mainly on starchy staples and vegetables, with very minimal consumption of animal products and fruits. Furthermore, our research indicates that the impact of processing on nutrients is dependent on processing method and variety. The addition of protein-rich crops and by-products of distillation increases the protein quality and quantinty of food products. In conclusion, adding value to agricultural produce, and linking crops grown to foods consumed and nutritional status of women of childbearing age and preschool children may offer opportunities of leveraging agriculture to improve nutrition as it will help identify gaps in nutrient intakes resulting in targeted interventions that may also include improving food systems.

Keywords: Bio-fortification, consumer preference, dietary diversification, malnutrition, sensory characteristics, under nutrition

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Integrated Pest Management in Africa: Developing and Deploying Bio-Pesticides

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Chemical insecticides are very often used by farmers as the first line of defence to control arthropod pests attacking their crops, also because there might not be other alternatives such as resistant varieties or appropriate agronomic practices. However, the inappropriate use of such agro-chemicals has led to adverse impacts on human and environmental health. Farmers are aware of these drawbacks and have long expressed a strong need for safer pest control options.

Formulated and used correctly, bio-pesticides are excellent alternatives to harmful pesticide regimes. Work carried out by IITA and its partners has found that entomopathogenic micro-organisms and natural plant extracts can function as safe and effective pest management agents. During the past 20 years, IITA has investigated the use of bio-pesticides for the control of several agricultural pests including locusts, grasshoppers, termites, storage weevils, mites and caterpillars attacking most of the African staple crops.

Entomopathogenic fungi including *Metarhizium anisopliae* var. acridum and *Beauveria bassiana* have been successfully tested at large scale for the control of several agricultural pests and are the object of commercial production. Bio-pesticide mixtures using baculoviruses and emulsifiable neem oil have showed a synergistic effect in the field, which warrants further investigations and might be expanded to include other compatible products.

While more stable and sustainable solutions against some of the most intractable pests are being pursued through biological control pipelines, e.g. the development and deployment of hymenopteran parasitoids which can establish themselves in the natural environment, bio-pesticides remain a valid pest management option for resource-poor farmers in Sub-Saharan Africa, who are very often not adequately educated and equipped to handle harmful chemical pesticides.

Keywords: Baculoviruses, *Beauveria bassiana*, entomopathogenic micro-organisms, *Metarhizium anisopliae*, neem oil

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Conservation and Characterisation of Germplasm Diversity to Underpin Efforts to Enhance Food Security

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The Genetic Resources Centre (GRC) of IITA holds important germplasm collections of most of the major staple crops of sub-Saharan Africa: Cowpea, Yam, Maize, Cassava, Soybean and Banana/Plantain. In addition, it holds smaller number of accessions of important but underutilised legumes including Bambara groundnut, African Yam Bean and Winged Bean. A total of more than 33,000 accessions are held. GRC collects, characterises, conserves, documents and distributes accessions of these crops. Seed propagated crops are conserved under cold storage conditions and safely duplicated at 2 geographically different places, including at the Svalbard Global Seed Vault (SGSV). Conservation of clonal crops (Cassava, Yam, Banana /Plantain) is carried out both in the field and *in vitro* genebank, with cryo preservation also being developed.

Distribution of accessions is carried out free of charge as part of the multilateral system under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) to all requestors for research purposes or breeding for food and agriculture. Where possible, passport and characterisation data are also made available on-line and we have started uploading these data to Genesys, a web based portal that is bringing together accession level information for CGIAR and some national Genebanks. GRC collaborates with national programmes including genebanks, particularly in West Africa, and plays an important role in training and capacity development.

A major objective is to increase the effective utilisation of germplasm in breeding programmes within and outside the CGIAR. One of the routes we are taking toward this collaboration with colleagues within and outside IITA is the molecular characterisation of our collections.

Plans are in place for a new facility in East Africa at IITA, Tanzania for the conservation and cleaning of cassava landraces of South East Central Africa which are threatened by cassava brown streak disease. This disease has not reached West Africa and so it is advisable for collection and conservation to be carried out in the East with the collaboration of national partners and to support their breeding programs.

Keywords: Banana/plantain, cassava, cowpea, cryo preservation, *in vitro* genebank, maize, soybean, Svalbard global seed vault, yam

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Geo-Spatial Tools to Bring Agronomy to Scale

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During the last 40 years IITA conducted thousands of agronomic and plant breeding trials. Most experiments have been carried out at the IITA HQ Campus, an IITA station or nearby because it was more convenient to travel and access the farmland. Existing connections to farmers, communities and strategic partners or donors also caused a limitation in the spread of farm sites used for experiments. Over the years the continuous use of fertiliser, inoculants, herbicides or insecticides modified the soil properties such that the overall soil condition on-station is likely to differ from most smallholder farmlands in sub-Saharan Africa which means that the transfer and the repeatability of results from the on-station experiments to other places is likely to be poor and unreliable. Environmental factors often have been neglected in the site selection or have not been described in such a way that they could serve as covariates in analyses. The research often focused on short-term results like testing varieties for susceptibility to pests or response to fertiliser application. Soil samples were taken and analysed to interpret yields but there was no investment in long- term integrated soil fertility management (ISFM) strategies as a process to prevent soil degradation or rehabilitation of already degraded soils. Without sound knowledge of the local soil conditions and appropriate strategies to maintain or increase soil fertility any predictions of expected crop responses to interventions outside the usual on-station situation are likely to be biased. To overcome poor extrapolation of results on larger areas, IITA is interested to carry out trials in more and so far not used locations. Two approaches appear feasible to identify new locations: one option is looking for similar environments to which findings are transferred into "real" cropland and farmer conditions to be verified there; the other option is looking for different environments to evaluate interventions' effects and to assure that new technologies can be disseminated to regions where they have not been tested. The IITA GIS Unit aims to explore new unbiased methods of identifying locations to conduct experiments (with strong focus on long term trials) that fully consider soil conditions and climate factors without neglecting accessibility, market connection and other social and economic factors. Geo-Spatial methodologies are known to help in this regard. The poster outlines the use of similarity/distance calculations and classification procedures to identify new locations.

Keywords: Classification procedures, extrapolation domains, similarity/distance calculations, site selection

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Sustainable Systems Intensification: The Humidtropics Approach in West Africa

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HUMIDTROPICS, the CGIAR research programme on integrated systems for the humid tropics, seeks to improve the livelihood of poor smallholder farmers in the humid tropics regions of the world through integrated systems approach. To do that, partnerships are built among stakeholders through platform establishment to identify major constraints and accordingly entry points for research interventions and system research implementation. This poster presents the approach used in the West Africa Action Area countries of Cameroon, Nigeria, Ghana and Ivory Coast. Multi-stakeholder platforms, research for development (R4D) and innovation platform (IP) were set up respectively at action sites and field sites levels in each country. R4D platforms are research oriented whereas IPs are action and implementation oriented. Both R4D and IPs are formed by representatives from farmer organisations, research and training institutions, private sector (agricultural products processors, transporters, marketers, inputs dealers, microfinance institutions, etc.), NGOs and civil society, and government. The R4D platforms identified the research entry points and these were validated by the IPs through stakeholder based constraints identification and ranking. Both platforms develop and implement the research approach to generate solutions. In all countries cocoa intensification was identified as a major entry point yet with differences in the components that require improvement. In Cameroon farmers prefer cocoa diversification with other fruit trees, food crops and vegetables. In Nigeria cocoa rejuvenation and new plantation establishment appears the first choice. In Ghana the long term sustainability of the relatively young plantations is a concern and addition of shade trees with commercial value is an entry point. In Ivory Coast food crop production in cocoa growing areas is insufficient and farmers focus on integrating cassava, maize and grain legumes to attain food security and cash income. Although at different stages of implementation, the on-farm trials/demonstrations encourage joint learning and adoption of innovations, shown by the number of 'baby' trials established by farmers themselves in their own farms. We conclude that the identification of entry points by the platforms and the joint development and implementation of the research to find place-based and demand-driven solutions supports the learning process and technology adoption.

Keywords: Cameroon, constraints, Ghana, innovation platform (IP), Ivory Coast, Multi-stakeholder platforms, Nigeria, research entry points

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Actual and Potential Impacts of Improved Cassava Varieties in Sub-Saharan Africa

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In its 2012–2020 strategy IITA is committed to contributing to lifting 11 million Africans out of poverty. In an attempt to measure progress towards this goal, the team of social scientists has chosen to analyse impact of a number of IITA's projects and programs. One of these case studies is presented here. The study assesses the actual and potential poverty impacts of the adoption of improved cassava varieties. Propensity score matching and endogenous switching regression model were applied to data on a sample of 2060 households that came from four major cassava producing countries, namely Tanzania, Democratic Republic of Congo, Sierra Leone and Zambia. Findings are consistent across the two estimation methods, revealing negative realised and potential impacts on poverty. It was established that a 1 % increase in per capita consumption expenditure due to adoption of improved cassava varieties has resulted in a 0.8 % poverty reduction among the current adopters compared to 1.25 % among potential adopters. This implies that if concerted efforts are made to enhance adoption of improved cassava varieties among the current non-adopters, the payoff in terms of poverty reduction would be even more than what had actually been realised among the current adopters. Potential adopters would also fare better than the actual adopters in terms of income shortfall or depth of poverty. A 1 % increase in per capita consumption expenditure due to adoption would reduce the depth of poverty by 1.31 % among potential adopters compared to 1.03 % among the current adopters. This implies that the minimum cost required to lift a potential adopter out of poverty is much smaller than what was needed to lift the actual adopter. While both actual and potential adopters face less inequality due to adoption, the impact of adoption in reducing severity of poverty was higher among the current adopters than would be case among the potential adopters. These findings imply that the cassava research programme had already benefited cassava growing population and would benefit potential adopters even more. Therefore, it is important to strengthen the extension services to enhance adoption by the current non-adopters for greater impacts of the improved cassava varieties.

Keywords: Impact, improved cassava, poverty, sub-Saharan Africa

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Research-for-Development (R4D) Platforms - A Multi-Stakeholder Initiative for Integrated Farming Towards Sustainable Intensification

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One of the main challenges to agricultural development in Africa is to recognise and take advantage of heterogeneity, both in terms of socio-cultural variation and bio-physical diversity. The research-for-development (R4D) platform is an initiative to address these challenges of diversity and heterogeneity, while at the same time focus on smallholders' demands and opportunities for different interventions to have positive impact.

The presentation will focus on the organisation, facilitation and long-term sustainability of R4D platforms established by the USAID/Feed the Future research programme Africa RISING (Research in Sustainable Intensification for the Next Generation) in Tanzania. The platforms serve as vehicles for prioritising and scaling of sustainable intensification through integrated farm practices, focusing on crop/livestock interactions at the farm and landscape levels, and also linking farmers to input dealers, markets, extension and policy. The ultimate goal is to stimulate learning and innovation to improve livelihoods in terms of productivity, income generation and nutrition.

The primary beneficiaries are small-scale farmers and other stakeholders in rural areas who, through the platform, will have better access to information, technologies, expertise, credits, markets, etc., supporting agricultural intensification for improved and sustainable livelihoods. An important aim of the platforms is that research outputs as well as outcomes of platform discussions/negotiations will inform decision makers, public and private players in agricultural development and educators about how R4D platforms can work to promote technological, social and institutional change, in order to put sustainable intensification to scale.

The main reasons for applying a multi-stakeholder approach are related to the basic functions of "research for development": Firstly, research institutions need a demand-driven approach as a complement to more traditional "science-driven" approaches. Secondly, the focus is on targeting and effectiveness of development interventions. The third reason is that while research is normally a relatively small-scale activity (in terms of beneficiaries), development initiatives supporting good governance and market access must play the role of promotion of new ideas to a wider audience. Lastly, when these things are in place, the potential for platform sustainability beyond the project lifespan is increased.

Keywords: Demand-driven approach, multi-stakeholder, R4D platform, sustainable intensification, Tanzania

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Humidtropics, a CGIAR Research Program on Integrated Systems for the Humid Tropics

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HUMIDTROPICS, a CGIAR Research Program led by the International Institute of Tropical Agriculture (IITA) started in July 2012 and seeks to transform the lives of the rural poor in tropical Americas, Asia and Africa. It uses integrated systems research and unique partnership platforms to increase overall agricultural productivity in a sustainable manner for better impact on poverty and ecosystem integrity. Core programme partners are: AVRDC, Bioversity International, CIAT, CIP, FARA, icipe, ICRAF, IITA, ILRI, IWMI, and WUR.

Integrated systems are complex, dynamic and vary from location to location. The main programme entry points are poverty status and ecosystem integrity status to determine social and technical intervention pathways where research is aimed at changes in systems productivity, natural resources management, and institutions and markets. Its multiple intervention pathways display trade-offs and synergies between competing use of resources and benefits based on different entry points and priorities based on area related extrapolation domains. Innovation Platforms and other change coalitions in selected field sites help to identify and prioritise systems problems and opportunities, invest, test and experiment with social and technical interventions and share experiences.

Some characteristics of Humidtropics are:

• Holistic systems approach: research puts smallholder farmers at the centre of a wider integrated system that considers multiple farming system components, institutional and technological environments to develop multiple social and technological interventions at farm and institutional level.

• Blend of biological and social sciences: research includes external environmental, cultural, social, behavioural, political and economic variables.

• Demand-driven: research is driven by people, livelihoods and living environments using multi-stakeholder Research for Development (R4D) and Innovation Platforms as key participatory mechanisms through which challenges, bottlenecks and opportunities are identified and prioritised.

• Sustainable intensification: increase total farm-level productivity, optimise returns, while preserving the natural resource base for future generations.

• Capacity to innovate: the essence of sustainability and resilience lies in the capacity of system actors to innovate and adapt; Humidtropics strives to build innovation capacity.

• Gender and youth empowerment: is an integral part of the Program, its goal is to narrow the inequities between men and women in access to and benefit from the productive resources that are central to rural livelihoods.

• Linking research to development: linkages between research and development are used as an essential mechanism towards attainment of impact at scale.

Keywords: Integrated systems research, livelihoods, productivity, sustainability

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Sustainable Root & Tuber Crop Production Systems for Sub-Saharan Africa

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Root & tuber (R&T) crops are the mainstay of many smallholders across Sub-Saharan Africa (SSA). Yam and cassava, two of IITA's mandate crops, have undergone differential changes over the last 50 years. While cassava is ascending from a marginal subsistence crop to a major commercial cash crop, yam, previously a major staple, is threatened by declining soil quality no longer supporting high and reliable yam yields. Cassava germplasm improvement created high yield potential and pest & disease tolerance/resistance. In yam very little genetic improvement was attained. Agronomic research to increase production has not received adequate attention and funding over the last 20 years. The fact that cassava with a yield potential of >80 Mg ha^{-1} realises 12 Mg ha^{-1} in Nigeria today, almost as much as 30 years ago, raises the question how to realise more of the potential by farmers.

Today R&T agronomy receives major attention in IITA with the final goal to develop site specific crop management expert systems (CMES) that will be at farmers' disposal through an open access software application. The CMES will be a decision support tool comprised of 5 modules along the production process: (1) varietal choice, (2) soil and crop management including land clearing and preparation, tillage, planting density and pattern, intercrops, and weeding regimes, (3) nutrient supply, (4) pest and disease control and (5) locally adapted methods to maintain or improve soil fertility.

Currently research is on locally optimised cassava varieties, planting density, choice of intercrops and pattern, tillage and weed control methods and frequency. The nutrient supply expert system is developed in collaboration with the International Plant Nutrition Institute (IPNI). Trials on nutrient limitations, fertiliser responses and application rates are conducted in 4 countries across SSA. Legume integration, erosion control, soil amendments and fertiliser are options to improve, maintain or rehabilitate soil quality to support R&T crop production. The IITA Biocontrol Center in Cotonou, Benin provides expertise on pest and disease control in R&T systems focusing on bio-pesticides to avoid environmental damages.

The R&T agronomy research focuses on interventions that farmers can implement without major capital and labour investment and those that are gender neutral or improve the situation of women, children and the youth. With a large number of projects investigating component technologies the next step is developing efficient approaches to take cassava agronomy to scale across the major producer countries in SSA.

Keywords: Agronomy, cassava, legume integration, nutrient manager expert system, scaling, weed control, yam

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From Rural Situation Analysis to Farmer Entry Points and Grassroots Actions: Humidtropics Research for Development in West Kenya

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The Humidtropics Program explores and advances livelihood strategies where poverty reduction, system productivity and natural resource integrity are effectively achieved. This goal results through a stepwise process that conducts a situation analysis, then examines systems improvement through strategic entry points, and then promotes collective actions and institutional innovations that advance emerging proven technologies. One of the Action Areas within the Program is West Kenya where four promising and interacting entry points (and impacts) were identified: legume integration (increased BNF), cassava intensification (enterprise diversification), *striga* elimination (increased food security) and improved livestock enterprise (improved diets and incomes). The key to building upon these four entry points is their intersection at the farm level as a means of deriving multiple household benefits. First a conceptual farm model was developed that describes these entry points in terms of yield, value and resource transfers. These elements were linked to findings from baseline and impact surveys, field actions planned around them, and then linkages forged with farm organisations, extensionists and commercial interests around the emergent useful technologies. Actions were conducted with the WeRATE R4D Platform composed of 26 grassroots organisations reaching 79,506 households. Outreach efforts revealed that *striga* emergence in maize is reduced by 63 % using IR maize technologies leading to an additional 1.2 t ha^{-1} yield and $640 profit. Inoculation and blended fertilisers improved soybean nodulation 3-fold, increasing yield by 0.8 t ha^{-1} and profits by $370. Improved cassava production focused upon the release of six new varieties at 18 community demonstration sites and seven bulking centres with widespread sales of cuttings beginning in late 2015. Beneficial impacts from this work include widespread availability of IR maize through local agrodealers and farmer organisations, marketing of 299 tons of soybean per season as grain, seed and processed products, and increased demand for cassava with improved disease resistance and best tasting leaves. These efforts led to the establishment of 13 new agrodealers and the networking of 27 others. The timeframe of the three year project was insufficient to address the livestock enterprise entry point other than to quantify and increase organic resource flows useful as better feed. Otherwise, this approach led to widespread technology adoption by farmers and improved linkage of member farmers to input suppliers, commodity markets and other rural development interests.

Keywords: Collective actions, institutional innovations, strategic entry points, systems improvement

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IITA Youth Agripreneurs – An Initiative to Empower Young People

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Youth unemployment, poverty and a lack of positive outlook on life across many developing countries is becoming an increasing threat to the social fabric of communities. Agriculture is an essential driver of youth employment and empowerment and offers unique opportunities to create jobs and increase skills for young people in sub-Saharan Africa. IITA, under the leadership of Director General Dr Nteranya Sanginga, created the IITA Youth Agripreneurs (IYA) in August 2012.

The goal of IYA is engaging youths in productive market-oriented agriculture, agribusiness and service provision. IYA directly engages youth to use linkages along the value chains from production to processing, marketing, and ultimately to industrial and domestic consumption.

IYA's initial focus was production and distribution of quality seeds and has expanded to value addition leading to production of cassava bread, soymilk, and tidbit snacks, service delivery in capacity building and consultancies. The group also diversified into vegetable production, catfish farming and pig feeding for low fat pork.

IYA members come from various disciplines such as History, Computer Science, Quantity Surveying, Statistics, Biochemistry, Mass Media, Economics, Soil Science, Agronomy, and Crop Breeding. The group began with reorientation to prompt a change in mindset about agriculture in the youth. Despite limited knowledge of agriculture and agribusiness at the commencement of the program, the youths were able to gather great understanding and knowledge of "agripreneurship" through training both on and off the field.

IYA uses science-driven improvements in agriculture to make a distinctive contribution to solutions of the challenges faced in agriculture and agribusiness. In 2014 the Nigerian IYA cultivated 70 ha with a projection of 175 ha in 2015.

Currently the IYA concept is expanded to more countries and new groups have been established in DR Congo, Kenya, Tanzania, Uganda and Zambia.

Keywords: Job creation, lack of positive outlook, poverty, science-driven, skills improvement, unemployment

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Aeroponics System: An Effective High Ratio Seed Yam Propagation Technology

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Yams (*Dioscorea* spp) are traditionally propagated by tuber with very low multiplication rate (less than 1:10 compared to 1:200 in some cereals). The use of the edible tubers, for propagation makes seed yam scarce and very expensive. Many methods for high ratio propagation were developed these included the "minisetts technique" generating up to 30 setts per tuber of 1kg; the vine cutting multiplication technique with up to 60 vines of one node per plant, the temporary immersion bioreactor system with well-developed tissue culture plantlets up to 100 per container fully developed in 6–8 weeks. In comparison to these methods the aeroponics system that has been applied successfully by the International Institute of Tropical Agriculture for seed yam, has shown more advantages in terms of type and quantity of planting materials (tubers, bulbils and vines) generated. The basic principle of Aeroponics technology is to grow plants in a closed or semi-closed environment by spraying the plants' roots with a nutrient rich solution. The most important yams species used as foods *D. rotundata* (white yam), *D. alata* (water yam) and *D. cayenesis* (yellow yam), *D. dumentorum* (bitter yam), *D. bulbifera* (bulbil yam) were tested soilless aeroponics. Only vines of *D. dumentorum* did not grow. Vines of all the other 4 species grew profusely, developing good plants. *D. bulbifera* grew for more than 4 months and produced small bulbils before senescence. *D. cayenesis, D. alata* and *D. rotundata* are growing like perennial crops in aeroponics. These three species grew for 9, 21 and 28 months, respectively, in aeroponics. The vines of these species originating from field plants grow slowly in aeroponics but vines issued from plants in aeroponics produced roots and shoots easily in soil, sand, carbonized rice husk. Plants in aeroponics offered 3 different types of planting materials: tubers every 3 to 5 months, bulbils regularly starting in the second month and vine cuttings after establishment of canopy. The highest number of harvested materials was 3 tubers per plant ranging from 1 to 6. The tuber mass harvested in aeroponics ranged from 0.1 to 326 g/plant and up 40 bulbils (shoot born tubers) per plant at one harvest. Vines generated ranged from 110 to 300/plant with an average rooting of 99 %, of these 93.4 % to 96.4 % (mean 95.1 %) developed into normal plants.

Keywords: Bulbils, clean planting material, propagation ratio, vine cutting

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Biotechnology for Enhancing Agricultural Productivity in Sub-Saharan Africa – The Role of the IITA Bioscience Center

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The challenge of large yield gaps in sub Saharan Africa (SSA) provides an opportunity for biotechnological intervention. One of the strategies to boost agricultural productivity is genetic improvement of germplasm. However, genetic improvement of many of the under-studied staple food crops of Africa is hampered by lack of genomic resources. IITA deploys a wide array of techniques and tools to mitigate the myriads of constraints in agricultural production. Our mission is to develop and deploy innovative biotechnology products and new tools for modern molecular breeding, genetic engineering, disease and pest diagnosis, conservation and characterisation of biological diversity, and plant health management.
Key strategic objectives and major outputs:
• Employ next generation genotyping (e.g. GBS) to discover desirable traits and describe the germplasm collection at the Genbank for crop improvement. Thousands of accessions of yam, cassava, cowpea, banana, and maize have been fingerprinted by GBS (genotyping by sequencing)
• Plethora of genomics tools (markers, whole genome sequence, transcriptome) developed and applied to accelerate the selection of superior varieties by shortening the breeding cycles of target crops. Modern breeding schemes such as genome selection (GS), marker-assisted recurrent selection (MARS) and forward breeding using MAS for simple traits are deployed resulting in varieties with high nutritional quality, high yield and stress tolerance. IITA is also engaged in the development of data management and decision support tools tailored to the implementation of innovative breeding strategies.
• Genetic engineering for resistance to crop diseases for which there is no or limited host resistance (e.g. Banana Xanthomonas wilt, nematode resistant plantain and cassava resistant to virus diseases). Tissue culture and micro-propagation techniques such as temporary immersion bioreactor are used for rapid multiplication of planting material and to eliminate diseases from germplasm.
• User-friendly and affordable tools for disease diagnostics to determine the causal agent of important diseases to enable designing of appropriate control measures as well as to pre-empt emerging threats posed by pests and diseases.
• Enabling partners to develop adequate infrastructure and expertise through training and provision of laboratory and computational services to realise the full benefits of agricultural biotechnology. The Bioscience facility of IITA is Africa's gateway to modern technologies and a platform for innovation and discovery for our partners in SSA.

Keywords: Disease diagnostics, genotyping, markers, resistance, transcriptome, whole genome sequence

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Progress and Current Trends in Cassava Improvement in Sub-Saharan Africa by IITA and Partners

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The International Institute of Tropical Agriculture (IITA) and partners have engaged in cassava improvement for over 45 years with over 400 variety releases in over 20 African countries. Cassava breeding and IPM have prevented losses of over US$2 billion from pest and disease constraints such as the cassava mealy bug, cassava mosaic disease, cassava bacterial blight and cassava green mite. Recently, cassava brown streak disease losses and increased prevalence of abundant white flies have become severe constraints in East Africa with threats to West Africa. Cassava improvement programs are modernizing by combining improved agronomic practices with use of genomic technologies, improved phenotyping and data management. Breeding objectives seek to improve dry matter content in varieties with high stable yield across diverse agro-ecological zones. Additional objectives include improved plant architecture, low cyanogenic potential, early material with good in-ground storage, improved nutritional and end-user qualities for diverse region specific uses, and improved performance with improved soil fertility management and weed control. Breeding programs are becoming more gender responsive to meet diverse needs of men and women cassava farmers including youth who will recognise cassava business as attractive and profitable.

Cassava breeding addresses distinct markets for high starch, white varieties for food and industry and markets for yellow biofortified varieties with enhanced pro-vitamin A content to improve diets and reduce Vitamin A deficiency. Six biofortified varieties released in Nigeria with beta carotene levels of 6. 1 to 10.4 μg/g of fresh weight will reach over 1 million farmers in 2015. One variety has been released in DR Congo and testing is underway with NARS in additional countries.

A revolution in understanding the cassava genome, genetic diversity and genetic markers associated with cassava traits is being applied using genomic selection and marker assisted selection to improve rates of genetic gain and reduce the time to deliver varieties to farmers. DNA technologies are helping to identify cassava varieties to understand adoption patterns and make decisions for future research.

Keywords: Beta carotene, dry matter, genomic selection, marker assisted selection, root yield, starch content

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Transforming Cassava into Bread: The Contribution of Food Science and Technology Research at IITA to the Agro-Industrial Development of Cassava in Africa

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This paper explores the underlying food science and technology research advances and technological innovations that led to the development of unfermented high-quality cassava flour (HQCF) technology by IITA. It traces the policy imperatives that nurture the broad application of the techniques for transforming cassava into bread. From 1995 to 2000, IITA spearheaded the development and pilot-testing of HQCF technology at small-scale in Africa. Further research and collective action by a variety of stakeholders led to a technology progression from sun-drying to pneumatic-drying of cassava. Thereby, reducing the commercial risks for the processors and generating better income opportunities for smallholder farmers. The investment and policy initiatives adopted by Nigeria and other countries, aimed at commercialising the HQCF technology, have enhanced the use of cassava both as an urban food item and as an industrial raw material. National and international research partners collaborated to develop proven agricultural technologies that addressed some of the cassava production constraints. The capacity of value chain actors was built, and technical support was provided to support the agricultural development agendas of some African governments. In evaluating the role of postharvest activities on nutrient availability and food access, the consultative group on international agricultural research (CGIAR) in 2000 commended the exemplary outcome of IITA's research on HQCF processing. In particular, the CGIAR observed that fostering private sector involvement in processing of cassava into HQCF would increase the possibility of creating an agro-industry that could absorb cassava produced by the smallholder farmers through processing into HQCF. Consequently, IITA and other partners increased the thrust towards private sector participation, leading to the commercialisation of a broad range of post-harvest technologies for processing cassava into value-added products. Private sector investment in HQCF processing plants has created demand for at least 50,000–65,000 MT of cassava roots per annum, which is expected to increase to at least 2.0 million tons by 2010. Therefore, the HQCF example demonstrates how a focus on research for development, partnership with other actors, training and technology dissemination efforts can influence public policy and stimulate public and private sector participation to achieve rural agro-industrial development.

Keywords: High quality cassava flour, private sector involvement, processing, unfermented

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Managing Alien Invasive Species through Classical Biological Control: Case Study of the Papaya Mealybug in West and Central Africa

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West and Central Africa have been repeatedly exposed to exotic pests and diseases - accidentally introduced - rapidly spreading and causing serious crop losses (e.g. 40 % typical yield losses for the introduced cassava mealybug, 35 % for cassava green mite, 90 % for mango mealybug, and 66 % for the water hyacinth). In all aforementioned cases, biological control through introduced natural enemies (e.g. parasitoids or predators) has redressed the situation maintaining the pests below economic damage levels. The latest exotic pest invading West Africa, the papaya mealybug, Paracoccus marginatus Williams & Granara de Willink (Hemiptera: Pseudococcidae), a native to Mexico, was first detected on the African continent at the end of 2009 when outbreaks were causing severe damage in papaya orchards near Accra, Ghana. Currently, this highly polyphagous pest has already spread to at least 15 countries on the African continent attacking more than 80 host plants in 33 botanical families including important tropical crops, fruits, ornamentals and wild plants. To contain this invasive pest, a classical biological control project involving national partners from Ghana, Togo, Benin, Nigeria, Cameroon and Gabon was initiated by IITA in 2012. For its implementation, the specific exotic encyrtid parasitic wasp Acerophagus papayae Noyes & Schauff (Hymenoptera: Encyrtidae) originating from USDA Puerto Rico was imported following a pilot project in Ghana, mass reared at IITA Cotonou, Benin, and field released in papaya mealybug hot spot locations in West and Central Africa between 2013 and 2015. Field evidence shows that by 2015 the exotic parasitoid had been able to spread and establish in all papaya mealybug infested areas of Ghana, Togo, Benin, Nigeria and Cameroon covering a distance of more than 1500 km. Field monitoring conducted at regular intervals over 2 years in Benin shows that already shortly following its introduction, the natural enemy was able to decrease papaya mealybug populations by more than 90 % of their initial densities and to maintain it at such levels. This drastic reduction in the mealybug pest population underpins, along similar actions conducted in the Caribbean, Pacific islands and elsewhere, a good ability of the parasitoid to adapt to a wide range of climatic conditions which

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is crucial for a successful and permanent control of the papaya mealybug in Africa. In addition to the above cases with reported estimated savings of e.g. 7.9 to 20.2 US$ billions for the cassava mealybug alone, depending on the modelling scenario, the recent case of the papaya mealybug further shows that classical biological control remains the most efficient and practical control option against alien invasive species. All these successes have only been possible because of sustained effort by dedicated research and extension staff, effective partnerships within and beyond the African continent, and the continuous support of development investors who have been factually convinced by this type of approach.

Keywords: *Acerophagus papayae*, alien invasive species, exotic pests, parasitic wasp, yield losses

Sustainable Intensification of Cocoa Farming Systems in West and Central Africa: the IITA R4D Experience

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In West and Central Africa, recent developments suggest the potential for transformative productivity gains in cocoa farming systems through sustainable agricultural intensification. The total population of the sub region is over 300 million. This is expected to exceed 600 million by 2040 with approximately two-thirds in urban environments. Feeding this rapidly growing urban population will be a challenge. Cocoa contributes substantially to the agricultural foreign earnings in West Africa, plays a major role in providing food for over 2 million households, and is also one of the most extensive production systems in the landscape. Historically, smallholder cocoa farmers have grown the sector through expansion into new regions with abundant forest resources. This is no longer feasible as most of the West African Guinea rain forest has been replaced by agriculture. In order to conserve the remaining forest remnants while addressing social and economic demands for development and food security, it is essential that a new paradigm of growth be developed for the cocoa sector. While progress made by countries like Côte d'Ivoire, Cameroon, Ghana, and Nigeria are laudable, the sustainability of this growth is being questioned and policy reforms are expected. Using participatory and on-farm research approaches IITA's R4D in the cocoa sector across the humid tropics of West Africa is helping to build a productive, efficient and growing cocoa sector where both male and female farmers invest in land sparing technologies provided by a vibrant and responsive private sector enabling a pathway to a middle income status for producers. Together with its partners, IITA is developing sustainable cocoa intensification and diversification strategies for climate smart cocoa farming systems that improve livelihoods, strengthen service provision in farmer-based organisations and reduce ecosystem degradation. Expansion of cocoa is researched by introducing cocoa into degraded land such as already and still used cropland and sites abandoned near homesteads. Cocoa / food crop intercropping systems can be an option to recover production, reduce maintenance labour (weeding), and rehabilitate degraded areas into forest like perennial systems. Critical aspects of cocoa establishment such as shading and irrigation in the dry season are key issues tackled in farmer participatory approaches. IITA's role is knowledge development, coaching, capacity building, introducing innovations and actionable tools for cocoa farming households.

Keywords: Diversification, food security cash income, perennial cash crop, rehabilitation, rejuvenation

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Controlling Emerging Virus Diseases of Food Staples in Sub-Saharan Africa

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In the past two decades, emergence of new- and reemergence of established viruses have posed serious threat to crop production and also to agricultural research and development and trade due to restrictions on movement of germplasm and crop products. The most notable virus epidemics in 21st century are caused by Maize chlorotic mottle virus (MCMV) and Cassava brown streak viruses (CBSVs) in East Africa. Introduction of MCMV, previously not known to occur in Africa, contributed to maize lethal necrosis epidemic; whereas CBSVs where known to be endemic in the coastal plains in southern and eastern Africa. They have gained importance around the Great Lakes region since 2000s. Several other viruses occurring in Africa have different status based on the presence or absence in a given country. For instance, Banana bunchy top virus (BBTV) is endemic in Central Africa, and is an emerging threat to banana and plantain production in West and Southern Africa. In countries where it is absent BBTV is a List-A quarantine pathogen. Agricultural intensification, changing farming practices, weak monitoring capacity and increasing inter-continental trade appear to be the key drivers for the emergence and spread of new and known virus diseases. The Plant Health Research group at IITA is focused on countering the viral threats to important food staples such as cassava, maize, yam, cowpea, banana/plantain and soybean. Development of host resistance, deployment of virus-free planting material and enforcing phytosanitation and containment strategies have been the major tactics adopted for virus disease control. This applied work is underpinned on the knowledge and technologies generated by characterisation of viruses, understanding virus diversity, virus-host-vector interactions, disease epidemiology, development of diagnostic tools, and production of virus-free planting material and development of resistant verities both by conventional and transgenic approaches. IITA is emphasising on an 'alliance' approach by bringing together national and international organisations to tackle virus disease epidemics. 'Alliance against BBTV in Africa', is one of the models being used for recovering banana production in BBTV-affected areas and arrest further spread of the virus. Early success indicates that a unified agenda and collective approach is critical to the successful control of trans-boundary virus diseases in sub-Saharan Africa.

Keywords: Banana bunchy top virus, cassava brown streak viruses, maize chlorotic mottle virus, maize lethal necrosis virus, virus free planting materials

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Cowpea Breeding

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Cowpea (*Vigna unguiculata* (L.) Walpers) is the most commonly grown grain legume in the dry savannah regions of sub-Saharan Africa. It is also an indigenous crop to these parts. It is grown for the protein rich grains and fodder for livestock. The bulk of cowpea produced is consumed in the sub-region hence very little international trade is associated with the crop. The productivity of the crop in SSA is hampered by a number of abiotic and biotic stresses some of which are drought, low soil fertility, insect pests, fungal, bacterial and virus diseases. Mean grain yield is less than 600 kg ha^{-1} which is a far cry from its potential of up to 2.0 tons ha^{-1}. Being a legume, cowpea can fix most of its needed nitrogen in the root nodules. Breeding activities, taking advantage of the world cowpea germplasm collection maintained at IITA's genebank, are ongoing with the aim of increasing the crop's productivity in African farmers' fields where limited inputs are applied by the generally resource poor farmers who produce the most amount of the crop. Through conventional breeding procedures it has been possible to develop and release to farmers varieties with resistance to insect pests such as aphid (*Aphis craccivora*), flower bud thrips (*Megalurothrips sjostedti*), diseases such as *Cercospora* leaf spot, macrophomina, bacterial blight, and the parasitic plants *Striga* and *Alectra*. In addition, these varieties possess traits preferred by farmers and consumers. There are varieties that mature as early as 60 days after planting as well as those with significantly reduced cooking time, helping to conserve energy. Recently efforts have commenced to facilitate progress in the breeding process by applying new breeding tools such as marker assisted selection. To this end genetic linkage maps have been generated for cowpea and molecular markers associated with important quantitative trait loci (QTL) like resistance to macrophomina, bacterial blight, flower thrips, foliage thrips, aphids and drought were identified. Some of the markers have been validated and are currently being used to introgress desirable traits into improved varieties using marker assisted backcrossing (MABC) and marker assisted recurrent selection (MARS).

Keywords: Flower bud thrips, germplasm collection, insect pests, marker assisted backcrossing, marker assisted recurrent selection, *Striga*, *Vigna unguiculata*

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Maize Breeding at IITA

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Maize is a major staple throught sub-Saharan Africa. However, a wide yields gap remains to be bridged in many areas. Thus farmers require varieties able to realise more of their potential under sub-optimal conditions. Here the approach of the maize breeding programme in IITA is presented. The goal: Supply productive and broadly adapted germplasm to breeders in the national program, seed companies, NGOs and extension system to accelerate their efforts for making good quality seeds available to farmers in WCA. The objective: Exploit diverse germplasm to develop inbred lines, high-yielding varieties and hybrids with increased yield dependability under stresses prevailing in different agro-ecological zones. The research strategy: (1) Breed for high yield potential with good post-harvest quality, (2) Improve stability of performance by incorporating multiple types of genetic defenses useful to withstand biotic stresses (diseases, insects, and parasitic plants) and abiotic stresses (drought, low soil nitrogen), (3) Develop distinct inbred lines, varieties and hybrids for each agroecological zone. The Research approach: • Germplasm Enhancement, • Cyclical Improvement of Adapted populations, • Development of Open-pollinated Varieties, Inbred lines and hybrids.

Our targets for different agro-ecologies are in the Savannahs: • High-yielding hybrids • Open-pollinated varieties of different maturity, • Inbred lines, • Resistance to Maize Streak Virus, • Resistance to *Striga spp.*,• Nitrogen use efficiency, • Tolerance to drought, • Resistance to lodging; in the Midaltitudes: • High-yielding hybrids • Open-pollinated varieties of different maturity, • Inbred lines, • Resistance to Maize Streak Virus, • Resistance to foliar diseases, ear rots, • Resistance to lodging; in the Forest zone: • Open-pollinated varieties of different maturity, • Inbred lines, • Resistance to downy mildew, • Resistance to stem borers, • Resistance to foliar diseases, ear rots, • Prolificacy.

Other targets are Postharvest quality: • Dry milling quality, • High micronutrient content (Vitamin A, Zn, Fe), • Resistance to Aflatoxin contamination; Improved knowledge base and Information: • Better screening methods, • Inheritance of traits, • Heterotic patterns of inbred lines, • Molecular maps for key traits, • Genotype $\times$ Environment interactions, • Varietal databases, • Impact of technologies; Enhancing the capacity of NARS: • Provide support to the NARS (WECAMAN, AMS, DTMA), • Provide funds through special projects • Supply elite germplasm through Regional Trials, • Distribute breeders' seed for on-farm trials, • Training.

Keywords: Hybrids, multiple resistance, open pollinated, quality, yield

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Improvement of Matooke and Plantain

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Bananas are a major staple food and source of income for millions of people in Africa. West and Central Africa produce 50 % of all plantains in the world. In East Africa, one third of the available land is grown to East African Highland bananas (EAHB, also known as matooke). In Eastern and Central Africa, EAHB cooking and beer bananas (AAA) constitute 80 % of the bananas grown. The remaining 20 % are ABB cooking (10 %) and dessert bananas (AAA and AAB, 10 %). Poor agronomy, pests (weevils and nematodes) and diseases (black Sigatoka) cause low yields in banana. Breeding offers the most sustainable intervention to tackle yield, diseases and pests in both EAHB and plantains. Through breeding, yields have the potential to be increased from the current 7.8 t ha^{-1} yr^{-1} to 20 t ha^{-1} yr^{-1} for plantains and from 5–30 t ha^{-1} yr^{-1} to 70 t ha^{-1} yr^{-1} for EAHB.

Twenty years of IITA-NARO collaboration has produced 27 improved triploid hybrids and named NARITAs. These are the results of crosses between triploid (3x) EAHB female fertile clones with a wild diploid (2x) to generate tetraploids (4x). The latter were then crossed with improved diploids (2x) to generate improved secondary triploids (3x). These were subject to three levels of evaluation (early evaluation trial, followed by a preliminary yield trial and then an advanced yield trial), which resulted in the selection of the 27 NARITAs. The 27 NARITAs were selected because they were resistant to black Sigatoka, had a good yield and had well pending bunches. A complete report on the NARITA performance during 3 cycles can be found: http://www.banana.go.ug/index.php. NARITAs are going to be further tested with farmers in Uganda and Tanzania and other Eastern and Central Africa countries. For plantain breeding, for the first time IITA has achieved the production of tetraploids from colchicine or oryzalin-treated diploids. This strategy will shorten the breeding cycle otherwise needed for the production of 4x through 3x $\times$ 2x crosses. Moreover, classical plantain breeding was resumed and seeds from tetraploid-diploid crosses have been germinated. Additionally, IITA plantain hybrids developed years ago are now being tested in Ivory Cost, Ghana, Benin, Nigeria, Rwanda, Burundi, DR Congo, Uganda, Tanzania, The Comoros and Colombia.

Keywords: East African Highland bananas, banana, black Sigatoka, plantain

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Advanced Technologies for Genetic Enhancement of Yam

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Yam (*Dioscorea* spp.) is a multi-species clonally and sexually propagated edible tuber of the tropical and sub-tropical regions. The majority of yam production comes from West Africa which accounts for about 93 % of the world's production of 63 million tons from 5.3 million hectares. The crop makes major contributions to the livelihood of more than 60 million people in West Africa, providing about 300 dietary calories per person per day. Most of the yams are cultivated landraces using indigenous cropping methods, showing considerable lack of resistance to pests and diseases. Nematodes *(Scutellonema bradys*, *Melodoigyne* spp.), the yam mosaic virus (YMV), and anthracnose (*Colletotrichum gloeosporioide*s) are most devastating, reducing yield by 30–90 %. Yam cultivation also faces the challenge of progressive declining soil fertility, increased exposure to irregular rainfall, extreme weather events and prolonged dry spells during the growing season, all contributing to tuber yield losses.

Dioscorea rotundata (white Guinea yam) and *D. alata* (water or greater yam) are the most important among the 10 cultivated *Dioscorea* spp. Genetic enhancement of these species is constrained by a number of challenges imposed by clonal nature of the crop, negligible knowledge on genetic diversity, long breeding cycle, low propagation ratio, and limited tools and technologies to aid breeding and selection. An integrated approach, combining advanced technologies to enhance yam breeding, is essential to improve efficiency and accuracy in improvement for disease resistance, food quality, and other desired traits. The International Institute of Tropical Agriculture (IITA) has been leading efforts for more than a decade to develop and apply advanced techniques for yam improvement. The introduction of vine propagation at the nursery and early clonal stages of the breeding programme enables early availability of planting materials for multi-site field evaluations and a shortening of the breeding cycle. Next-generation sequencing techniques such as genotyping-by-sequencing (GBS) and whole genome re-sequencing are being used to understand the genetic structure and relationships between different *Dioscorea* species. These will facilitate genomic studies such as linkage mapping, gene/QTL identification and association mapping for marker-assisted breeding.

Keywords: *Dioscorea alata, Dioscorea rotundata*, disease resistance, food quality, soil fertility, stable yields

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Methods, tools and impact applications

Invited Paper

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On the Use of Agricultural Systems Models for Exploring Technological Innovations under Climate Risk in Africa

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One of the major challenges of the 21st century is to achieve food security under roughly a doubling in food demand by 2050 compared to present and marked shifts in climatic risks. Increased frequency and severity of extreme events are threatening future harvests, especially challenging agricultural production systems in African regions that are already food insecure. Sustainable intensification is required that meets the dual goal of improved environmental sustainability and economic efficiency. *Ex ante* evaluation of technological innovations to support agricultural production and food security taking into account climate-induced risks is of major concern. Here we consider technological innovations as new or improved agro-technologies, such as new breeds, integrated soil fertility practices or labour-saving technologies meeting the goals of sustainable intensification. Agricultural systems models, including process-based crop simulation, statistical crop yield models, economic optimisation and bio-economic models at household, regional and supra-national scales are in principle capable to quantify important environmental and economic performance indicators of alternative technologies and their variability under current and future conditions. In this paper, a systematic review is presented of such agricultural models with emphasis on their application to smallholder farming systems in Africa. Capabilities and limitations of these models and underlying data are summarised in view of the degree they meet pre-defined quality criteria and comply with the demands of evaluating relevant technological innovations in terms of their potential to maintain or increase crop yields and income at acceptable risk levels. This is illustrated by two cases from East Africa looking at technological changes for the near (year 2020) and more distant future (2030–50). Apart from closing data gaps and carrying out specific model improvements, the way ahead for modelling technological innovations lies in multi-scale integrated analysis with more attention and proper linkages to the farm household level.

Keywords: Adaptation, Africa, agricultural systems models, climate risks, food security, technological innovation

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Food Security, Species Richness and Nitrogen Budgets in Uganda - A Baseline and Scenario Analysis

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Achieving food security requires resource intensive land management practices which have contributed significantly to global environmental changes. In our study, we quantify the potentials of sustainable agricultural intensification in combination with different protected area strategies for harmonising future food security and conservation of species richness in Uganda.

In Uganda, the annual population growth rate is 3.3 %, around 37.8 % of the population lives on less than 1.25$ per day and 14.1 % of the children, weight for age under 5, show malnourishment prevalence. The soil nutrient depletion rates are among the highest in the world. Only 2 % of smallholder farmers use mineral fertilisers. However, despite the small country size, Uganda still has a record of 18,783 species of fauna and flora, and thereby, ranks among the top ten most biodiverse countries in the world.

In our study, we apply regionally developed socio-economic scenarios which are quantified for food production demands under climate change conditions. These scenarios are utilised to simulate spatially-explicit land use changes as well as their impacts on species richness and soil N budgets.

Our results show, it is feasible to meet the scenarios food demands of the year 2050 (between +183 % and +193 % of total crop production and +66 % of livestock production) and, at the same time, increase the extent of the conservation area system. Cropland expands between +29 % and +47 % with an average crop yield increase between +99 % and +118 %. In the scenarios, agriculture withdraws between 143 kg and 153 kg N ha^{-1} which is not replaced through current N inputs levels. Nevertheless, the average species richness declines in all scenarios (-5 % to -9 %) but the current protected area system is capable of conserving habitat diversity and species rich areas to some extent. Habitats with high species richness decrease between -41 % and -54 % compared to -50 % and -76 % without effective conservation areas. The mitigation potential can be increased by +11 % and +13 % through the additional conservation of currently un-protected key biological diversity areas.

Keywords: Biodiversity, climate change, land use change, nitrogen depletion, simulation, sustainable agricultural intensification, trade-offs

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Agricultural Monitoring for Food Security in Smallholder Farming Systems

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National-scale monitoring of agricultural production, as the season progresses, is critical for food security assessments, agricultural policy and decision making. The Food Security Division in the Ministry of Agriculture, Food Security and Cooperatives (MAFC) of Tanzania relies on a large system of agricultural extension agents covering nearly all villages in the country. The system is based on manual field data collection and surveys and tends to not consistently deliver accurate and timely information that is critical for decision making.

The AgriSense-Africa project, part of the STARS initiative (Spurring a Transformation for Agriculture through Remote Sensing), is focused on improving the monitoring and estimation of agricultural production at the national scale. The project is lead by the University of Maryland, United States (UMD) and the Sokoine University of Agriculture, Tanzania (SUA) in close collaboration with MAFC. The project is developing and implementing satellite and unmanned aerial vehicles (UAV), remote sensing techniques, electronic data collection tools using smart phones, internet technology and statistical methods, and is providing comprehensive training and capacity-building. The core technology is an online system for the automated processing of MODIS satellite image time series and the production of NDVI time series graphs to support reporting by MAFC crop analysts. Methods for mapping cropland areas, field sizes and the detection of maize cropping systems from high resolution satellite image time series (Worldview–2, RapidEye) are being developed using field data, aerial photographs and digital surface models derived from UAV imagery. Electronic field data collection using smart-phones and online submission of the data to a central database dramatically increases data quality and data sharing efficiency. The project is also implementing a Crop Monitor portal for Tanzania, which is an online tool and system through which regional and district analysts submit local and current information to be used for food security assessments at MAFC with the objective of developing monthly crop bulletins.

The main project outcome is an improved information base and system incorporating remote sensing data, smart phone and online tools to support decision making by political and business leaders in Tanzania, ultimately benefitting smallholder farmers.

Keywords: Food security, ICT, monitoring, remote sensing, Tanzania

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Impact of War on Land Use Systems in South Darfur by Applying Multi-Temporal Satellite Imageries

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Land resources play an important role in shaping rural livelihoods. They are considered as a source of wealth, tribe identity, and social peace, but can also act as a source of conflict. Humans are largely argued to be responsible for land and natural resources management because they have the capacity to engage in productive activities that require planning, technology and collective work. For this reason, land has always been an important aspect in defining and reshaping relations between the different beneficiary groups. Conflicts in Darfur, as a result of civil war, has shattered the lives and livelihoods of more than a million people, mainly through its devastating effects on land use and land cover. The current paper aims to assess the impact of civil war on land use/land cover (LULC) change in Nyala locality, South Darfur State, Sudan, using multi-temporal satellite imagery for 2 points in time (1986 and 2011). In detail, the study intended to detect, identify and map the vegetation cover change during the study period. This enabled quantification of change and analysis of drivers and direction of change due to different land use/land cover patterns. Moreover, the study was designed to identify the main causes of this change regarding the role of local and displaced people in dealing with the fragile natural resource base in the area. The change detection analysis was carried out using supervised classification to end up with different types of land cover. The study found continuous land cover change during the period and it was evidently that these changes were man-made and this is basically due to over-cutting, over-grazing, charcoal and bricks making and construction activities. It could be concluded that land use/land cover structure in South Darfur State underwent obvious changes and that there were significant relations between land cover changes / land degradation and the civil war in Darfur.

Keywords: Civil war, land use systems, remote sensing, South Darfur

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Determinants of Rural Food Security in Iran: A VEC Model

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This paper investigates the effect of fuel subsidy, income and area under wheat production on rural food security. Wheat is the most important crop in Iran cultivated on 38 % of arable land. Wheat products contribute with more than 1400 Cal per capita per day to Iranian dietary energy intake. Since the revolution of 1979, self-sufficiency in wheat production has been the major strategic Iranian agricultural policy. Although total arable land has decreased slightly, productivity and the area under wheat production have increased in the last two decades. We used the Aggregate Household Food Security Index (AHFSI) to measure rural food security using time series data of food consumption for the period of 1988 to 2009. A Vector Error Correction (VEC) model with one lag and two cointegrating equations is employed to estimate food security effects of income, fuel subsidy and area under wheat production. Area under irrigated and rainfed wheat is considered separately. Results showed that in the short run, income and area under irrigated wheat has a positive effect on rural food security. However, fuel subsidy and area under rainfed wheat has no significant effect. In the long run, area under irrigated wheat, rainfed wheat and income has a positive effect on rural food security. Fuel subsidy shows a miniscule negative effect. We conclude that in the short run fuel subsidy as an input subsidy is not in favour of producers (rural people) and in the long run has even a negative effect on food security. Despite concerns about economic efficiency of self-sufficiency policy in wheat production, it has contributed to enhancing rural food security. We suggest a comprehensive and simultaneous policy that includes transition from rainfed to irrigated wheat cultivation, reforming the current fuel subsidy regime and increasing rural income.

Keywords: Iran, food security, vector error correction model, wheat

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Analysing the Effects of Different Land-Cover Datasets on Modelling Deforestation and GHG Emissions Associated with Land-Use Changes

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Human induced land-use changes have strong impacts on the global earth system. In particular, agricultural activities have been identified to be responsible for much of the negative impact. To evaluate future impacts of these changes, spatially explicit land-use change models (e. g. LandSHIFT) have been developed. These models use different external information like geophysical, socio-economic and climate data, as well as land-cover data derived by remote sensing satellites.
All these different types of information affect modelling results. Socio-economic and climate data are considered in modelling studies due to different scenario pathways, but geophysical and land-cover data is usually not varied this way. However different land-cover datasets like MODIS (by NASA) or CCI-LC (by ESA) have considerable discrepancies due to different sensor technologies and processing methodologies and these discrepancies will affect modelling land-use results and as a consequence also follow-up analysis like impact studies and live-cycle-assessments.
To quantify and analyse these effects we developed a method that allows using different land cover datasets in LandSHIFT. The method includes (1) a parameter estimation which determines the correlation between geophysical parameters such as slope, infrastructure and potential crop-yields, and the occurrence of arable land changes. The estimation is based on the concept of agro-ecological zones (AEZ) to deal with global variations in growing seasons and climatic conditions; (2) a model initialisation that uses a multi-criterial-analysis (MCA) to allocate country specific croptype area statistics (FAO) according to the land-cover dataset; (3) a model validation including model performance and model efficiency tests; (4) model scenarios and (5) calculations of deforestation rates and GHG emissions from land-use changes that are based on the approach of the EU Renewable Energy Directive (RED). Results for each step of each of the two mentioned land-cover datasets will be presented individually as well as compared with one another.

Keywords: CCI-LC, deforestation, GHG emissions, land-cover, land-use, LandSHIFT, modelling, MODIS

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Food Security Impacts of Rural Households' Employment at a Large-Scale Biofuel Project in Madagascar

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After the initial hype in 2007/08 and the subsequent downfall of Jatropha, Jatropha production is currently still being promoted and new projects are being undertaken. Besides economic, agronomic and environmental questions, doubts exist on the social dimension of sustainability. There is little evidence quantifying the socio-economic impacts of large-scale production of Jatropha on smallholders mainly due to a lack of baseline studies and detailed data collection.

This paper seeks to make a contribution to addressing this knowledge gap by making use of panel data collected between 2008 and 2014 for 390 randomly selected households in three villages in the vicinity of a large-scale Jatropha plantation in Madagascar. The main objective of this study is to provide insights into relationships between employment on the plantation and household income and food security. As indicators of food security, we use diet diversity and food expenditures for a recall period of seven days, as well as more mid- and log-term indicators like the length of the food gap. Impacts on income and food security are estimated with the help of a fixed effects model.

Former studies showed that wage employment by smallholder farmers on the plantation has significantly contributed to income poverty reduction and reduced income inequality. Focus group discussions revealed that wage income derived from daily labour on the plantation, in particular during the off-season and droughts, helps to increase households' resilience against climate variability. Nevertheless, as the labour demand by the plantation declined substantially after the build-up phase in 2010, very few regular jobs have been created. Plantation incomes are mostly used for food and other necessities and only a small percentage is invested in agriculture or business. Results from the fixed effects models show that the number of days as well as the number of household members working on the plantation contribute significantly to an improved food security.

Keywords: Biofuels, food security, Madagascar, smallholder farmers, socio-economic impacts

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Energy Security and Global Warming Mitigation versus Food Security: What They Think about Biofuel

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Biofuels could make a significant contribution to resolving the challenges of climate change, slowing the depletion of energy resources, reducing dependence on oil, and increasing agricultural incomes. The cultivation of biofuels would have the added benefits of enhancing soil and water quality. Yet, in Iran, there has been little debate on their role. Some suggest that cultivating biofuels could be one way of addressing some of the many climate-change-related problems currently faced by Iran. However, if countries' aim is to achieve the binding targets of biofuel development, there must be greater emphasis on improving the education of farmers and consumers with respect to biofuels, and on communicating effectively with them about such crops and their role in the larger energy picture. As education and communication could be a catalyst for biofuel adoption, the role of agricultural professionals and experts is very important. Agriculture professionals and experts are an important source of information for farmers regarding adoption and innovation. They can facilitate the adoption of innovations or they can limit their diffusion. However, only if these people are knowledgeable and well disposed towards the biofuel concept, the necessary knowledge and values can be properly incorporated into the farmer and consumer learning process. Extensive research has been conducted regarding the perceptions of biofuels held by stakeholders such as the public, students, consumers, and foresters. To the best of the authors' knowledge no such studies have concentrated on the case of agricultural professionals and experts. The aim of this study is to provide much needed empirical data about the perceptions of Iranian agricultural professionals toward biofuels. It will provide a knowledge base for the development of public policy measures that aim ultimately to increase biofuel adoption among Iranian farmers.

The results of the study revealed that, on the one hand, agricultural experts are well aware of the role of biofuels in future energy security and in mitigation of global warming. They are also aware of the potential effects of biofuel on food production and prices. Further, they also show a high degree of willingness to consider developing these products.

Keywords: Biofuel, climate change, energy security, food security

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Development of Land-Cover Classification Focusing on Wetlands Impacted by Subsistence Farming Using Satellite Remote Sensing

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Wetlands provide essential ecosystem services, especially in countries affected by drought. They are often the only habitats for subsistence smallholder farming within barren landscapes. On the other hand non-sustainable farming causes their irreversible degradation. In a study area within the Maputaland Coastal Plain in KwaZulu-Natal, South Africa, the international interdisciplinary project AllWet-RES (Alliance for Wetlands, 2012–2015) aims at the development of intervention strategies for restoration and wise use of wetlands (mainly interdunal peatlands) under pressures of farming and urban development. Using a broad holistic approach AllWet-RES investigates socio-cultural acceptance and economic viability of restoration measures and adapted farming practices that are necessary for the sustainable use of natural resources and biodiversity conservation.

One significant part of the project is the development of tools for the assessment and evaluation of existing human interventions, especially smallholder farming, on wetlands on the landscape level. Hence, a study has been carried out to assess the possibility of delineating different wetland types (amongst other land-cover classes) according to an adapted classification system based on commonly used systems of South Africa. Supervised classification of multi-temporal, multispectral and multisource satellite imagery (SPOT 4/5, WorldView2) was carried out using the machine learning algorithm "Random Forests" on the open statistic platform R. About 900 individual training points at different sites spread over the project area were on-site recorded and classified to train the algorithm. The classification system was also reviewed during field work to coincide with on ground conditions.

The classification method allows distinguishing between three wetland types and an approximated spatial extent of the impact caused by farming. Possibilities and limits of the utilisation of multispectral, multi-temporal satellite data for the land-cover classification and the evaluation of wetlands are discussed. In combination with the results obtained from the socio-economic studies as well as from the investigations on soil characteristics and the restorability of the wetland habitats, the landscape analyses based on remote sensing allow the development of scenarios and recommendations for sustainable use of wetlands and other natural resources. These should be further developed and implemented in close cooperation with the local community and tribal authorities.

Keywords: Land use classification, machine learning, organic soil, peatland, remote sensing, socio-economic, South Africa, SPOT, subsistence farming, swamp forest, WorldView2

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Rapid *ex-ante* Environmental Impact Assessment of Livestock Intensification Strategies on Mixed Crop-Livestock and Agro-Pastoralist Farmers in Tanga Region, Tanzania

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Livestock production supports the livelihoods of about 600 million poor smallholder farmers in the developing world. Environmental impacts include atmospheric and water pollution, global warming, soil degradation, water use and pollution and biodiversity loss. Thus, long-term sustainability needs to be assessed before embarking on large-scale livestock development projects. Quick scientific results are often requested to support development actors in their investment decisions. However, data availability for smallholder farming systems in the developing world is typically limited. Therefore, the CLEANED project developed a generic conceptual framework for rapid *ex-ante* impact assessment of interventions in livestock value chains across temporal and spatial scales.

In this study, parts of the framework were operationalized for smallholder dairy production in the Tanga region in Tanzania. Representative farming systems were identified through a participatory GIS workshop: more commercial mixed crop-livestock farmers and mostly pre-commercial agro-pastoral farmers. On-farm greenhouse gas emissions including enteric fermentation from livestock, manure, soils, soil organic carbon, aboveground biomass, rice cultivation and residue burning was calculated using IPCC tier 2 methods. Nutrient balances and well as soil erosion were projected with NUTMON and RUSLE approaches. Minimum input data for baseline performance included focus group discussions as well as two hour household interviews with two representative farmers. Four intensification scenarios were derived from existing village development plans and extension officer interviews: genetics, health, feeding, and marketing.

First results show that on-farm emissions of agro-pastoral farmers are higher (20.5 t CO_2-eq) than from mixed crop-livestock systems (2.6 t CO_2-eq). Mixed systems are more efficient than agro-pastoral systems, with 1.02 kg CO_2-eq kg^{-1} fat and protein corrected milk (FPCM) as compared to 1.42 kg CO_2-eq kg^{-1} FPCM. In both systems, the bulk of emissions originates from enteric fermentation (75 % and 69 % for agro-pastoralist and mixed crop-livestock respectively), while manure contributes 24 % and 22 % and soil N_2O 1 % and 9 % to the overall balance. Nutrient balances were neg-

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ative for both systems. Mixed crop-livestock systems do not produce sufficient manure, whereas agro-pastoralists do not reallocate their large amounts of manure from rangelands and homestead to cropland. The scenario analysis shows efficiency gains from intensification, but underlines potential feasibility issues. For example, potential gains from improved cattle breeds may in reality manifest as diminished long term sustainability if implemented without a concurrent improvement of veterinary health, improved feeding, housing and water supply. Many such interventions are currently constrained by lack of land, labour, cash and markets.

Keywords: GHG emissions, livestock production, rapid assessment, sustainable intensification

Biodiesel in Brazil: Analysis of the First Decade of Production

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At the end of the 20th century and early 21st century, agricultural systems incorporated one more purpose: generating energy for a growing world population whose lifestyle demands not only food, but also increasing amount of energy with low environmental impact. In March 2005, Brazil produced its first 49 barrels of pure biodiesel (B100) and began its addition to mineral diesel, currently at 7 %. The production of B100 in Brazil is obtained mostly from two sources: soy and animal fat. In 2013, the nominal capacity for industrial production of B100 was of about 8 million m^3 and national production was of 2.9 million m^3, that is, equivalent to 36.4 %. Brazil, like other countries, aims to promote biodiesel production due to social, environmental and technological aims. However, there is a growing concern about the sustainability of such programs. In the last ten years, the soybean planted area grew 8,872,134 ha, with a total area of 31,621,800 ha in 2014. In the period from 2005 to 2010, there was an increase of the area designated to B100 production, in comparison to total cultivated area. This estimated share has stabilised at around 20 %. Despite sugarcane being used for sugar, planted area increased with 3,164,170 ha in the period from 2005 to 2014 – it too was stimulated by the renewable energy policy. In order to meet this new demand for land use (mounting up to 12,036,304 ha), the broadening of agricultural frontier and further expansion over areas previously used for other crops or animal production took place. The reduction of land used for others crop was 4,566,000 ha. Thus, 7,470,304 ha came from other agricultural activities, specially former livestock production areas and employment of previously unused land.

Keywords: Biofuel, Brazilian biome, land use, soybean

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Assessing Land Use Diversity within Subsistence Production to Achieve Food Security in Northern Vietnam

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According to the World Bank, Vietnam is considered as one of the success stories among the developing economies because it has reduced its poverty rate from 58 % in 1993 to 14.5 % in 2008. Within this achievement, agriculture was an important sector with 22 % and 52 % contributions to the country's GDP and employment, respectively. Despite the improvement in the prevalence of poverty, its rate among the rural populations, especially those living in the country's upland areas is still high. Since reunification, the communist state has attempted to integrate the northern upland into modernising development programs to increase food security. Nevertheless, the ethnic minorities, who live mainly in the upland regions, have remained relatively autonomous in economic production and adopted diverse subsistence production systems among the groups in combination with cash crop production. This study assesses the contribution of land use diversity within subsistence production to food security in northern Vietnam where the level of food insecurity is relatively higher than in the southern part of the country. The main research question is whether having a diverse system of different subsistence activities helps to improve food security? The analysis is carried out using the ordinary least squares method and the data are collected from a survey of 300 households in 2007 in the rural district of Yen Chau in Vietnam. The choice of independent variables in the regression analysis is based on the conceptual model of rural household food security such as credit, food expenditure, income, as well as characteristics of the research area in social and political capital. In summary, this paper examines whether different type of activities within subsistence production – especially fish and paddy farming – has an impact on achieving food security.

Keywords: Fish, food security, paddy, subsistence farming, Vietnam

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Application of Remote Sensing Techniques to Assess Land Use Changes in Western Gedarif State, Sudan

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Gedarif is one of the most promising states pertinent to food and cash crops production in Sudan. Despite that, it is also considered as one of the most fragile areas with regard to land degradation, desertification and drought risks. The state depends heavily on large-scale agricultural production particularly the largest mechanised rain-fed schemes with annual rainfall amount sufficient partially to secure production of food and cash crops. Most of agricultural lands in the area are classified as mixed savannah-woodlands that for provide transhipment pastoralists with palatable grasses.Conflict between Eritrea and Ethiopia, as well as the civil wars in eastern Sudan,have led to over-exploitation of land use as a result of the expansion of mechanised agriculture, over-cutting, overgrazing and expansion of residential refugees' camps. The paper aims to assess land use changes in Western Gedarif State, Sudan via application of remote sensing techniques. Moreover, the paper was also intended to identify the main factors and drivers affecting changes in vegetation cover in the study area. The paper used two land sat images for the period 1999 and 2013. The subset images were analysed and classified using supervised and unsupervised classification approach. The result of paper induced that land use changes was man made through mechanised farming and shifting cultivation and the urbanisation activities. In addition, it was demonstrated that the application of remote sensing technology is an efficient method to be applied for detection of land use changes in the study area. Furthermore, the linkage between the remotely sensed data and the field observations provided strong arguments that changes in land use patterns, which have led to degradation in vegetation cover in the study area.

Keywords: Human activities, land use changes, supervised classification, western Gedarif State

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Analysing Future Scenarios of Land-Use Change in Southern Amazonia and its Impacts on CO_2 Emissions

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The calculation of robust estimates of future CO_2 emissions from land-use change is an important element to support the framing of the Brazilian climate mitigation strategy. Prerequisite is information on the future development of land-use changes under the combination of various driving factors operating on different scale-levels (e.g. regional planning policy and global world market prices for agricultural commodities). The scenario technique in combination with land-use models offers a suitable tool to systematically explore a wide range of plausible future development pathways of the regional land-use system. The available scenarios for the Amazon region concentrate on future deforestation and include only very simple assumptions regarding the driving factors (e.g. rates of deforestation). However it is debated that these efforts neglect the linkage between regional and global drivers or have only a much idealised representation of regional land-protection strategies without considering existing policy frameworks.

One aim of the BMBF project CarBioCial was the development of a set of more detailed scenarios as a basis to analyse future land-use changes until 2050 and its impact on environmental factors such as soil erosion and greenhouse gas emissions (CO_2, N_2O) on different geographic scale levels. Going beyond the existing regional scenarios, four storylines were developed by experts that portray both regional development trends and their linkages to the global scale (e.g. to global markets of agricultural commodities). In this study we will apply the regional LandSHIFT model especially developed to be applied for this regional approach to land use modelling to generate land-use maps for the different scenarios. On the basis of these maps we will calculate resulting CO_2 emissions from land-use change using the INPE-EM model. The results from this study will be a valuable source of information for regional decision makers to frame potentials and risks of the different future development pathways for achieving the Brazilian climate mitigation goals.

Keywords: Carbon dioxide emissions, landSHIFT, regional land use change modelling

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Using Bayesian Networks to Depict Favouring Frame Conditions for Sustainable Land Management: Umbuzeiro-Tree Planting by Smallholders in Brazil

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Dam construction in 1988 changed the economic basis of ten-thousand farming families who resettled involuntarily on the less fertile areas around Itaparica reservoir, semi-arid Northeast Brazil. A few now derive income through irrigated cropping on rather small plots, whereas, the majority of rural dwellers has no access to improved irrigation infrastructure as a compensation for flooding the area. These smallholdings rely on small-scale livestock farming, and collecting fruits and firewood from the Caatinga vegetation (native dry forest). The farmers' livelihoods are however threatened by recurring droughts, in sustainable land-use practices and the difficult access to water. In this context, the 'Umbuzeiro-tree planting experiment' tests the endemic, drought-resistant species *Spondias tuberosa* Arruda, applying different soil amendments. The tree is deemed sacred by indigenous tribes and generally considered multipurpose with several benefits for both ecosystem and people. The purpose of the study is exemplarily estimating the adoption potential of innovations for a sustainable land management, in this case planting the Umbuzeiro-tree. We used constellation analysis to identify elements of the current situation and developed a Bayesian Network (BN) to estimate probabilities of practice uptake. Two representative groups of farmers, an organisation supporting the farmers, a plant cultivation company, and three plant and soil experts took part in the study as main stakeholders. The BN focusses on the sustainable conservation and use of the natural environment (environmental health), and securing incomes of smallholders cultivating dryland crop areas ('sequeiro'). The objectives are mathematically improved or not by 25 interacting nodes under different scenarios. Enabling, disabling or setting factors at different values allows analysing different frame conditions to identify crucial elements for the intervention's future success and positive impact on objectives. Exemplarily, incentives and supply of externally grown, grafted *S. tuberosa* seedlings reinforce likelihood for project innovations being adopted by 41 %. Ultimately, pushing chances for improved farmer incomes while benefitting ecosystem health with long-term character to 91,5 %, *vice versa*, the analysis allows identifying conditions, which may impede farmers to adopt the innovations.

Keywords: Adoption potential, Bayesian networks, Caatinga, native species, Northeast Brazil, smallholdings, sustainable land management

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Evaluation of Remotely Sensed Evapotranspiration as a Proxy of Water Balance and Land Cover Changes

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Evaluation of water losses and land cover dynamics of a basin is an important step in conditioning hydrological models. In this study the tempo-spatial pattern of remotely sensed evapotranspiration (ET) are used to explain the causes of changes in water balance and land cover in the river basin. To the Wami River basin in the central east of Tanzania, a time series of 644 ET images (year 2000–2013) from 8-days MODIS ET was extracted and analysed using a novel approach. First, the principal component analysis (PCA) was used to compute the principal components of time series. Then the Mann-Kendall trend test and Sen's Slope was used to analyse long term trends of loadings. And finally the Kendall, Wilcoxon and Kruskal-Wallis tests were used for comparison of component scores against elevation, slopes, soil and land use patterns. The first five principal components of ET covering the basin, explained the 99.88 % of the total variance in the dataset. The first four components reflect the meteorological patterns leading to seasonal and event based water balance changes, whereas the fifth component reflects the land cover trends in the basin. From the findings, the components may be used to explain the season lag between rainfall and ET when the latter is used to condition the hydrological model. The extreme ET patterns may also be used to explain the difference between rainfall peaks, changes in streamflows and the delayed ET responses. The land cover trend may be used to factor in the impacts of land cover change in the hydrological model. The natural forest in the Eastern Arc Mountains and low slopes/ downstream loam soil may also be explicitly considered in conditioning the hydrological model because they exhibit relatively higher ET from deep groundwater and shallow groundwater respectively at the end of the dry period. It is expected that, these findings will highly improve the conditioning of the hydrological model in the Wami River basin.

Keywords: ET, land cover, MODIS, PCA, water balance

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Land Use Changes and its Implication for Food Security and Sustainability in Northern Ghana

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Urban and peri-urban agriculture are dynamic niche activities that take advantage of urban connectivity and a complex socio-political environment. It has been advocated by many researchers as a means to improve food security. Vegetable production, a strand of urban agriculture, doubles as a source of food and income for many urban dwellers, especially women and migrants. It takes place in open spaces, backyards and irrigation sites where there are water bodies like streams, broken gutters, drains, dug-outs and wells. A mixed-methods study was carried out for fourteen months to assess the sustainability of vegetable gardening in dry season open space farming sites in Tamale, northern Ghana. The study used the Food and Agricultural Organisation's international framework for evaluating sustainable land management. In addition, changes between 2008 and 2014 in the spatial area of the vegetable sites were measured. The study found that vegetable production was viable but not sustainable. Urban poverty and climate variability has prompted an increase in the cultivation of highly profitable vegetables like cabbage and lettuce, providing income to farmers. Sixty percent of such fresh vegetables in Tamale are provided by open space farmers, and their increased availability has diversified urban diets and increased food and nutritional security. However, many such more newly introduced vegetables are eaten raw, and are sometimes irrigated with waste water. This, and the use of pesticides in high dosages, poses health hazards. A growth in industrial activities has reduced the area of open space used by urban agriculture by 3.9 % between 2008 and 2014. Farmers attempt to cope with this by cultivating along electrical power lines, on public property, and on undeveloped private land. Some are moving their production sites to the peri-urban fringes. Urban and peri-urban vegetable production in Tamale is thus viable, but a lot more must be done for it to be sustainable.

Keywords: Food security, northern Ghana, open space, spatial change, sustainability, vegetable production

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Mapping Urban Agriculture in West African Cities: Spatial Extent & Temporal Dynamics

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In recent years, urban and peri-urban agriculture have gained increasing attention worldwide. Urban farming contributes to food security and income generation for urban dwellers and to greener cities. On the other hand, urban agriculture faces challenges, such as polluted irrigation water and land insecurity, particularly in developing countries.

In the West African cities of Tamale (Ghana) and Ouagadougou (Burkina Faso), urban farmers benefit from available urban water sources and provide the urban population with irrigated vegetables during the dry season, while in rural areas rain-fed farming systems dominate. The seasonal climatic variations add to the already high spatial and temporal diversity of urban agricultural land use in these cities.

In order to get a comprehensive picture of the spatial extent of urban crop production in Tamale and Ouagadougou, agricultural land was mapped at various spatial scales and in different seasons and years. The study draws on a set of data sources and methods to account for highly diversified land uses spanning the two cities, ranging from in-situ mapping and the use of an unmanned aerial vehicle to the classification of high and medium resolution satellite imagery.

Preliminary results show that urban cultivation patterns change considerably in terms of the area, location and crop mix of cultivated patches across seasons. Water availability (both abundance and scarcity) is a major explanatory factor for these changes. In Tamale staple crop production is vital in the rainy season, both in open space sites and backyards, while in Ouagadougou such rain-fed agriculture is limited to a few open contiguous areas. In the dry season, highly commercialised production of a variety of leafy vegetables, mostly traditional (e.g. different types of Amaranths, *Amaranthus* spp.) but also exotic (e.g. Lettuce, *Lactuca sativa*), takes place generally along streams and around reservoirs in both cities.

We have used GIS data to show the particular spaces and times that are important for people to grow crops and generate income in each city. Such comprehensive assessments reflecting the complex spatio-temporal dynamics should therefore be used to better inform city planners.

Keywords: GIS, GlobE, remote sensing, urban and peri-urban agriculture (UPA), UrbanFood^{Plus}

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Soil-Borne Gamma Radiation and its Attenuation through Lime, Organic Material and Water

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Gamma ray spectrometry has evolved as a promising tool to ease certain analyses and interpretations in soil science. It is a non-invasive method and it can be readily applied in the field e.g. for soil mapping with a handheld gamma ray device. Also air-borne gamma ray investigations get more and more important in soil mapping. Especially in the tropics where geological maps or soil data are sometimes still lacking, it has a lot of advantages like faster interpretation of soil changes *in situ* or determination of erosion and sedimentation locations. Even distinction between clay illuviation soils is possible in the field.

For further method development and elimination of interfering signals, their influences as well as their compensation have to be examined more in detail. Interfering signals are for instance cosmic radiation and different magnitudes of gamma ray attenuation through different contents of soil moisture or organic material. Attenuation through soil moisture often has inhibited to exactly measure gamma ray signals, particularly in humid or sub-humid tropical environments. Dependable coefficients for reliable results are still lacking. The present study shall fill this gap.

For attenuation coefficient development, several layer thicknesses of gamma ray attenuating materials were measured repeatedly over soil. Chosen attenuating materials were water, peat and lime as they are normally present in soils. The measurements were carried out in two locations in Baden-Württemberg. Afterwards, the attenuation coefficients were calculated. Mass attenuation coefficients for lime, water and organic material as well as for a mixture of these materials were identified.

Keywords: Attenuation coefficients, gamma ray spectrometry

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Napier Grass Productivity under Different Cropping and Fertilisation Systems in Lushoto Highlands, Tanzania

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In Tanzania, 21.3 million cattle are reared by estimated 1.7 million smallholder farmers. Only 1 million of these cattle are improved dairy breeds, while the rest are East African Zebu. Tanga is one of the most important dairy production regions, together with other highland areas such as Arusha and Kilimanjaro. Poor feed resource base and quality are among the main challenges of livestock production, resulting in low milk yields of 5–10 liters day^{-1} from an improved dairy breed.

Forage technologies have been promoted in Tanzania for sustainable intensification of crop-livestock systems. However, there is a dearth of research that quantified the impacts of these systems on productivity and natural resource management. One probable reason for the lack of research is that the effects of planted forages on the environment, especially soils, can only be recorded after many years of observation. To address this issue, computer modelling tools can be used to estimate numerous forage technologies and their effects on the environment. CropSyst is a widely used cropping system model for simulating the growth and productivity of crops in response to various environmental conditions. Among many other biophysical variables, CropSyst is able to simulate soil C dynamics, N_2O emissions, N leaching, soil erosion and soil water dynamics.

This study presents preliminary results from a forage trial in two villages in Lushoto district in Tanga region, Tanzania. The trial was laid out in a completely randomised block design (three replications) in November 2014 on farmers' fields. The trial consists of three treatment factors: forage species (local Napier, Napier hybrid, *Brachiaria* hybrid cv. Mulato II); soil fertility level (no manure, with manure); and cropping system (monocropped or intercropped with *Desmodium uncinatum* cv. Silverleaf). Assessed agronomic performance included establishment, biomass production, leaf area index, emergence, tillering, and forage quality. Soil was analysed and climate data obtained from the nearby weather station. All data was used to calibrate CropSyst for Napier, and to test a new intercropping routine for the model.

Keywords: Agronomic trials, crop modelling, intercropping, tropical forages

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Evaluation and Analysis of On-Farm Demonstration Trials for Small-Scale African Farmers: Yield and Economic Parameters from four Countries (Uganda, Nigeria, Ethiopia and Mali)

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On-farm demonstration is done through a series of practical farm demonstrations over a period of time supported by extension workers or researchers with the ultimate objective to adequately impact the new and improved technology at farm level. Additionally, on-farm demonstration has the ultimate goal of increasing crop production and can be described to be a centre pivot used in capacity building of the small-scale farmers. On-farm demonstration can also be defined to be a measure put in place to effectively reduce the risk farmer's perceive and they are designed to take new innovations out of the 'unreal' scientific realm of the research station and place them firmly within the bounds of farmer's daily experience. Dataset from on-farm demonstrations for small scale farmers was collected for three years by a non-governmental organisation Sasakawa Africa (2011 - 2013) in four countries namely Uganda, Nigeria, Ethiopia and Mali. Statistical evaluation and analysis involves managing the huge dataset by first coding of the variable names and thereafter developing linear mixed models to test the yield and economic parameters. Evaluating and analysing dataset generated in farmers' field by non-research personnel requires much competent background in statistical methods, flexibility of thought, dedication to the task and innovativeness to match standards of statistical rigor to achieve the perceived objectives at the end of the research work. The statistical evaluation and result of the dataset appear to have a particular trend whereby about 85% of the yield results from the treatments (input levels namely farmer input, half input, full input, respectively) appear to increase and grow higher as the rate of the fertiliser input and other inputs increases. However, some parts of the data could not be analysed due to presence of only single treatments as in the case of women assisted demonstrations for maize plots in Mali and Ethiopia. Nevertheless, the results from Uganda and Nigeria appeared to be very interesting and gave a very good insight into the research work and showed a distinction of the statistical evaluation for the economic parameter of the dataset. Overall results showed that a general conclusion across the four countries could not be made.

Keywords: Half input and full input, economic parameters, input levels, farmer treatments

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Gender perspectives, analyses and strategies

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An Analysis of the Effects of Large Scale Land Acquisition on Rural Livelihoods in Sierra Leone. Integrating a Gender Perspective

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In Sierra Leone, one of the smallest and most food insecure countries in sub-Saharan Africa, huge tracts of land have been leased to mostly foreign investors. Guided by the sustainable livelihoods framework, this study investigates land rights and ownership patterns in this country, as well as the gender dimensions of large scale land acquisition and its effects on rural livelihoods. Field work was carried out in Samalen Chiefdom in southern Sierra Leone between April and July 2014, applying a mixed methods approach. Qualitative data were collected through five key informant interviews and five focus group discussions and analysed using Nvivo, while structured interviews were conducted with sixty households to collect quantitative data and analysed using SPSS.

In the study site, large scale land acquisition has contributed to high levels of unemployment, reduced income and increased food insecurity due to loss of land as the main livelihoods asset. Alternative livelihood options are limited, with only few employment opportunities offered by the land investor. Prevailing cultural and traditional local practices that are embedded in the predominantly patriarchal society, in conjunction with gender discriminatory national laws, result in women having been disproportionately affected by large scale land acquisition compared to men. For instance, women's share of land and property holdings and their role in land use decision making were in general marginal to non-existent. Also, while more women than men have been employed by the land investors, they struggle to combine household tasks and their day jobs. At the same time, men complained that women were "disrespectful" and felt "equal" to men since they started working for large scale land investors. Recommendations include the review of land laws to include explicit provisions that define the role of governing bodies and land owners in large scale land acquisition processes and provide equal access to and protection of land ownership and use for men and women. It is further suggested that an international legally binding framework to regulate the process of large scale land acquisition be developed and institutionalised

Keywords: Food insecurity, gender, land grabbing, large scale land acquisition, national land laws and legislations, Sierra Leone, smallholder farmers, sustainable livelihoods

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Using Role-Play to Investigate How Gender and Socio-Economic Factors Influence Farmers' Selection of Innovations

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The likelihood that smallholder farmers adopt innovations depends *inter alia* on their view of their problem and resource situation, and on their assessment of the innovation in relation to the various forms of capital and capabilities needed to implement it. Farmers' views and assessments are in turn influenced by multiple cultural and socio-economic factors that will differ even among farmers that live and produce under similar ecological conditions.

Within a transdisciplinary research project focused on improving household food security in Tanzania, we aim to assess how social-economic factors, including gender, affect farmers' decisions to adopt different innovations.

A participatory scenario building (PSB) methodology was designed, integrating role play as a core activity. Fieldwork was undertaken with three farmer groups in the Dodoma and Morogoro regions of Tanzania between January and April 2015. The PSB activity involved 8–10 days working with each group to explore farmers' perspectives on the potential challenges and benefits of different innovations. The role play activity was deployed in order to assist farmers in enacting social difference; in making explicit their perceptions about how gender and socio-economic factors could come to matter in terms of the potential pathways and outcomes of different innovation options.

This paper highlights how farmers portrayed the implications of factors including gender, age and marital and economic status, in relation to the feasibility and usefulness of different innovations. Results show that these social differences affect the time, energy and various capitals available to farmers and thereby influence the choices made in terms of innovation selection. The performance of these issues during the role-plays had importance for everyday material realities of the participating farmers, as they influenced their decisions on which innovations to select for adoption.

After critically evaluating the methodology deployed, we argue that in innovation processes, efforts need to be made to consider the social heterogeneity of smallholder farmers in order for innovations to be workable and relevant to the respective sub-group(s) of farmers.

Keywords: Farmer groups, gender, innovations, participatory action research, role-play, scenario building, social difference

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Can Cooperatives Contribute to Women's Economic Empowerment? A Case Study in South India

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The Indian dairy cooperative system has around 13 million producer-members; mostly landless or small scale farmers with less than two hectares land. Village dairy cooperative societies provide an important mechanism to connect these disperse producers to the national dairy value chain and contribute to food security. In India, women typically perform most of the dairy-related production activities. Therefore, dairy cooperatives have a potential to benefit especially rural women and provide them with independent incomes and employment.

Our paper studies effects of women empowerment through cooperative membership. Since the year 1997 the Government of Karnataka and the Karnataka Milk Federation (KMF) established over 800 women dairy cooperative societies to economically and socially empower and benefit rural women in the State. We measure empowerment levels among 58 female dairy farmers of four different dairy cooperatives. Borrowing measurements from the Women's Empowerment in Agriculture Index we discriminate membership and non-membership status in single-gender versus mixed-gender cooperatives. We find that in a context of rural poverty in which women-only cooperatives are promoted without offering additional development opportunities for men, the expected effects of these programs cannot fully unfold. Gendered power structures within the community and the household limit economic benefits for women. Depriving men from new income opportunities may even lead to stronger male household income control and reverse effects on the economic empowerment of female cooperative members. We conclude that many ongoing policies in support of women cooperatives may require re-evaluation. Development policies in support of women empowerment may have to target income opportunities and capacities of women and men in order to reach their goals.

Keywords: Cooperative organisation, dairy, development planning, empowerment, India

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A Gender Focused Analysis of Learning Processes of Smallholders within a Development Program in Nepal

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Smallholder farmers in Nepal are facing increasing problems caused by climate change. Within the action research and development project Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAF-BIN), Caritas collaborated with the University of Natural Resources and Life Sciences (BOKU), Vienna, associated partners from civil society and research as well as smallholder farmers collectives to build resilience towards climate change. Based on the Theory of Transformative Learning, this study analyses learning activities, outcomes and potential impacts of SAF-BIN in Bardiya and Kaski, Nepal. Learning activities lead to instrumental (technical knowledge about farming practices and site-specific technologies) and communicative (communication skills) learning outcomes, which can result in learning impacts. In order to examine if and in which ways women and men benefit from the project, a focus on gender was applied. Through participant observation and 32 semi-structured face-to-face interviews with project participants (16 women, 16 men), qualitative data was collected in 2014. A fieldwork diary and photographs completed the dataset. A comprehensive structure analysis and descriptive statistics were performed using Atlas.ti and Excel. Results show that - due to male job migration - more women, with diverse social backgrounds, than men participated in SAF-BIN activities. Especially learning activities like regular group meetings and on-farm adaptive field trials lead to learning outcomes. Instrumental learning outcomes included: increasing knowledge about climate chance and its' links to farming, new inputs, new cultivation practices, new management approaches as well as diversification and professionalisation of farming. Communicative learning outcomes included: enhanced analytical capacities, improved presentation skills and self-confidence and increased understanding of abstract concepts. Realized impacts were increased crop production, increasing reflection of gender roles and formation of (saving-)networks. Men were more likely to achieve technical learning outcomes, while women were more likely to benefit from communicative learning outcomes. Potential impacts are increased food security, commercialisation of farming and a changing role of traditional knowledge about farming. Thus, the project setting provides a fruitful learning environment. Ways how male and female farmers can achieve equal learning outcomes need to be explored.

Keywords: Action research and development, gender, learning, Nepal

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Grazing Fields and Fishponds on the Rice Farm — The Contested Nature of a Commercial Agricultural Investment in Ghana

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Large-scale land acquisitions (LSLA) in countries of the South are increasingly challenging the food security of rural communities. While intensifying land use and raising yield output within the investment perimeter, LSLA substantially affect livelihood patterns of local individual households by altering and limiting access to resources for food production and consumption. Gender, kinship and social position within the community are crucial variables that define an individual's ability to benefit or suffer from a LSLA. Taking on a feminist political ecology perspective, this study analyses the impacts of a 2500 hectares rice plantation in the South Tongu District of Ghana on the food security of households living in and around the farm. Data was collected through questionary-based interviews with female and male small-scale farmers and focus group discussions, focusing on changes in livelihood patterns, availability, access and utilisation of food and the related resources. Transect walks and the attendance of community meetings provided additional insights. Further information was gained through semi-structured and informal interviews with company representatives, governmental and customary authorities. The case study is located in a rural community, where livelihoods are shaped to a high degree by a customary system. Its' various institutions define the control and use of land, the distribution of power, the inclusion or exclusion of individuals from negotiation processes as well as the accessibility of information. Through the collaboration between the company and the traditional authorities, new institutions are also created and intra-community tensions arise. This further affects people's ability to sustain their food security and aggravates the marginalisation of some kin and gender groups. Through the LSLA, communal land, crucial for the collection of wild foods and firewood as well as for pasture, turned into private farmland. Hence, some sorts of food allocation, like fishing, are under constraint. Other resources, like wood, an important source of quick income to women, are getting scarce. However, through negotiation and adaptation, women and men develop innovative ways to compensate for the various losses. Furthermore, employment opportunities with the company, in particular an outgrowing scheme, are providing promising opportunities to diversify the livelihoods of households.

Keywords: Communal land, food security, gender, large-scale land acquisition, small-scale farmers

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Understanding the Pathways to Improved Diets from the Production of Nutritious and Marketable Commodities

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Value chains and agricultural commercialisation are increasingly being promoted as mechanisms for agricultural transformation, inclusive growth, and, more recently, improving food security and diets. Theoretically, market-oriented production should allow farmers to increase their incomes and purchase more nutritious foods. Furthermore, crops that are both nutritious and commercially viable can overcome the inherent risks in engaging in markets because they can be consumed if market prices are not profitable. However, there is limited empirical understanding of the pathways through which such production impacts diets. Given Malawi's high stunting rates and current policy focus on commercialisation of the agriculture sector, the implications of commercialisation for diets and nutrition is highly relevant here.

This qualitative study contributes to the empirical understanding of this issue by examining gendered household preferences and decisionmaking dynamics related to the production, consumption, and sale of nutritious commodities. We analysed 80 individual interviews from a sample of households in 3 districts in Malawi.

Respondents had a relatively good understanding of nutrition; however, it was not seen as a priority issue compared to other criteria underlying their food decisions. Food security was top-most and was largely reflected in concerns about maintaining sufficient supplies of maize. Needs for cash are numerous and important, but people avoid selling food crops if they do not feel they can meet their immediate food needs with their stocks.

While financial barriers were the most commonly mentioned barriers to purchasing preferred or nutritious foods in the market, lack of availability was also important. Many nutritious crops that households produce are both consumed and sold. Decisions about what or how much to sell are based on consideration of a range of factors. While respondents tended to reject the idea of men's and women's crops, on the whole, they tended to conform to stereotypical gendered roles in terms of men having more power over crops with high exchange value rather than those produced primarily for consumption. Soybean, groundnut, and maize fit into a unique category as they play an important dual role for household consumption and as commodities and, thus, a dual role in terms of gendered control.

Keywords: Africa, agriculture, commercialisation, gender, Malawi

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Gender Discrimination in Land Access, Ownership and Control in Oyo State, Nigeria

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Gender equality and the empowerment of women are widely recognised as key dimensions of livelihoods improvement and sustainability. This study examined the nature and extent of discrimination against gender groups with respect to access, ownership and control of land. The farming and rural systems approach was used in the research. The study location was purposively selected because it is a cocoa producing community hence land would have a high value. A total of 120 households were selected from two villages in the local government area and data were collected through oral interviews using structured questionnaires. The data were analysed using descriptive statistics and a resource profile used to generate a Gender Discrimination Index (GDI) for the gender groups. The results showed that at least 70 percent of the households were male headed most (40 %) of who had at least primary education, were mainly cocoa farmers (75 %) and worked an average of 50 hours on the farm weekly. Most of the women had at least a junior school certificate (44 %) and were mainly self employed (49 %) thought about 39 percent were farmers. About 10 percent of the households had dependants who were economically inactive. The GDI showed that adult men had always access (258), ownership (246) and control (251) of land while adult women sometimes had access (186), ownership (132) and control (128) of it; it also revealed that young men had better access (191) to land compared with women and young women but they never had control (18) and ownership (13) of it. Young women experienced the highest level of discrimination because they had the lowest level of access (179) and never have ownership (11) and control (14). This study suggests that policies or programs which will ensure transfer of land access, control and ownership to both young men and women who can use it efficiently should be pursued.

Keywords: Gender discrimination index, gender groups, land, resource, youths

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Impact of Insufficient Land Rights to Women on Food Security in Bangladesh

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In most of the developing countries, men are the land owners but women are mostly the land users. Although women comprises more than half of the agricultural labour force in Bangladesh, they are significantly less likely to own land those are poorer quality. Though evidence shows that women have a pivotal role in improving household food security, lack of land rights leaves many women almost entirely dependent on men in assuring food security. This paper examines the importance of women's land and property rights in the context of food security. The study considered 100 households from which 50 with female members having land ownership. It has been found that when women have secured property rights, they take decisions to cultivate land, have greater influence over household decisions that improve the food and nutrition needs. It has been found that families spend more money on food, where women have land use right. Women with land title get better nutrition and enjoy better prenatal care. The HHs where the women have land rights consume more oil, pulses, vegetables, fish, egg, meat, fruits. On the contrary, the other types of households consume more rice only. It has also been clear that men mostly tend to plant crops with a high market value, whereas women tend to plant crops that can supplement a family's diet. Several reasons have lied behind the gender disparity of land ownership. Land is usually transferred though inheritance and it is almost always men who inherit the land. Sometimes, women are usually less able to purchase land. Where formal land and property laws do not discriminate against women, enforcement of those laws can be challenging. Enforcement institutions may be weak or reflect deeply rooted structural factors, social norms or traditional attitudes that suggest women should not be equal participants in ownership or control of land. As governments, the private sector, multilateral institutions, and international development organisations weigh the options for improving food security around the world, they must address one of the most promising elements – secure land rights for women.

Keywords: Food security, land rights, women

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How Do Women's Lands Rights Affect Their Value Chain Participation? The Case of African Indigenous Vegetables (AIVs) Value Chains in Kenya

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This paper investigates how gender asymmetries in access to and control over land affect women's participation in the value chain of African indigenous vegetables (AIVs) in Kenya. Women significantly contribute to AIVs value chains; they are involved in production, post-harvest handling and processing of AIVs. However, women lack access to and control over land which has negative implications for their access to other productive resources. These constraints reduce women's productivity in AIVs production on the one hand and their market participation on the other hand. The paper scrutinizes the complexity of land rights – weaknesses of governance systems, land tenure systems and customary laws – and probes the way how this impedes female small scale farmers from engaging extensively in both AIVs production and marketing. Further, challenges to market participation are aggravated by a lack of streamlined marketing systems which result in the exploitation of women by middlemen and market cartels which reduces their bargaining power and their benefits.
The paper presents preliminary results of the HORTINELA Subproject entitled "Gender Order: Embedding Gender in Horticultural Value Chains to Close or Reduce the Productivity Gap". The results are based on field research conducted in the urban, peri-urban and rural areas of Kenya. Qualitative methods of data collection – semi-structured in-depth interviews and group discussions with female small scale farmers and female traders – were applied in order to examine the implications of women's limited control over land on their AIVs value chain participation; particularly on their involvement in marketing. The method of qualitative content analysis (with MAXQDA) was applied for data analysis. The paper is structured as follows: Firstly, the paper discusses the current state of women's land rights in Kenya by referring to primary and secondary sources. Secondly, after outlining the research methodology, it presents first results which show that existing gender norms regarding land rights impede women from their full participation in AIVs marketing. Finally, the paper draws conclusions in regard to inclusive value chain development, by arguing that both the realisation of women's land rights and the creation of a support structure in marketing are pivotal for inclusive value chains.

Keywords: African indigenous vegetables (AIVs), gender perspective, inclusive value chains, land rights, land struggles, market access

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Gender, Land Tenure, Food and Nutrition Insecurity in Northern Ghana

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Food and nutritional insecurity remains a global challenge, with sub-Saharan Africa bearing a large share of this burden. Despite much policy attention, it remains unclear whether the goal of eradicating worldwide food and nutritional insecurity will be achieved. There is considerable evidence that women's land rights is central in this discourse, and this is especially relevant in the urban zone, where residents continue to face challenges in accessing land to produce food for their households. A mixed-methods study was carried out between October 2013 and November 2014 in urban and periurban Tamale, northern Ghana, to understand the dynamic and recursive links between gender, access to land and access to nutritious food under the communal land tenure system pertaining in northern Ghana. Results show that although women in the northern region of Ghana are expected to provide soups (usually consisting of vegetables such as okra - *Abelmoschus esculentus* or roselle - *Hibiscus sabdariffa*) to accompany starch based dishes (mostly maize - *Zea mays*, pearl millet - *Pennisetum glaucum* and sorghum - *Sorghum bicolor*), they do not own land. In many cases women were given less than 0.5 acres of land at the fringes of the farmland to produce these vegetables. Women also rely on economic trees like the dawa dawa (*Parkia biglobosa*) and sheanut trees (*Vitellaria paradoxa*) to help provide nutritious soups and generate income for basic household needs. These important trees grow on land owned by men, whose permission is needed for access. The dilemma of women worsens if their spouse dies and they are left with the responsibility of providing food for the family, whilst not having land. As a coping strategy, they borrow land from male relatives for cultivation of staple food crops and also engage in trading of food stuffs to improve their livelihood. Finally, they engage in gathering, harvesting and gleaning to improve household food availability. Although women do not own land in northern Ghana, they play a critical role in providing nutritious and diverse diets for their families. Therefore, their innovative methods of food provisioning should be recognised and supported in agricultural and food policy.

Keywords: Food and nutritional insecurity, gender, Ghana, land tenure

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Gender in Cassava Leaves Value Chains – An Exploratory Study of Tanzania

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When agricultural value chains are being commercialised, empirical evidence shows that distribution and production relations may change between men and women in terms of control and access to markets, resources and benefits of production. Commercialisation, including introduction of new technologies, may alter the intra-household division of labour and the bargaining positions of household members, consequently affecting their income and nutrition and food security.

Cassava is an important staple food in Africa and cassava commercialisation has been identified as a viable pathway for improving economic opportunities and food security amongst low-income populations. Cassava leaves is widely consumed where cassava is produced and nutritionally important due to their micro-nutritional advantages, low price and high availability. Yet, despite high attention to cassava in the scientific community, value chain analyses invariably focus on the tubers alone.

This study was conducted in collaboration with International Institute of Tropical Agriculture (IITA) in Dar es Salaam, Tanzania. It explores the market structure for cassava leaves, who benefits from it and how. In view of ongoing cassava commercialisation in Tanzania, it explores the value chain with a gendered perspective. By drawing on qualitative and quantitative data collected through interviews, focus group discussions, questionnaires and observations during three months in Mkuranga District, Tanzania, the study seeks to understand constraints and opportunities for value chain actors and to examine information flows and dynamics between actors along functional nodes of the value chain.

Production, consumption and marketing of cassava leaves was widespread in Mkuranga District. Production and retail were dominated by women, whereas male participation was higher in wholesale in large volumes in urban areas. Processing was manually performed by women. Value added activities were limited and despite high urban demand, cassava leaves were perceived as a last resort food. Women's increased market participation was impeded by limited business skills and low financial capital, confidence and education. Issues were grounded in social gender roles and norms and perceived to limit further value chain development. External support and engagement by government, research institutions and organisations was limited.

Keywords: Cassava leaves, gender, Tanzania, value chains

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Constraints and Gender Perspectives at Various Nodes of Cassava Value Chain in Osun State, Nigeria

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Cassava, based on its versatility and product values, presents great potential to reducing food insecurity and poverty in sub-Saharan Africa. However, in Nigeria, actors along the cassava value chain often face challenges that limit the realisation of this potential. With focus group discussions involving 168 respondents and quantitative data drawn from 225 farming households, this study describes the cassava food value chain around small-holder cassava farmers in two local government areas, Ayedire and Iwo, in Osun state, Nigeria. We aimed at understanding the major constraints of each stakeholder group at different nodes of the value chain. Women played an important role at each node except for transportation and dominated product selling, and 3 of 5 managers of the predominantly small scaled processing centres interviewed were female. For farmers (about 90 %), cassava root provides cash for immediate exigencies, however, cocoa, oil palm and yam were considered more important for household income generation. For traders and transporters cassava was one of several crops; only processors (about 100 %) relied exclusively on cassava with gari as the major product. None of the actors had access to formal credit facilities and this was viewed as a constraint by farmers, processors and traders of the final product. Similarly, only farmers (30 %) had access to extension with perceived quality described as poor. Furthermore, poor road network (traders and transporters), lack of modern or poor state of equipment (farmers, transporters, processors), and fluctuation of prices or availability of root material according to the season (traders, processors) were among other constraining factors. The weak market, mentioned by processors (>60 %) and final product traders (>80 %), may indicate that the potential of the cassava value chain for our participating actors is limited if no new ways of marketing are explored. On the other hand, the cassava value chain in Ayedire also held several opportunities: farmers and transporters stated that they could generally trust their informal contract partners, and traders were satisfied with their final product. Therefore, concerted efforts targeting local constraints like better coordination among root producers and processors, for example trough an innovation platform, to overcome seasonal root shortages, should be undertaken to enhance the viability of the value chain.

Keywords: Processors, product sellers, root producers, roots traders, transporters

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Understanding Gender Relations of Smallholder Farmers to Improve Pig Feeding in Uganda

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Pig production is rapidly growing in Uganda, but generally research on pig production systems is just beginning. Information lacks on gender-based constraints and benefits experienced by pig-keeping households. Emphasizing smallholder farmers in rural areas with predominantly 1-3 pigs, this study aimed to understand current gender relations and how they dictate access to and control of land, labor, purchases and sales of pigs and the pig production system as a whole. Gender dynamics in pig production relate to feeds, (planted improved) forages and feeding, consequently, to dynamics of technology adoption.

Focus group discussions guided by the Feed Assessment Tool (FEAST, http://www.ilri.org/feast) and unstructured individual interviews in two sub-counties each of Masaka and Kamuli Districts in June and December 2014 were used for information gathering. Pigs typically feed on collected herbs, weeds, and crop and kitchen left overs. The pig feeding job is mostly women's duty. Time to collect feeds can be as short as 30 minutes in the rainy season when vegetation abounds; however, it can take up to 4 hours during the dry season. In most cases, women gather the feeds and, hence, do the feeding. Culturally, men hardly feed pigs even if they may own one or two, which are fed together with the women's pigs and that of the child/youth if there is any.

In a pig-keeping household, pigs can belong to husband, wife and at times teenagers. Concerning management (feeding, cleaning and ensuring their health), it is often the wife who is in charge of all the pigs in the homestead irrespective of ownership. Whoever owns pigs keeps the income from sales irrespective of gender. Most of women's income from pigs goes to family expenditures, while men's and young people's incomes more often go to their personal needs. The highest expenditure serviced by income from pigs is education in most households, followed by health. Thus, women pig farmers contribute substantially for family welfare. Women attributed pigs' contribution to family incomes to 20% and above, while men attributed lower percentages. Pig-keeping women have to negotiate spaces to plant forages with their husbands who are the land owners.

Keywords: Feed assessment, forages, gender, livelihood, smallholder agriculture

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From Grazing to Stall-Feeding: Livestock Feeds Assessment in Nyandarua Highlands of Central Kenya

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Livestock production plays a central role in household incomes and nutrition in many smallholder farming systems in Kenya. However, prevailing increases in human population coupled with increasing food demand are likely to impact on the crop allocation dynamics and management of farming lands. Mixed farming is common in the Central Kenyan highlands, with both crops and livestock supplying the agricultural produce for domestic consumption and sale. Dairy production at relatively low level is a typical land use; though lately, the trend goes away from grazing to stall-feeding cattle in order to improve productivity. The IFDC-led 2SCALE project (http://ifdc.org/2scale/) aims to encourage this process by applying agribusiness principles. To appraise the current status of dairy production at Oljoro Orok in Nyandarua County of Central Kenya, the Feed Assessment Tool (FEAST; http://www.ilri.org/feast), modified for the specific target, was administered amongst four farmer groups. Three of the groups were organized around marketing their produced milk to a commercial processor collectively, while the fourth had no organized milk delivery and was considered a control group. FEAST was separately applied to women (total N=50) and men (total N=60) in each of the four groups. Differences and similarities emerged between the genders and across the parameters assessed. Most households were perceived as small or medium-sized across the groups. Main planted forage species' contributions to support livestock were largely in the order of maize > Napier grass > oat, by both women and men. Seasonal feed availability trends were similar between the genders; however, use of conserved feeds was mainly stated by men. Clear deficiency of dry-season feeding resulted in seasonally even lower milk production (i.e., dry season 3-6 L cow^{-1} d^{-1}, rainy season 7-10 L cow^{-1} d^{-1}). The contribution of dairy to household incomes was substantial, yet, no difference was found between women (35-69%) and men (34-67%). Improving livestock productivity in the area will require strategies that support forage production and conservation to enhance year-round fodder availability. The pull provided by the secured market for milk by the processor engaged in the project will help facilitate such change in land use as long as milk prices benefit the smallholder farmers.

Keywords: Dairy, feed assessment, forages, gender, livelihood, seasonality, smallholder agriculture

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Participatory Approaches of Women and their Impact on Natural Resources Management

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The issue of gender mainstreaming has become a major concern over the past years in Sudan, where the country is weak in strategies, policies and legal frameworks that support the women's rights. Despite that women play a cornerstone in rural areas through responsibilities in decision making, extension, motivation and outlook within the milieu of natural resources. As a case study, South Kordofan State of Sudan now has existing risks and vulnerabilities associated with many reasons; the environmental and climatic impacts, high rate of poverty, as well as ethnic conflicts between nomads and sedentary farmers, in addition to with socio-ethnic and socio-political conflicts destabilising the critical areas on the western and southern parts of the state. This study aimed to investigate the role of rural women in forest management (covered both the displaced and non-displaced women), effects of forced migration on their land uses, in addition to identify the potential developments strategies. Primary data collected through a stratified two-stage random sampling technique. 200 households using a cluster survey methodology were interviewed. Moreover, rapid rural appraisal (RRA) with focus on 5 group discussions disaggregated by sex and age was applied. Descriptive statistics and correlation analysis of data were made using SPSS software. Furthermore, multi-temporal satellite imagery (i.e. LANDSAT TM, and RapidEye) from 1984 to 2014 were used to evaluate and assess the land use/land cover (LU/LC) changes in selected areas under different scenarios of gender participatory approaches covering 15 sampled areas. Post classification analysis (PCA) technique was applied. The results revealed a high rate of reforestation, which in nearly 50% of the sampled areas was related to the significance of women's influences on forest harvesting and processing. The other main reason of reforestation was the insecure condition. On the other hand, the study showed that the women's economic opportunities remain restricted by the rigid cultural patterns and social rules in marketing of forest products. More emphasis on the potential role and the ability of women to participate in public forums by integration with more developed programs as much as possible could contribute to both rural development and objectives of biodiversity conservation.

Keywords: Conflicts, gender, LU/LC, remote sensing, South Kordofan State

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Gender Roles, Choices of Crop Types and Value Chain Upgrading Strategies in Semi-Arid and Sub-Humid Tanzania

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Different cultures assign roles and responsibilities differently along product value chains according to gender. Upgrading strategies on a given product value chain might not lead to the intended impact on the different gender groups in different cultures if gender analysis is not undertaken. This study involved two societies; the first consisted of mainly one ethnic group in a semi-arid area and the other highly multi-ethnic group in a sub-humid region. The study aimed at determining the influence of gender on preferred food and cash crops, and upgrading strategies in the two societies. A mixed methods research design was used to collect information from participatory workshops, focus group discussion and key informant interviews. Content analysis method was used in the analysis of gender disaggregated information. Results show that both societies in semi-arid and sub-humid areas being gender neutral on the first priority cash and food crops. The first priority cash and food crops in sub-humid area for all gender groups were sesame and maize, respectively, whereas in semi-arid area were bulrush millet and groundnuts. Gender difference showed on the second priority food crop in semi-arid area and third priority food crop in sub-humid area, where women and youth differed with men (maize vs. sorghum in semi-arid region) or youth differed with women and men (cassava vs. rice in sub-humid region). Regarding upgrading strategies, which were only done on first priority crops, it was found that most strategies preferred by men were much different to those preferred by women and youth. This is because of the roles and responsibilities of the different gender groups in the different societies. In both areas, youth and women preferred upgrading strategies related to crop harvesting, transportation and primary processing compared to men whose preference were upgrading strategies on farm inputs and crop marketing. The study recommends that site-specific gendered analysis on upgrading strategies in agricultural value chains should be done before an intervention is introduced.

Keywords: Crop production, gender roles, upgrading strategies, value chain

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Gender Specific Perceptions and Adoption of the Climate-Smart Push-Pull Technology in Eastern Africa

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Performance of agricultural sector in Africa is rated below average with the staple cereal crops being the most affected by both biotic and abiotic factors. The African witch weed, *Striga*, stemborers, poor soil fertility and climate change are among the main factors attributed to poor productivity. This is also in part attributed to inability of women to access to productive resources, yet they represent a crucial resource in agriculture and the rural economy through their roles as farmers and entrepreneurs. International Centre of Insect Physiology and Ecology (icipe) developed and adapted the push-pull technology (www.push-pull.net) for integrated management of cereal stemborers, *Striga* weed and improved soil fertility with the ultimate aim of increased food security among the smallholder farmers in Africa. This study evaluated perception and extent of adoption while dis-aggregating data by gender. Data analysis combined descriptive statistic and tobit model. The findings show significant gender variations in farmers' perception on farming constraints and on beneficial technology attributes. More women rated low cereal yields (98.2 %), poor soil fertility (96.3 %) and limited land (26.3 %) as major constraints compared to men; and also more women highly rated the beneficial attributes of the technology; e.g. 97.3 % of the women vs 94.6 % of men cited increased cereal production; 97.2 % women vs 92.4 % of men cited decline in *Striga* weed; 95.9 % of women vs 90 % of men cited an increase in soil fertility; 94.1 % of women vs 91.3 % of men cited an increase in fodder production and 82.3 % of women vs 66.5 % of men cited an increase in cereal and fodder production even with drought. Male farmers allocated larger portions of their land to the technology compared to the female farmers (Coefficient = 0.0947) and also expanded the technology more (37.3 % males had expanded vs 33.5 % of female farmers; and 99.6 % of males were willing to continue using vs 98.6 % of females).The results further show that a positive relationship between land size and adoption extent (Coefficient = 0.0146). Future trainings programmes, technology development and dissemination strategies and policy options should take into account gender and cultural considerations in order to reduce vulnerability.

Keywords: Gender, perception, push-pull, soil fertility, stemborers, *Striga*

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Innovative Conservation Agriculture Approaches: Food Security and Climate Action through Soil and Water Conservation (INCAA)

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The crucial challenge for smallholder farmers in sub-Saharan Africa is feeding a growing population while preserving the natural resource base of the agricultural system. In future, this challenge will be exacerbated by soil degradation and climate change. Conservation Agriculture (CA) has been promoted as a strategy that can improve yields, soils and effective water use. CA thus has potential to increase the resilience of farming systems facing the mentioned challenges.

However, CA since its introduction in sub-Sahara Africa has not moved from the invention to the innovation stage: the CA innovation seen as a package is not meeting the farmers' needs, capabilities and opportunities. Overall, the attempt to transfer this innovation in a conventional linear way from science to farm has been disappointing. The INCAA project is designed as an action research process aimed at targeting the challenging (and often missing) interfaces of science-driven technology and local realities in innovation systems. The overall objective of INCAA is to mentor and analyse a learning process that supports the innovation of CA in sub-Saharan Africa. The case studies of the project are Laikipia County, Kenya and Koumbia District, Burkina Faso. Building on the experiences of past projects, INCAA will (1) map benefits and adaptations of CA in innovation systems around the partner projects; (2) foster joined learning of stakeholders to test and validate CA tools; and (3) develop learning strategies for an innovation process towards CA including institutional and individual dimensions.

This project will start from those who take the final decision on the fate of CA - the farmers. By assessing how farmers have actually adapted and implemented CA, we can derive lessons on the benefits and losses related to such CA modes for all stakeholders involved in the agricultural system. This contribution will 1) introduce the

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overall conceptual, methodological and structural design of the project and 2) highlight its first preliminary results which so far show high influence of gender aspects towards the adoption decision process. Differing roles of and expectations towards men and women within the farming communities are often an invisible obstacle for further adoption of CA.

Keywords: Conservation agriculture, food security, gender aspects, innovation systems

Improving Incomes of Rural Women through Better Parboiling Processes in Ghana

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Rice has become the second most important staple food in Ghana after maize, with substantial and continuing growth in rice consumption over the past two decades. Despite the importance of rice in the Ghanaian diet, the sector is bedeviled with a lot of challenges. Central to these challenges has been improving the yields and quality of grains produced and sold on the markets. This has affected domestic rice production significantly which has not grown as fast as domestic demand. The country depends on imports to supplement the growing local demand and spent $374 million in 2013 on importation. There is therefore the need to improve on the quality standards of local rice in Ghana to compete well with the imported. Rice processing is one of several major income earners for Ghanaian women. Rural women especially in the north and other rice growing areas in Ghana typically process rice grains using a technique known as parboiling, which literally involves partially boiling the grain. This process enhances the nutrient content of the rice and milling quality. A study was conducted in the Ashanti region of Ghana to assess the status of parboiling and identify the characteristics of parboiling equipments that meet the needs of women processors. The survey employed multi-stage sampling technique to draw the sample. Data was analysed using descriptive statistics and inferential analysis by carrying out a profitability analysis of the business. The results revealed that the women were employing rudimentary methods and basic equipments such as traditional pots, tripod stands and poor drying mechanisms. A lot of pressure was put on the forest as firewood was the main source of fuel. The benefit- cost analysis revealed a return on investment of 22 % made in the business. The return could be improved exponentially if improved parboiling technologies and equipments are adopted.

Keywords: Incomes, parboiling, profitability, rice, rural women

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Collective Action, Gender and Food Security

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Collective action and institutional arrangements can play a crucial role in facilitating subsistence and commercial horticulture, increasing food security and improving gender equality.

Due to gender inequalities in land distribution, women's lacking access to capital and low decision making power, hunger and malnutrition often have a particularly impact on women (and children). This is especially the case with smallholder farmers where women represent the majority. On a structural level, women in Kenya are seen as being responsible for the provision of food (and therefore for the food security of the household) as well as for the (horticultural) food production. One reason for the latter is that subsistence crops like African indigenous vegetables (AIVs) are considered women's crops. Therefore assigned gender roles cannot be neglected in a food security assessment and are taken into account in this study.

Literature shows that collective action can offer an alternative to markets or strengthen market positions. The latter can be particularly important for those groups that are in a disadvantage in market relations, the former for those lacking the access to markets. Both aspects are especially important for women since their access to markets is limited in various ways.

The study assesses what impact collective action and institutional arrangements have on food security and women's issues in horticultural African indigenous vegetables production systems (subsistence and commercial) in Kenya. The authors thereby examine the interlinkages between collective action, gender relations and food security. The interviewed women self-help groups include individuals who share a certain common interests (food security and AIVs production), face collective action problems (e.g. within the production and marketing of AIVs) and have certain rights and responsibilities (within the women self-help groups), meaning the group has institutionalized rules for collective decision-making.

Therefore, the authors supported by the research project "HORTINLEA-Horticultural Innovation and Learning for Improved Nutrition and Livelihood in East Africa" employ semi-structured interviews to identify collective actions of producer organisations (women self-help groups) and the underlying institutional arrangements.

Keywords: Collective action, food security, gender, institutions, Kenya

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Unraveling the Gendered Effects of Climate Change Policy Frameworks in Climate-Smart Agriculture in Nwoya, Uganda

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Achieving long-term gender-sensitive climate change adaptation at local and national level requires supportive climate policy framework, especially in vulnerable and food insecure countries such as Uganda. Intertwined with the multiple climate change related regulatory frameworks and action is the recognition and examination of the differentiated needs, constraints and preferences that men, women and different socio-economic groups have in a changing climate. However, the way gender is understood and articulated in climate change discourses will influence and shape how gender issues are dealt with in policies and interventions. Discourses on gender and climate change will determine which lenses are being used to study social vulnerability and adaptability to climate change and consequently shape what are the perceived problems and potential solution. Differing gender considerations in policy and programs might subsequently ameliorate, perpetuate or exacerbate pre-existing social inequalities. Taking a poststructuralist reflexive approach to narrative policy analysis, this study unfolds different understandings of gender issues in climate change adaptation policies in agriculture and analysing the effects of gender discourses in climate-smart development projects in rural communities of the Nwoya District in Uganda. Throughout the research, narratives are taken as a central object of study by focusing on the diverse ways in which people make sense of their lived experiences. This research examines both narratives originated in non-structured interviews and in more informal accounts such as ordinary conversational exchanges. For the latter, narrative research is combined with observational data and ethnographic methods of data collection. Results reveal serious disconnects among gender issues addressed at national level and the reality in rural communities of Nwoya. Compared to formal policies, customary traditions and laws play a stronger role in everyday lives and in the gendered practices in the rural communities. Notwithstanding gender considerations in national agricultural-related policies, cultural practices ultimately dictate that women can only have access to land through relations with men (husband, father or brother). This lack of access to resources limits women´s interest in engaging in new climate-smart agricultural practices and creates conflicts over harvest ownership, which in turn translates into a spike of gender-based violence during the main harvest season (December-January).

Keywords: Climate-smart agriculture, conflict, gender, land ownership, policy, Uganda

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Women, Cocoa and Natural Resource Conservation in the Ecuadorian Amazon

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The Waorani, one of the seven "nationalities" that inhabit Ecuador's Amazon rainforest, live in one of the most highly contested areas of the country. They inhabit an ethnic reserve which is partially surrounded by the famous Yasuní National Park, one of the global bio-diversity hotspots which also happens to be situated above some of the most conspicuous crude oil reserves, the country's main export.
For centuries they have inhabited their ancestral lands but the increased presence of "alien" actors, such as petrol companies, has changed the dynamics of their territory by establishing infrastructure and by kick-starting a drive to modernisation which has had dramatic effects for indigenous populations, such as pollution, deforestation and uncontrolled wildlife extraction.
In this environment the Waorani, lead by their own women's association (AMWAE - *Asociación de Mujeres Waorani de la Amazonia Ecuatoriana*) and aided by the support of other international NGO's, are pursuing the objective of finding new, economically viable and sustainable means of income. They have chosen chocolate production as their best option and have begun by planting *Theobroma cacao*, a native species, in previously deforested plots, thus reclaiming marginal areas and linking them to their communities. Their objective, which is on the verge of becoming reality, is to be able to process the raw cocoa beans, a cash-crop, into an own brand of chocolate by integrating into an existing value chain. The sales of the chocolate will benefit their communities as the raw cocoa will be purchased above market price at an increasing rate, thus raising the financial and social status of the Waorani.
There are many difficulties to be overcome however as the Waorani are only recently converting from hunting to agriculture. In this qualitative student's investigation the deeper meaning of cocoa will be explored from the perspective of AMWAE, using ethnographic enquiry and interpretative phenomenological analysis.
In collaboration with AMWAE a number of entries to the territory have been arranged which have provided primary data for the production of a MSc. thesis written at Wageningen University (NL) under the framework of the International Master in Rural Development, supervised by Universiteit Ghent (BE).

Keywords: Amazon, chocolate, cocoa, gender, relational place-making, Waorani

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Value chain analysis and marketing

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Market Survey of Traditional Rice Varieties at Great Silk Road Bazaar in Osh City, Southern Kyrgyzstan

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Study presents the results of market survey on trade with traditional rice varieties at the Great Silk Road Bazar in Osh, which is considered as regional market hub. Despite of being rather minor product in terms of total volume consumed among Kyrgyz population, rice still holds an important position in food culture of the country. The research was focused on exploration which rice varieties are traded there, their geographical origin, estimated trade volume, stock and value. Consequently, socioeconomics and demographic background of vendors was documented as well. In July 2014, 30 vendors (out of total number 81) selling rice at market were interviewed. Data were analysed via IBM SPSS statistical programme as well as Microsoft Excel for calculation Spearman correlations between variables and other statistical characteristics. Study documented a total eight national varieties and three international varieties were identified during this research. Preliminary results showed that 15.6 % of sold rice originated from outside the Kyrgyzstan, which in below the national level (44.93 % in 2011). Based on traded volumes, the most traded national varieties were from Uzgen region (33 %), followed by those from other provinces Jalal-Abad, Batken and Osh provinces all (17.1 %). All vendors replenished stock via middlemen on average 2.7 ($\pm$1.35) times per week and a majority of them (93.3 %) had stock covering trade volumes for 4.65 days on average. Positive correlation was found between trade volume and supply frequency (α=0.586; p-value 0.001), it expresses that vendors with increasing trade volume choose more frequently option to increase supplies frequency with similar volumes instead of preservation of supplies frequency and increasing of supply volume. Furthermore, stock positively correlated with traded volume for national varieties (α=0.241; p-value 0.009) as well as for international (α=0.416, p-value 0.009). Price annually reaches the maximal value during harvest period from June to July, which causes maximal demand due to uncertainty about future harvest. Minimal price is from September to October at the time of the main rice harvest in Kyrgyzstan. Hypothesis based on the basic economic theory that price positively correlate with trade volume was not approved. It suggest that price does not play the key role in consumer's behaviour and that they put higher importance to other factors influencing their individual decisions, such as personal preferences, custom, or position of shop at market.

Keywords: Kyrgyzstan, marketing, traditional rice varieties

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The Role of Social Capital in the Management of Sustainable Coffee Certifications

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Social capital, defined as trust, reciprocity, rules, norms, sanctions and networks, has many applications in the management, adoption and acceptance of sustainability certifications. On an individual level, generalised trust in others has been shown to be an important predictor of an individual's participation in voluntary environmental programs and on public-good contributions. On the organisational level, social capital, considered a public good, effects organisational learning, management and collective action.

To better understand the link between social capital and sustainability certifications, we conducted case studies of four Costa Rican coffee cooperatives with supplementary interviews with administrators at two additional cooperatives. We used a mixed-methods approach consisting of qualitative interviews with cooperative administrators and quantitative household surveys. Social capital of the cooperatives was assessed in six dimensions: groups and networks, trust and solidarity, collective action and cooperation, information and communication, social cohesion and inclusion and empowerment and political action. We applied this information to its effects on the management of sustainable coffee certifications.

We found that the level of these six dimensions of social capital affected the manner in which cooperatives manage certifications, incentivize certified members and cooperate with outside organisations. On an individual level, generalised trust was found to have an important link with voluntary participation in environmental certifications when no financial incentive was provided. Strategies for managing certifications and other programs have the potential to build social capital in cooperatives.

This research has important implications for the management of certifications and other similar schemes such as payment for ecosystem services and participatory guarantee systems.

Keywords: Certifications, cooperatives, social capital, trust

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Agro-Industry Investments, Smallholders and Workers: Evidences on Household Income and Poverty Effects from Tanzania

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The study aims at shedding light on the potential income and poverty effects of different organisational arrangements for linking the rural poor to modern food supply chains. Specifically, this study analyses effects of large-scale agro-industry investments within the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). Investments in two different agricultural sub-sectors (sugar cane and rice) and impact channels - smallholder integration models and employment within the agro-industry - are analysed using original cross-section survey data. The survey covers about 650 farm and labour households, half of which are participating directly in these investments. The group of non-participating households is used as a comparison group. Potential selection bias is addressed using Propensity Score Matching (PSM).
Matching models disaggregated by sub-sector and impact channel predict positive and significant effects of participation in the sugar cane investment as worker or smallholder. The effects of participation in the two impact channels in the rice sector are significantly lower with only weak statistical significance. The differences between the two agro-industry labour markets may be explained by longer seasonal labour requirements in the sugar cane sector compared to the rice sub-sector. Differences in the smallholder integration model, may be explained by the stronger direct effects of adopting a new crop and entering into a new market (sugar market). In the rice smallholder integration model that works primarily through adopting a technology package, the project is still in an early stage and adoption yet below 50 % of participating households. While yield differences are significant, before these benefits achieve significant effects on the farm level may need longer time of engagement with the investment.

Keywords: Estate employment, impact evaluation, outgrowers, Tanzania

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Innovation Networks in the Bioeconomy: The Case of Sugarcane in Brazil

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The shift from a fossil-based to a bio-based economy requires better utilisation of the entire biomass that that can be generated from agricultural production. The proposed paper applies the concept of the "biomass-based value-web" as an analytical approach to capture this new dimension of the bioeconomy. This concept is an extension of the commodity-oriented value chain approach and captures alternative use options of the biomass of a crop and the potential by-products that arise during production and processing. Sugarcane in Brazil is a particularly interesting case study to demonstrate the application of the value web concept primarily because the county was a pioneer investor in biofuels, in addition, Brazil demonstrated the viability of an alternative to a purely fossil fuel-based economy and the willingness to shape markets technologies into a bio-based system. To develop a strong international competitiveness in sugarcane, sugar and ethanol, Brazil showcases the effective use of the entire biomass from sugarcane production, e.g. by cogeneration of electricity. Sugarcane also has the potential to provide biomass for a large number of other uses in the bioeconomy. The case study is based on the analysis of documents and a series of in-depth interviews with stakeholders involved in different "branches" of the value web. The application of the value web concept shows that important lessons can be learned from the case, highlighting the role of innovation, institutional alignment and policy frameworks. The case study emphasizes the role of innovation networks from the past developments and presents an assessment of future development options in Brazil.

Keywords: Bioeconomy, Brazil, innovation networks, sugarcane, value-web

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Small-Scale Farmers' Integration in Agricultural Value Chains: The Role for Food Security in Rural Tanzania

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Small-scale farmers' integration in agricultural value chains is considered an important pathway to raising farmers' welfare, including food security. Through activities such as diversification in production, purchase of improved inputs, initial processing, storage and marketing, smallholders are an important part of agricultural value chains. Distinct from literature that has dwelt on high-value and export-oriented agricultural value chains, we focus on domestic, traditional agricultural value chains of staple and cash crops in rural Tanzania. The study examines smallholders' integration into traditional agricultural value chains and aims to assess its implications on household food security. Using primary data from around 900 households in the Kilosa and Chamwino districts, factor and cluster analysis are employed to explore different smallholder' livelihoods, in the context of activities and extent of participation in traditional agricultural value chains. Results identify six clusters with varying levels of participation in traditional agricultural value chain activities. The data reveals that households in clusters with higher levels of integration are, on average, more food secure than those being poorly integrated. Econometric analyses, through propensity score matching and inverse probability weighted regression adjustment, confirm the role of integration in aspects of traditional AVCs for food security. Integration into input markets through the use of improved inputs in primary crop production and output markets through storage and selling, have significant positive influence on household food security. No significant impacts are found for horizontal co-ordination through collective action among smallholders. The findings highlight the importance of promoting policies that enable effective integration of smallholder farmers in traditional agricultural value chain activities for enhanced food security and improved livelihoods.

Keywords: Agricultural value chains, food security, integration, small-scale farmers, Tanzania

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Private Standards, their Institutional Arrangements and their Theoretical Links to Livelihoods Improvement and Food Security

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This paper analyses the differences of the tripartite systems of the most active private standards (UTZ Certified, Rainforest Alliance and Fairtrade) involved in the cocoa value chain. During the last decade, private standards have gained momentum within the cocoa value. This is reflected in the level of engagement from industry and retail actors as well as on the continuous increase of certified producers (volume of product) at the producing countries. These private standards are very similar in their overarching aim, namely, to improve the income, the yields, the environment or social conditions of the farmers they certify. Herewith they aim to improve the livelihood and food security of those farmers. Although, these standards make an effort to differentiate themselves from each other at the market place i.e. emphasis on environmental issues or working conditions and social aspects. All standards are based on the same concept of a tripartite system. However, the differences among the systems in place result in considerable implications on the quality infrastructure which can be reflected during implementation such as costs or efficiency. We analyse all the documentation publicly available related to the quality infrastructure in place of the above mentioned standards and analyse it using basic institutional parameters/indicators. Key informant interviews were done to verify the results and for cross-verification. We conclude that these standards are converging in their systems over time. Furthermore, we urge to bring into the discussion the accreditation bodies in place and/or the system in place to control/monitor the certification bodies, since the latter control/monitor the implementation of the standards at the farm level and thus a considerable amount of integrity is needed, which is being currently questioned by various actors in the cocoa value chain.

Keywords: Certification, cocoa value chain, tripartite system

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Public Distribution System vs. Market: Analysis of Staple Food Consumption in India Using Quadratic Almost Ideal Demand System with Rationing

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There is a growing concern about the high fiscal and economic costs, as well as effectiveness of the Targeted Public Distribution System (TPDS) in insuring food security in India. The current study, apart from better explaining the impact of the TPDS on total staple food consumption, contributes to a growing discussion on implementing cash transfers instead of food subsidies. Our research questions are as follows:

- What is the impact of TPDS wheat and rice consumption on total wheat and rice consumption?
- How does a higher subsidy affect consumption?
- What are the reasons for PDS under-purchase?
- Would cash transfer be a more cost-effective way to increase cereals/staples consumption?

Our analysis is based on the 68^{th} round of the Indian National Sample Survey (NSS) of Household Consumer Expenditure, carried out by India's National Sample Survey Office of the Ministry of Statistics and Programme Implementation.

First, we show that under-purchase from TPDS is due to the supply constraints and as a result consumption from TPDS is exogenous to market consumption. Next, we estimate a three-stage demand system for staple foods. In the third stage, we estimate a Quadratic Almost Ideal Demand System with Rationing (QAIDSR), where the TPDS wheat and rice are treated as strictly rationed goods and the rest of the consumption good s in the system are the market consumed staples.

As an output, we will present results of the simulations of higher subsidy, higher ration and higher income (cash transfer) on wheat, rice and other staple food consumption.

Keywords: Demand estimation, India, public distribution system, quadratic AIDS

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Implicit Prices of Goat Traits in Three Production Systems of Ethiopia: A Choice Model Approach

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Given the lack of data on costs and benefits associated with goat traits under smallholder conditions, an alternative way of determining economic values of traits is required to understand farmers' trait preferences in order to design sound breeding programs. The objective of this study was to determine economic values of goat traits in three production systems of Ethiopia. A choice experiment with 360 households was carried out in Abergele, Konso and Meta Robi districts of Ethiopia, representing arid agro-pastoral (AAP), semi-arid agro-pastoral (SAAP) and highland mixed crop-livestock (HMCL) systems, respectively. The study revealed that body size, libido and disease resistance were desired traits for breeding bucks. Farmers in the HMCL were willing to pay 768 Birr (USD 40) for a breeding buck with an active libido, which was 401 Birr (USD 21) and 630 Birr (USD 33) more than farmers in the AAP and SAAP systems, respectively. Farmers in the AAP system were willing to pay 3.5 and 3.7 times more than farmers in the HMCL and SAAP, respectively, for breeding bucks with a higher disease resistance (sick one time per year) compared to those with a relatively low disease resistance (sick three times). Milk yield was highly valued in the AAP system, but it was less important in the SAAP and HMCL systems. Farmers in the HMCL system were willing to pay 736 Birr (USD 39) more than farmers in the SAAP system for large body sized does, while this trait was not a significant criteria for valuing breeding does in the AAP system. The results suggest that farmers living in a harsh environment represented by the AAP system valued functional traits such as disease resistance more than performance traits, except for milk yield. Cultural habits of goat milk consumption also affected economic values of goat traits. In low input agricultural systems, choice models could be used as an alternative tool to determine the relative economic weight of traits for designing breeding schemes that are in line with site specific farmers' trait preferences.

Keywords: Choice experiment, Ethiopia, goats, implicit prices, production systems, traits

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Social Capital and Agricultural Technology Adoption among Ethiopian Farmers

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Ethiopia is one of the largest countries in Africa in terms of population and land size. Despite the efforts in recent years, food production and distribution is still a major challenge in the country. Hence, improving living conditions and food security of smallholder farmers through increasing agricultural growth remains the main objective of decision makers in the country. Many studies suggested that the way forward is fostering smallholders' productivity, which mainly hinges on the adoption of suitable new and/or improved agricultural technologies.

Understanding the determinants of agricultural technology adoption is crucial for designing appropriate policies. While previous researches highlighted the importance of socioeconomic and demographic factors, they mostly overlooked the role of social capital in technology adoption. In the Ethiopian context, however, social capital and support systems are expected to have a substantial effect on decisions related to testing and adopting new technologies since social capital is capable of creating collective action, relaxing financial constraints, reducing transaction cost, and disseminating information among farmers.

This study uses socio-economic data of 404 Ethiopian farming households living in a 200 km radius around Awassa town. First, it describes the characteristics of farming households with a special focus on different social capital indicators and the agricultural innovations available in the communities. Second, using a probit model and other regression analysis methods like OLS, it assesses the effects of social capital on the adoption of purchasable agricultural technologies (e.g. fertiliser, chemicals, etc.) and non-purchasable improved practices of land-water resources management (e.g. terracing, crop rotation, etc).

The findings of the study are expected to clearly identify social capital indicators relevant for the research area and estimate the effects of social capital on technology adoption. This provides the empirical foundation based on which relevant policy options for smallholders' livelihood improvement can be recommended.

Keywords: Ethiopia, social capital, technology adoption

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Improving Dairy Value Chains through Influencing Policy, Practice, Enhancing Women's Participation, Strengthening Skills and Networks

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Milk and other dairy products are important food and items of trade in Somalia. However, the actual local milk supply does not meet ever increasing demand. In spite of popularity for fresh milk, the quality and marketing of milk remains poor due to inadequate regulatory system, quality assurance systems and low knowledge on hygiene practices. The project implemented by VSFG focused on three areas for improvement of dairy value chain: i) strengthening the public sector to be an effective regulator of food hygiene ii) supporting the private sector and public-private partnership for economic development of the dairy sector, and iii) developing human resources and provision of appropriate equipment for handling milk to reduce health risk for consumers. In the process, it came out that improved hygiene does not only reduce health risks but that higher revenues were realised at household level. Use of aluminum cans increased amount of fresh milk sold by a vendor per day from 26.5 to 45 liters; number of customers from 25 to 35 and price of a liter of milk from $0.61 to $ 0.77 and a profit margin of $0.16 per liter. Since fresh milk was found to have the highest value, interventions to improve storage were initiated: replacement of plastic cans by aluminum cans, a shorter transportation time, milk cooling facilities, and milk testing before bulking. At times of poor accessibility, milk processing becomes necessary to produce storable products; Ghee and sour milk. Interventions in the dairy value chain promote gender equity since women play complementary roles; small ruminants are milked by women, while camels are milked by men, transporting milk is done by men and trading dairy products is carried out by women. In order to establish effective regulatory frameworks for the dairy value chain, community projects can serve as role models. Even with interest from public institutions changes in the sector will take time until favourable macroeconomic policy environment is created. But in the meantime, small scale dairy value chain involving business development such as Village Milk Centers and women groups are representing a successful model for sustainability in rural development.

Keywords: Capacity building, dairy value chain, food security, gender equity policy, natural resource management, pastoralism

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Agricultural Market Integration in Tanzania: An Analysis of Select Maize Markets

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Tanzania government has been sceptical on agricultural market liberalisation arguing markets are not sufficiently integrated, hence intervening from time to time. This paper evaluates spatial market integration of maize, a major food crop and important cash crop in the country. Being a main staple, its market integration not only is important for income and poverty alleviation for about 70 percent of Tanzanians who depend on agriculture but also for countrywide food security. Standard spatial equilibrium framework of Enke-Samuelson-Takayama-Judge (ESTJ) was employed to study sets of monthly price data covering 30 years (1983 – 2013). Dodoma and Morogoro regions markets (deficit and surplus regions respectively) were analysed for extent and degree of integration. Correlation coefficients of market prices of maize, tests for non-stationarity of residuals and persistence profile characteristics results are presented. Findings are mixed, there are high correlation coefficients of prices but there are not sufficient to conclude that these markets are integrated, prompting use of Gonzalo – Granger (GG) model which assumes system is driven by single common factor of prices. Use of Augmented Dickey Fuller (ADF) tests to check robustness of the price movement relations rejected non-stationarity of the residuals for maize prices in Dodoma and Morogoro markets. Possible long-run relationship among regional set of prices are sorted according to eigen values from which cointegrating vectors are derived to build a persistence profile. Generally, extent of integration studied is not sufficient to elicit essential condition for efficient trade. Despite the robustness of the method applied in this paper, the number of observations seems insufficient for econometric requirements in this kind of studies. Also, government intervention might not be as necessary, if it is required then timing is of high importance.

Keywords: Enke-Samuelson-Takayama-Judge framework, maize, market integration, Tanzania

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Understanding Food Safety Awareness and Practices Along Smallholder Pig Value Chains in Vietnam Using Participatory Approaches

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Pig production plays an important role in both food supply and economic development in Vietnam. We assessed the food safety awareness and practice of involved key actors along the smallholder pig value chains in Hung Yen, Vietnam using participatory approaches. Data collection included quantitative (checklists, questionnaires) and qualitative (in-depth interviews and focus group discussions-FGD) tools and was done in three districts of Hung Yen. All survey tools were developed and pre-tested. Checklists (n=22) and questionnaires (n=12) followed random sampling procedures. The respondents for in-depth interviews (n=24) were randomly selected, while the participants for FGDs (n=5) were recruited by convenience. Data collection was done between January and June, 2013. Descriptive statistic was used for quantitative data, while content analysis was used for qualitative data. The outline for data collection for included groups and stakeholders (slaughterhouse workers, pork sellers, veterinary and public health staff, people living around slaughterhouses, pork consumers) was structured around food safety, diseases and health risks. Differences in what some groups found important or unsafe, based on their occupational priorities or labour focus were identified by using ranking tables and analysed accordingly. Analyses show that for slaughterhouse workers and pork sellers the food safety risks were highest and linked to lack of training, or relying only on "learning by doing" an experience provided by other workers or sellers. People living around slaughterhouses expressed concerns about health effects but also pointed out the advantages of their proximity to slaughterhouses, such as job opportunities and easy access to fresh pork. Pork consumer groups were more concerned about sensorial criteria (e.g. freshly looking, bright red colour) and expressed also some awareness on pork quality. Veterinary and public health staff emphasised the gap between existing legislation and food safety practices. Findings provide information on food safety awareness and practices along various actors and stakeholders. There is a need for improved standards, targeted training and collaborative mechanisms between veterinary and public health authorities to better manage the food production chain.

Keywords: Food safety, pig value chains, pork, practices, slaughterhouse, Vietnam

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Market Integration Analysis in the Presence of Trade Quota Policy: A Study in the Indonesian Beef Industry

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Market integration is generally believed as a positive situation in imposing an economic growth and poverty alleviation, particularly in the food sector in the developing countries. With a high degree of market integration, a smooth trade flow from the surplus areas to the deficit areas will occur, and thus the transmission of price signals will improve, less price volatility, and a more competitive market. Beef is one the most important food product in Indonesia which demand tend to increase over time along with the changing of socioeconomic condition. As a response of high domestic demand of beef, Indonesian government has tried to introduce a beef self-sufficiency program. However, in order to fulfil the local demand as the priority, some producer areas impose a trade quota policy which can potentially lead some negative effects to the extent of market integration. This paper aims to analyse the effect of regional trade quota policy to the market integration in the Indonesian beef industry which combines both vertical and spatial analysis. A panel co-integration approach was employed by using monthly data covering almost all provinces in Indonesia during 2008 until 2014. Then, the degree of market integration was analysed by applying a panel heterogeneous modelfrom 117 trade pairs. Our results found that the quota policy has a significant effect in the adjustment process between prices along the supply chain in the whole trade pairs. Some other variables representing the trade cost, trade flows, and the degree of self-sufficiency rate were also involved in the model explaining the transmissions of prices. The findings have confirmed the significant effects of these variables.

Keywords: Beef, market integration, panel cointegration model, quota policy

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Analysis of Fodder Value Chains in Burkina Faso and Nigeria Using Social Network Analysis

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In this paper we present an innovative transdisciplinary methodology that links value chain analysis with social network analysis. Our specific contribution is to investigate fodder value chains and the role social networks play to enable farmers to participate in fodder markets in two semiarid locations in Niger and Burkina Faso, respectively. The sites are part of the rapidly transforming subsistence mixed crop livestock farming systems of the Sudano-Sahelian zone. The relative high rainfall variability and degraded agro-ecological production systems constitute considerable challenges to provide sufficient biomass resources for livestock and people. Growing and selling fodder has the potential to improve farming systems as well as generate additional income for smallholder farmers. However, limited access to markets constitutes a persistent challenge for farmers to participate in fodder markets and lever agro-ecological production and productivity opportunities. In order to better understand existing opportunities and constraints faced by farmers in the Burkinabe and Niger field sites, we investigated critical actors and linkages across fodder value chains through a participatory network research approach. Social network analysis, a well-established method in sociology, is used to systematically assess how men and women farmers are embedded in webs of relations and what the implications of these relations are for functioning fodder value chains. The research methodology employs participatory visual network methods, where research participants draw network maps that describe their social relations with relevant actors along the value chain (e.g. traders, wholesalers etc.). The network maps are gender disaggregated to identify specific barriers as well as opportunities to address gender inequalities. We highlight key actors and discuss how a better understanding of the patterns of social relations affect small producers ability to take advantage of fodder related market opportunities to improve their farming systems and hence improve rural development. The research is part of the CGIAR funded Water, Land and Ecosystems Program, a ten year research initiative that has the aim to develop scalable solutions for reducing poverty, improving food security and maintaining healthy ecosystems.

Keywords: Agriculture, rural development, social network analysis, value chain analysis, West Africa

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The African Leafy Vegetables Value Chain: Organisational Linkages

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African leafy vegetables (ALVs) are widely grown in Kenya and contribute to food and nutrition security, income generation and environmental services. A number of challenges namely; uncoordinated research efforts, limited information and inadequate extension packages have hindered the development of these vegetables along value chain. In addition, to these challenges there is disconnect in the innovation dissemination pathways due to poor linkages among and between the actors. This study uses the concept of sectoral system of innovation and production that postulates three building blocks namely; knowledge and technological domain, secondly actors and networks and thirdly institutions. Emphasis is put on unpacking of the knowledge base and technology present, the actors/stakeholders and their networks/linkages as well as the institutions i.e. the standards, laws and regulations that govern the sector. The graph theoretical method was used to characterise the organisational linkages in the ALV value chain. Organisations were categorised into seven broad groups; farms (producers), research, extension, marketing, value addition, financial and policy. These categories were evaluated in a square matrix to identify the linkages between them and to identify the dominant and sub-dominant categories. The results show the relationships between actors, expounding on the competences of this actors, their organisation and behaviour in the value chain. This is useful for the development public policy guidelines based on understanding of the structure, working and dynamics of the value chain. Innovation can thrive on indigenous science and technology base however; the policy environment needs to be favourable to create access to knowledge and networks along the value chain. One can therefore not over-emphasise the importance of evidence-based policy making.

Keywords: African leafy vegetables, graph theory, organisational linkages, sectoral systems of innovation

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Transaction Costs in Indigenous Vegetable Marketing: Evidence from Rural and Peri-Urban Areas in Kenya

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The marketing of vegetables, especially of indigenous vegetables, in Kenya is still lagging behind despite researchers pointing out that providing small-scale farmers with access to efficient local markets can be an effective way of reducing rural poverty and increasing food and nutrition security. Transaction costs related to information, negotiation and bargaining, entering into contractual agreements, enforcement and monitoring, inter alia, are some of the impediments that farmers face in vegetable marketing. This research aims to identify the types of transaction costs that farmers in rural and peri-urban areas face and how these factors influence their selling behaviour and their choice of market channels. The outcome of the research will provide insights of how farmers' participation in the market can be enhanced. Data used in this research was collected from around 1,200 indigenous vegetable farmers from 3 peri-urban (Nakuru, Kiambu and Kajiado) and 2 rural (Kakamega & Kisii) regions in Kenya. The results of a logistic regression model indicates that savings and the experience of the farm household significantly influence both the decision to sell and the choice of the market channel. Collective action, education and information access have positive and significant influence on the decision to sell but not on the decision of the channel. On the other hand, the variables region, having specific buyer and having delivery agreements significantly influence the decision of whether to sell through a formal or informal channel. The findings highlight the importance of reducing transaction costs through farmer groups and improvement in credit and information infrastructure in ensuring farmers' participation in markets and in particular formal markets.

Keywords: Indigenous vegetables, Kenya, logistic regression, market channel, small holder farmers, transaction costs

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The Quinoa Value Chain in Colombia: Challenges and Opportunities

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The issue of global value chains is gaining increasing significance due to globalisation. The integration of countries of the South into the world market may lead to high economic growth for developing countries and reduce poverty and hunger. Quinoa becomes important in this context. Due to its high nutritional value and extraordinary characteristics, the plant can contribute to the eradication of hunger, malnutrition and poverty. In this sense the UN declares 2013 as "International Year of Quinoa".

The changing consumer behaviour to healthy and natural food resulted in a "quinoa boom". The traditional countries of quinoa cultivation, Peru and Bolivia, have become large producers. Market integration has led to significant economic benefits for farmers but also to adverse effects such as soil erosion by monocultures and sharply rising prices, due to shortage.

Colombia's interest in quinoa for food security and income generation through exports is growing. However, multiple challenges need to be addressed in this initial stage. The study, based on nearly four months of empirical research with collaboration of CIAT and financial support of GIZ, explores the opportunities and obstacles for the quinoa value chain development in Colombia. Bottlenecks are the lack of public policy support, lack of machinery, equipment and infrastructure especially in the post-harvest and processing sector, lack of high quality seed material, low horizontal and vertical cooperation, fluctuating prices and unstable supply, lack of a national research agenda, climate change, and in particular low domestic demand. In addition organic farming practices and certification need to be promoted for entering export markets. Competitive advantages can be seen in already existing high degree of product differentiation and in the high soil fertility resulting in possible higher productivity, combined with two potential harvest seasons per year. Including quinoa in the national research and development programme would strengthen the chain performance and competitiveness. The results of the present research will inform public and private key stakeholders and decision makers to be convened in a national quinoa multi-stakeholder workshop shortly, with the aim to facilitate the development of chain upgrading strategies and a national research agenda.

Keywords: Colombia, market integration, Quinoa, smallholder, upgrading, value chain development

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Without Rain, Markets Ineffectively Fight Smallholder Poverty: A M4P Analysis on Southwestern Madagaskar's Mahafaly Region

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Market access is often limited for smallholder farmers in much of sub-Saharan Africa - foreclosing beneficial trade, production and consumption options. In face of the extremely low level of agricultural inputs to rain-fed farming in southwestern Madagaskar's Mahafali region, we sought to identify constraints to intensified production of arable crops based on the "Making Markets Work for the Poor" (M4P) approach. M4P includes a methodology for value chain and institutional analysis. 120 farmers and traders from a transect of villages including several market places were interviewed in 2013/2014.

Our results confirm the importance of seasonal factors beyond the precipitation-induced timing of planting and harvesting decision. Before and during the rainy season, many households regularly run out of agricultural supplies. They are forced cut food intake for several month per year ("lean season" from October to March). Cash crops (maize, beans) are sold in April/May; also much of the main food crop cassava is frequently sold after harvest in August/September. Although storage losses are frequently reported, respondents do not cite a lack of storage technology as decisive for seasonal crop sales. In fact, sales are mostly related to postponed basic consumption needs, and to meeting cultural obligations. Households are more strongly integrated into regional value chains than expected from the low cash availability and extreme poverty in the villages. Likewise, the trading system appears relatively flexible and effective in spite of poor transportation infrastructure and security threats.

Although farmers benefit from market integration in terms of consumption choices, current market participation does not translate into a path out of poverty for most smallholders. The root cause is a severely restricted set of agricultural production options in this area of low and irregular rainfall. If the agricultural production potential was about to increase (e.g., through availability of irrigation water or higher precipitation), it is likely that the local trading system will make additional production inputs available. However, a lack of knowledge on alternative production options, as well as inefficient cultivation techniques and high labour costs still have to be overcome. Under current circumstances, the potential of market-facilitated sustainable intensification or value chain upgrading in agriculture is low.

Keywords: Market integration, markets, markets for the poor (M4P)

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Increasing Smallholders' Intensity in Cassava Value Web: Effect on Household Food Security in Southwest Nigeria

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Although cassava production and processing is on the increase in Nigeria, there is still a large gap to be filled in meeting the food and raw material need of the country in terms of cassava products and by-products. The reported increase in area cultivated with cassava has not been translated to higher resource use efficiency or productivity, thus cassava smallholders have low physical and economic returns on their activities. This has serious implications for their well-being attributes, chiefly food security. A value web system, involving multiple enterprises within interconnected value chains, has been proposed as a strategy for smallholders to increase resource use efficiency and financial benefits. This study examined the levels of intensity by which cassava smallholders utilise the cassava biomass using available resources. It also isolated the determinants of the different levels of participation in the cassava biomass value web. The study further investigated the effect of higher intensity of cassava biomass utilisation by smallholders on the food security status of their households with respect to their calorie intake and dietary diversity. The study also profiled the different risks to food security based on the level of intensity of the smallholders' participation in the cassava value web. The research used data from a survey of 150 cassava smallholders, from 7 local government areas in Ogun state Nigeria. The results revealed that food security status of households using the cost of calorie index generally increased with increasing intensity of participation in the cassava value web. Dietary diversity of households also increased with an increase in the intensity of participation in the cassava web. Smallholders who are multitasking are also less vulnerable to food insecurity. The study also found that smallholders are rational and respond to changes in market conditions for their products and are willing to take more active roles in the cassava value web. Policy thrust should thus focus on increasing market opportunities for smallholders which will serve as incentives to take more active roles in the cassava value web, with consequence for their productivity, income and hence food security.

Keywords: Cassava, food security, smallholders, value web

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Poverty Alleviation of Rural Communities in South-Eastern Kenya with the Help of Baobab, the "Candy Tree"?

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The baobab (*Adansonia digitata* L.) is a wild fruit tree occurring in the savannahs of sub-Saharan Africa and providing several products including food, medicine, fodder and handicrafts to rural communities. A growing demand for the highly nutritious baobab fruit pulp from Europe and North America raised the question whether the marketing of baobab fruits would be an opportunity for income diversification and poverty alleviation of rural communities in semi-arid areas of Kenya. A value chain analysis of edible baobab products was performed in south-eastern Kenya and identified strengths, weaknesses, opportunities and threads of the baobab business. By using a non-probability sampling, 134 baobab value chain actors from producing farmers to retailers were interviewed on baobab sales data, profits and bottlenecks of their business. The main actors of the baobab value network were farmer traders, collectors, wholesalers, processors and retailers; 72 % of the respondents were female. The products most traded were unprocessed pulp-covered seeds and mabuyu, a candy made out of baobab pulp-covered seeds, sugar and food colour. The average value of the product along the mabuyu value chain increased from 0.07 USD per kg of raw pulp-covered seeds paid to the farmer up to 1.50 USD per kg paid by the end consumer for the mabuyu candy. Depending on the marketing channel the farmers chose, their share of the total value addition was 7–12 % per kg pulp-covered seeds. The processors held the highest share of the total value addition with 45 %. The net profit margins (value addition minus costs) of the farmers were 11 %, of the processors 18 % and of the retailers, who held the largest share, 52 %. Farmers often engage in trading and processing of baobab products during times of scarcity, thus the baobab business can be seen as an important emergency coping mechanism for rural communities. The main weaknesses of the baobab business were insufficient storage practices leading to low product quality, lack of partnership along the value chain and high transportation costs. Increased commercialisation of baobab products and better integration of farmers into value chains could contribute to enhancing rural livelihoods in Kenya, particularly of women.

Keywords: Fruit tree, income diversification, mabuyu, net profit margin, value chain analysis

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Demand Analysis for African Indigenous Vegetables among Rural and Urban Consumers in Kenya

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African indigenous vegetables (AIVs) are consumed across the African continent and in Kenya particularly, they are consumed daily along with the main staple meal, ugali. These vegetables have high micronutrient content, medicinal properties as well as the potential to ensure food and nutritional security. Their demand is rapidly growing due to their availability in supermarkets and groceries, change in dietary habits, urbanisation and increased awareness of their nutritional and medicinal benefits, especially among urban consumers. Despite this, AIV consumption in Kenya is generally low and therefore, there is limited literature that explain their consumption patterns. The main objective of this study is to provide empirical evidence on the changes in demand and consumption patterns for AIVs among rural and urban households in Kenya. This is achieved through analysis of consumers' socio-demographic variables as well as estimating own-price, cross-price and expenditure elasticities of major vegetable varieties consumed in Kenya. The study is based on an exploratory research design, with primary data to be collected from a sample of 400 respondents through face-to-face interviews. In data analyses, descriptive statistics and a Linear Approximate Almost Ideal Demand System (LA/AIDS) model will be employed. Provision of information on price and income elasticity estimates as well as the effect of demographic variables on AIV consumption will be important in predicting future household consumption expenditure on AIVs in Kenya. Besides, this information is likely to assist various stakeholders in formulating appropriate policies to enhance AIV consumption levels as well as aid them in assessing the effect of agricultural policies on household demand for vegetables across different income groups in Kenya.

Keywords: African indigenous vegetables, almost ideal demand system, consumption patterns, demand

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Land Use Pattern by Small Holder Indian Vegetable Farmers, Market Participation in Enhancing Food Security

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This study attempts to understand the allocation of available land to grow vegetables, explain marketing choices of the smallholder farmers in selling their produce, and analysing performances of these marketing choices. Limited availability of the land resources paves challenge for the small holder farmer in choosing and allotting the available area for growing vegetables. Further, due to the perishable nature of the vegetables, they have to be sold as and when they are harvested. The available marketing choices for the farmers in the study area included co-operatives, regulated markets and local channels. Personal interviews with farmers and traders were conducted by using purposive sampling, and the concurrent data was collected with semi-structured schedules. Mixed methods were employed to analyse the data. The descriptive analysis indicates that the proportion of land allotted by smallholder farmers to cultivate vegetables is substantially more, while majority of the small farmers consider growing vegetables provides substantial income and it's a profitable enterprise and provides subsistence income. The comparative analysis between the co-existing marketing channels indicates that co-operatives are the more preferred channel than regulated and local channels. The results also revealed that selling in co-operative has positive effects on the participation performance. Socio-economic characteristics of farm households specifies that farmers with better access to extension services, and those engaged in sorting and grading of their produce showed financial stability with efficient production and higher returns and improved their livelihood conditions. The research emphasised for the smallholder farmers on the better allocation of the available land area and interactions of the all the possible outcomes of the co-existing market choices.

Keywords: Land use pattern, marketing choices, smallholder farmers

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Chances in Sustainability - Promoting Product Chains of Natural Products in Eastern Africa

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The improvement of natural resource management systems combined with the upgrading of product chains may considerably contribute to a better balance between human development and nature conservation. Although extensive experiences exist about the application of a collaborative management approach, not enough facts are available about potential contributions of natural products and their value chains to rural development. This paper presents a collaborative research project initiated in 2013 for participatory identification and implementation of pilot measures for promotion of bamboo and 'natural gums and resins' value chains in eastern Africa. The main focus of the pilot measure is the development of innovative management systems and upgrading product chains for three natural resource based commodities in East Africa (bamboo, gum Arabic, incense). The implementation of the research project follows a participatory approach, integrating all relevant stakeholders along the product chain. At levels of production, processing and marketing the research is focusing on (1) sustainable resource management practices, value adding activities and enabling frame conditions; (2) contributions to livelihoods and rural development; and (3) participation as innovative approach to study and to develop natural resource based product chains. In addition to the scientific objectives the project contributes to strengthen the cooperation between partners from research and practice. The research follows a standardised sequence, which permits to compare the case studies, learn from best practice cases and draw conclusions towards applicability for other production systems and product chains.
Preliminary findings confirm the participatory approach as a successful instrument for stakeholder dialogue, facilitation of common understanding and identification of priority measures for upgrading the chains.

Keywords: Bamboo, Ethiopia, natural gums, natural resins, participatory approach, Sudan, sustainability, value chain

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Value Chain Development for Food Security in the Context of Climate Change- A Contribution through Strengthening Capacity in Higher Education in Eastern Africa (ValueSeC)

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In East Africa, the sustainable use of natural resources and the preservation of productive agricultural land are priority objectives in the region to secure the nutrition of rural as well as growing urban populations. A large majority of the poor live in rural areas and depend directly on agriculture for their livelihoods. Likewise, in the region, climate change is projected to experience higher mean temperatures and dramatic changes in rainfall patterns, higher risk of droughts, shorter growing seasons and new distributions of pests and diseases. As a consequence, climate change will affect food security, food availability as well as food system stability. In particular, small-scale farmers are most vulnerable to changes in cropping conditions and climate change facing an immediate risk of crop failure. It is believed that strengthening didactical and technical capacity as well as regional integration of higher educations in the region enables to improve the performance of food value chains in response to challenges of climate change.

The EU-funded (ACP-EU Cooperation Programme in Higher Education) Project ValueSeC seeks to improve higher education in the field of natural resource management and value chains in the context of climate change. The partner universities (Humboldt-University Berlin, Germany; University of Nairobi, Kenya; Haramaya University, Ethiopia; Karatina University, Kenya) cooperate to foster locally relevant research and higher education in the East African region. Together, the partners intend to build a competence network including policy makers, policy advisors, professional associations as well as local actors in agriculture and rural development, such as smallholder farmer groups, extension services and non-governmental organisations.

This presentation offers the experience and results of the project on strengthening the capacity of higher education and creating competence network. Beside, it also deals the understanding of the inter-institutional linkages, networking and academic partnership among higher education with in Easter Africa and beyond.

Keywords: Climate change, food security, value chains

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Emergent Value Chains for African Indigenous Vegetables and Poverty Reduction: Smallholder Participation in Kenya

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The emerging high value markets presented by rapid diffusion of supermarkets retailing African Indigenous Vegetables (AIV) in urban areas present great opportunities for smallholders to participate in lucrative value chains in Kenya. This study focuses on the hypothesis that smallholder participation in agricultural value chains can provide a meaningful approach to food security and rural development. Many international development agencies are promoting value chain approaches for smallholder market participation for accelerated poverty reduction. However, integration of smallholders into commercial agri-food chains remains poor despite market intervention strategies by government and development agencies. This has been attributed to high cost of transactions, poor infrastructure, and high cost of inputs among others. A further possible reason could be that market interventions tend to focus on production efficiency and quality of produce while neglecting the influence of the power relations between actors in domestic value chains. The growing demand for AIV provides low capital intensive with high returns, which could greatly improve income and employment among smallholder farmers. This study provide a holistic analysis of value chains for AIV by mapping out actors and their activities, power relations, underlying reasons for current performances and opportunities and strategies for upgrading smallholders to better match the requirements for successfully participating in competitive agri-food chains. The value chain analysis within the integrated new institutional economics and social network frameworks, allow for a comprehensive analysis of the incentive structure embedded in the social, physical and institutional environment within which the farmers operate.

Keywords: African indigenous vegetables, food security, market participation, smallholders, value chains

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Economic Efficiency of Tidal Swampland Farming in Indonesia: Local and Migrant Farming Practice

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As the world's fourth most populous country, Indonesia has a high susceptibility to food supply and security. The effort to increase food production faces a rapid land conversion into agricultural land; in Java Island this conversion reached 100,000 ha per year. Indonesia has large swamplands which can be used for agriculture if managed well. Several large reclaim projects have been executed since 1981. These projects were followed by transmigration projects, which translocated more than 3 million families from populated islands to work on reclaimed agricultural land. Most of the transmigrants were young and landless farmers. They came from different cultures, farming skills, and land ecology. However, the project occupied communal land and later lead to conflicts between transmigrants and locals. The different cultures, characteristics, and backgrounds exacerbated the conflicts. Several efforts have been made to alleviate the tension. On the other hand, swampland ecosystem is of marginal and fragile nature (drought, fire, and flood) and susceptible for management failure (reclamation, opening and intensive cultivation). The fertility is low and characterised by high soil acidity, the present if high pyrite and some thick peat layer, and an uncontrolled tidal hydrology regime. Its success of agricultural development is determined by proper land and tidal water management, as well as adaptive farming practice and requires a mix between of indigenous farming practices and new technologies. However, a management exists.Transmigrants tent to use mixed improved techniques while local farmers rely on the indigenous techniques. The major problem is a low overall productivity that is caused by low efficiency of inputs use and it is aggravated through climate change and lack of resources to adapt. Thus, the study objectives are: to investigate the gap between transmigrant and indigenous farmer in terms of achieving productivity and efficiency. A stochastic frontier production function that incorporated inefficiency factors will be estimated using a maximum likelihood technique to provide estimates of technical and economic efficiency.

Keywords: Efficiency, indigenous farming practice, Indonesia, stochastic frontier, tidal swampland

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The Role of Food Standards in the Supermarket Value Chain of Traditional Leafy Vegetables, Kenya

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While producer of traditional leafy vegetables (TLVs) are discussed to have a positive influence on their income if they participate in high-value value chains, e.g. the supermarket value chain, this participation can be restricted by the producers' ability to comply with the required food standards. While prior studies set their focus either on supermarkets or producers, this study takes both sides into account. It aims to identify the drivers of standard development and adoption in the TLV value chain. Therefore, 22 semi-structured interviews were conducted with supermarkets or affiliated specialised wholesaler in an urban county (Nairobi) and around 1,200 structured interviews with producers in two rural counties (Kissi and Kakamega) and three peri-urban counties (Kiambu, Kajiado and Nakuru) on the awareness and plans regarding food standards of TLVs. Some qualitative findings suggest that the main food standards requested by supermarkets from their suppliers, which are either producers or traders, are the freshness and colour of the products. While food safety standards gain in importance, certification schemes, such as organic certification, play only a minor role so far. A value chain analysis however indicates that supermarkets and their specialised wholesaler drive further standard development as they increasingly govern the value chain. On the producer side the findings from an econometric analysis show that the awareness of certification mainly depends on factors related to information access. The willingness to adopt a certification scheme in the future is mainly driven by experience with high-value chain characteristics, such as contracts, and male headed households. Risk takers are more willing to adopt certification in the future. Group membership plays a significant positive role in both awareness and willingness to adopt. These results highlight the importance of policies which improve information access and strengthen farmer groups.

Keywords: Awareness, certification, food standards, Kenya, supermarkets, value chain drivers

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Integrated Assessment of Food-Value-Chains: The Case of Rural Tanzania

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Integrated assessment of alternative food securing strategies can be used to conduct stakeholder-inclusive assessments at local level and to explore possible trade-offs between the different food security targets. Based on the main food security pillars availability, access, utilisation and stability (World Food Summit 1996), the assessment framework integrates all components of the Food Value Chain (i.e. natural resources, food production, processing, marketing, consumption) while following the target of achieving Food Security. The proposed assessment framework supports (1) structuring the assessment process, (2) selecting suitable assessment indicators, (3) integrating local stakeholder and external expert knowledge, (4) conducting comprehensive impact assessments, and (5) drawing recommendations for sustainable agriculture. For this study different assessment tools such as the Framework for Participatory Impact Assessment (FoPIA) and the Scaling up Assessment Tool for Food security (ScalA-FS) are used in a complementary way. They have been adapted to (i) (*ex-ante*) explore possible impacts of alternative upgrading strategies (UPS) on selected food security criteria and indicators, and to (ii) assess possible trade-offs between the social, the economic and the environmental dimensions of Sustainable Development. Within ScalA-FS also the general suitability and local institutional requirements for UPS successful implementation are analyzed. Stakeholder participation is particularly required when identifying the local food security constraints (e.g. water shortage, harvest losses, market access etc.) and the local needs. Expert knowledge is needed when anticipating causal-linkages of food security strategies and selected indicators. In addition to this, monitoring of UPS implementation and follow up activities and household survey data of selected indicators will support verifying the mainly subjective results from qualitative type of assessments. Based on first findings, we discuss potentials and shortcomings of the integrated assessment framework.

Keywords: Food security, indicators, integrated impact assessment, stakeholder participation

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Feasibility Study to Establish a New Value Chain: Application of a Holistic Analytical Framework

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Since the 90s value chain (VC) approaches have received considerable attention by governments and development agencies for poverty reduction and strengthening the private sector. VC analysis has been used for developing intervention strategies to upgrade existing or to establish new VCs. Despite a massive number of frameworks and guidelines for VC analysis for upgrading existing VCs, there is no single recommendation on conducting feasibility studies for developing new ones. Addressing this issue, we undertook a feasibility study for developing a cut foliage VC based on wild-harvesting of *Gleichenia* ferns in New Caledonia using a holistic framework combining relevant conceptual elements and various analytical tools in VC literature.

Results showed the importance of starting with understanding goals of establishing the VC. In this case goals were creating employment in remote areas and starting to valorize New Caledonian horticulture on international markets. Once goals were understood, four interrelated analyses were conducted continuously: enabling environment, productivity, structuration, and feasibility analysis. In the enabling environment, analysis of market, institution, and infrastructure highlighted high demands for the species *Sticherus flabellatus*, well-maintained roads, and legal voids concerning wild harvesting. The productivity analysis on resource availability and harvesting potential pointed out randomness of the resource and its quality, and the rarity of *Sticherus flabellatus* along with *Gleichenia*'s stringent conditioning needs. A VC structure was put forward based on potential actors' interests and existing resource-related constraints. Governing the VC is through coordinating harvester/tribes in the *Gleichenia* areas involving locally active associations, and sharing responsibility for value-creation and distribution activities. Finally, the feasibility analysis underlined the importance of reflecting on findings from the previous analyses with regards to set goals in order to identify (mis)matches between expected benefits from the established VC and goals as well as potential vulnerabilities. In this case, a wild-harvesting activity would not allow valorizing horticulture as conceived by local horticulturists since these give preference to controlled replication in delimited spaces and do not consider wild-harvesting as a horticultural activity. Hence, research on controlled replication of *Sticherus flabellatus* and capacity building of local associations/actors could be appropriate interventions before actual establishment of a *Gleichenia* VC.

Keywords: Enabling environment, environmental impact, *Gleichenia*, governance, New Caledonia, resource, value added

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Impact of Sustainable Certification of Smallholder Farmers: The Case of Abaca Cultivators in Catanduanes, Philippines

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Abaca (*Musa textilis* Née), widely grown in the Philippines, is the key raw material for the production of specialty papers. Abaca cultivation in the country is largely dominated by smallholder farmers. Glatfelter, the world's leading tea bag paper manufacturing corporation, has developed a group certification scheme for sustainable Abaca cultivation, called the Catanduanes Abaca Sustainability Initiative (CASI). CASI represents the first group of Abaca farmers certified by Rainforest Alliance (RA). The purpose of the sustainability certification is to inform the consumers about the social and environmental production conditions of a particular commodity. This study aimed at examining the farming and trading practices in Catanduanes, the world's capital of Abaca, as well as the environmental, social and economic impact of RA certification on Abaca smallholder farmers. Primary data was collected in Catanduanes from August to October 2014. The study made use of mixed-methods combining quantitative and qualitative research, including semi-structured interviews with certified and non-certified Abaca farmers, strippers, sub-traders, and government functionaries.

The study suggests that farm cleanliness, improvement of the natural water reservoirs and awareness of the importance of wildlife protection are the main environmental benefits derived from the RA sustainability standards implementation. Observance of principles such as the prohibition of minor-age laborers and fair payment conditions for farm workers, poses the greatest challenge for standard compliance. Access to information about better farming practices is the leading motivation for farmers' participation although certification initiatives thus far, have targeted relatively better-off small holders in Catanduanes. Price premium is widely regarded as a key economic benefit of sustainable certification but the study found that certified produce is not entirely sold at certified prices and through certified channels, thus limiting its economic impact. Weak financial capabilities of farmers and traders, lack of good quality stripping knives and drying technologies, poor knowledge on classification of quality grades and fraudulent practices at the different levels of the Abaca supply undermine a fair distribution of economic benefits in the Abaca sector. Future efforts of sustainable certification in the Abaca sector should be targeted at enhancing transparency of the trading system and improving production of quality fibers.

Keywords: Abaca, Catanduanes, net map, rainforest alliance, smallholder farmers, sustainable certification

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Food Crops Production and Processing Technologies and the Perceived Impacts on Food Security in Nigeria

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Low level of adoption of modern agricultural technologies in Nigeria has been observed as a factor responsible for the declining food productivity and food security. The main objective of this study is to analyse the level of awareness and adoption of production, processing and storage technologies of crops (cassava, maize, rice and tomato), and its impact on farm households' food and environmental security in Nigeria. Data were collected from a cross-sectional survey of 1,663 farm households across the six agro-ecological zones in Nigeria in 2012. The data were analysed using descriptive statistics, rankings and analysis of variance (ANOVA). The results of the findings show that most farmers are aware of the grain processing and tomatoes technologies but have never tried them when compared to cassava production and processing technologies that they have adopted. The adoption level differs significantly across the selected states. Interestingly, all the available cassava production technologies are perceived by the sampled farmers as having positive impact on cassava products quality, their health, the environment and cassava's yield. Cabinet dryer used for cassava processing however has a negative impact on cassava product quality while parboiling machine for grains was reported to have a negative impact on grains product quality, farmers' health and the environment. Grinding machine (the only adopted tomato processing technology) negatively affect the environment. We therefore conclude that the modern agricultural technologies have mixed impact on both food and environmental security. The perceived negative impact of some adopted technologies on products quality, farmers' health, environment or yield can be adjusted during the designing stage.

Keywords: Adoption, food security, modern agricultural technology, sustainable food production

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A Multi-Output Production Efficiency Analysis of Commercial Banana Farms in the Volta Region of Ghana: A Stochastic Distance Function Approach

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The importance of the banana production and the export sector for Ghana's national development has increased over the past decades. Increasing export orientation and moving towards higher value banana supply chains has opened up new development pathways toward reducing rural-urban poverty. The initial government support in the early establishment phase of the banana sector led to a significant growth in export mainly to the EU due to a growing consumer demand of banana and other tropical fruits (i.e. banana export to the EU grew from a mere 1,788 tonnes in 2004 to 52,357 tonnes in 2010). The export oriented nature of the sector plays a very important role in generating employment opportunities for farmers and exporters which have in turn enhanced welfare and poverty reduction schemes in both rural and urban areas of this region. However, decreasing output trend in the sector due to lack of continuous technical support to improve production efficiency to help sustain productivity growth in the industry is hampering the ability of farmers and exporters to meet the rapidly increasing export demand. This has in turn denied the country of the urgently needed foreign exchange. Given the important contribution of the sector to the economy as well as Ghana's excellent comparative advantage (i.e. climate, soil, labour and proximity to Europe) in banana production, more could be done to enhance production in the sector. All of the 120 sampled farmers produce other crops beside banana using several inputs (i.e. multi-input, multi-output production process), either using the same piece of land or adjacent lands. This study therefore employed a stochastic multi-output distance function estimation technique to assess not only the current productivity level, but also what drives banana productivity in this region of Ghana where commercial production for export is most concentrated and provides some relevant empirical information regarding how to improve production efficiency of banana farmers in this region of Ghana.

Keywords: Commercial banana production and export in Ghana, determinants of technical efficiency, stochastic multi-output distance function

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Technical Efficiency and Food Security of African Indigenous Vegetable Farmers in Kenya

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The agricultural sector is well acknowledged to play a central role in the economy of sub-Saharan Africa. African indigenous vegetables (AIVs) are important as well since they are considered to contribute to food and nutrition security, employment opportunities and poverty alleviation. However, increasing productivity is crucial for improving the welfare of smallholder farming communities. Productivity can be improved either through the technological improvements or through the more efficient use of resources such as fertiliser, pesticide, labour etc. Considering the importance of AIVs, little research focused on the productivity, efficiency and household food security, particularly for farmers growing AIVs. Therefore, this study aims to determine the levels of technical efficiency of AIV farmers in Kenya and its determinants. In addition, the study attempts to determine the impact of efficiency on household income and food security using indicators such as the food consumption score and the household diet diversity score. Based on the rural and peri-urban household survey data of 1200 vegetable farmers collected in 2014, the study uses a Cobb-Douglas type stochastic frontier model and multivariate regressions to analyse technical efficiency and welfare impacts. The mean technical efficiency index is estimated to be 33 % indicating that there is a high potential to increase efficiency in vegetable production among the farmers through better use of available resources. Market participation, location to peri-urban areas and land are found to be the significant determinants of technical efficiency. Further, efficiency is significantly associated with household income. The positive and significant association of efficiency and income also showed higher household food security.

Keywords: African indigenous vegetables, Cobb-Douglas stochastic frontier model, food security, Kenya, technical efficiency

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Castor Oil as a High Value Raw Material Export Commodity for Smallholder Farmers - Linking Ethiopian Producers to German Companies

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Against the background of the finite availability of various resources, the concept of a bio-economy is emerging in many countries. A major aspect of this upcoming idea is to increase the use of renewable resources like plants as a sources for industrial raw materials. Here, oil plants are expected to play a major role as a direct substitute for fossil oil in different industrial sectors. In this context, the generally expected trend shows an increasing demand with often very specific product requirements of processors. In order to ensure food security and economic benefit of rural producers, as well as to achieve sufficient produce, it is necessary to develop concepts and partnerships of suppliers and processors.

This article addresses castor oil as an example product relevant locally and for export. We hereby focus on the potential of linking Ethiopian farmers with German companies to achieve a cooperation with mutual benefits. Using secondary information and key person interviews, we assess the framework conditions like opportunities, institutional requirements, and relevant stakeholders which need to be considered when attempting to set up a practical example. Our focus is on elaborating on the current demand and production structures related to castor oil for export.

We identified example companies showing a general interest in building a relationship with Ethiopian suppliers. Depending on the final product, the quality standards, produce quantities and reliability of supply are of critical importance. It appears necessary that the existing high demand would require substantial investments so as to ensure a sufficient local production and to build up a functioning processing and transportation structure. In addition, certain trade and export related conditions would need to be met. We conclude that there is potential for linking local farmers with the private sector. Through the connected investments, we expect that there is a good chance for development stimuli within the whole value web benefiting especially rural communities involved.

Keywords: Castor oil, Ethiopia, value web

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Economic Efficiency of Chili Pepper Producers in the Volta Region of Ghana

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Vegetable cultivation in both rural and urban Ghana is a germane economic activity. This is because of its importance as a major source of quick employment and income generation for both the rural and urban poor. This study sets out to investigate the economic efficiency of chili pepper producers in the Volta region of Ghana. The study used farm level data to examine the productivity of selected agricultural inputs, technical, allocative and economic efficiency levels of chili farms and the determinants of chili pepper production. The study further identified the key constraints militating against the realisation of the full frontier output using the Garret ranking technique. The modified translog stochastic frontier production and cost function models were analysed on the sampled chili farms using the maximum likelihood estimation procedure. Data was collected on 200 chili pepper producers through a multi-stage sampling technique. The results indicate that on average, chili farms were only 62.9 % economically efficient, whilst mean technical and allocative efficiencies were estimated to be 68.1 % and 92.3 %, respectively. This high mean allocative efficiency estimate lends support to the view that resource-poor farmers in developing countries are highly efficient in allocating the limited financial resources at their disposal. The findings also show that chili farms in the study area are characterized by decreasing returns to scale. The study also identified the difficulty in accessing credit, lack of market and lack of irrigation facilities as the key constraints militating against the attainment of the frontier output of chili pepper. The results further show that age, experience, gender, household size among others significantly influence technical efficiency. Allocative efficiency is however influenced by gender, off-farm income, education, access to credit inter alia. The combined effect of these factors is responsible for explaining the variation in the economic efficiency of chili farms in the study area. The study therefore concludes that chili farms in the study area are economically less efficient. The study recommends policies and programs that aim at attracting the teaming youth into chili pepper cultivation to be pursued by giving them incentive packages.

Keywords: Data, maximum likelihood estimation, modified translog model, multi-stage sampling technique, stochastic frontier

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Sustainable livelihood strategies

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Food Security and Traditional Farming Systems: A Case Study of Homegardens in Southwestern Uganda

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Homegardens are small-scale traditional farming systems, designed primarily to meet household food and nutrition security needs and for occasional product sales. Ugandan farmers manage their homegardens as diverse intercropped banana plantations under constant harvest but few data are available on food plant diversity of these gardens and their contribution to food and nutrition security; this study aims to fill that gap. In three regions of southwestern Uganda, 102 households with homegardens were randomly selected. Plant inventories of gardens (mean size 0.18 hectares) were followed by multiple-pass 24-hour recalls (n=601), the HFIAS food insecurity questionnaires (n=102), and anthropometric measurements (n=231). A total of 250 plant species were identified in the surveyed gardens with a mean richness of 24 species per garden (range 10–54) and a mean Shannon diversity index of 1.32 (range 0.12–2.74). 97 % of all individual plants and 50 % of all species were grown for food; correspondingly 90 % of foods cited in 24-hour recalls were sourced from homegardens. Households hunger score had a mean of 4.9 (range 0–16). Stunting rates of children <5 years were also high (44 %), while no child was wasted. Body mass index (BMI) data of adults >20 years revealed 16 % underweight and 17 % overweight/obese. Household dietary diversity was intermediate with a mean of 7.1 (range 3–11) out of a maximum possible value of 12. A weak but significant negative correlation was found between total plant species richness and households hunger score (r=-0.262; $p = 0.008$), therefore higher plant species richness was related to less hunger. However, anthropometric measurements such as BMI of adults and stunting of children <5 years did not correlate with total plant species richness. Multivariate regression analyses are on-going to identify additional socio-economic factors influencing dietary diversity and household hunger scores and results will be presented at the conference. Homegardens are the primary source of food in the southwest of Uganda, they offer a diverse range of products and contribute much to food and nutrition security of farmer families. However, future interventions could address low dietary diversity and high stunting rates by promoting the integration of specific micronutrient-rich crops in the homegardens.

Keywords: Body mass index, dietary diversity, household hunger scale, plant species diversity, stunting

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Family Farming and its Influence on Household Poverty: A Case Study of Northern Nigeria

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Food security and poverty alleviation have become issues of global concern and have continued to receive increasing attention in the recent time. Nigeria, with her huge endowed natural and human resources is not spared. Family farming, also known as "Gandu" system of farming is mostly practised by crop farmers with the view of pooling resources together within a family unit for domestic production. The study analysed the level of participation in family farming and its effect on poverty status of farmers in northern Nigeria. Primary data on household food consumption and expenditure patterns obtained from a sample of 396 farmers using structured questionnaire were utilised in the study. The Foster Greer and Thorbecke measures of poverty and regression model were used to analyse the data. The results showed a mean per capita expenditure of the farmers to be N 93279.84, while the poverty line calculated as 2/3 of mean per capita expenditure was found to be N 62186.50. The poverty profile of the households showed that 57.8 % of the farmers fall below the poverty line while 42.2 % of the farmers fall above the poverty line and thus categorised as non poor. Out of the poor farmers, (23.3 %) are core poor while (34.4 %) are moderately poor. The poverty headcount index was 58 %, poverty gap index was 37 % and poverty squared gap index was 24 %. The result further showed a high and significant R^2 value (0.72), a significant F-value (53.3) and a positive coefficient which is significant ($p < 0.05$), implying that poverty status was greatly influenced by farmers' participation in family farming. Estimates of the logit regression model revealed that age of farmers, land size, farming experience, household size and extension contact were socio-economic variables that significantly influenced the farmers' likelihood of participation in family farming at different levels of significance ($p < 0.1$, $p < 0.05$, $p < 0.01$). The study recommends measures to encourage participation in family farming as a means to improve livelihood of farmers, reduce poverty and enhance food security.

Keywords: Crop farmers, family farming, food security, poverty, regression

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Does Risk Mitigation Help Rural Households in Vietnam in Reducing the Impact of Extreme Weather?

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Extreme weather events frequently cause livelihood stress in rural households in developing countries and they are expected to become more frequent due to climate change. Local action for *ex-ante* risk mitigation strategies seeks to reduce livelihood stress due to extreme weather. The literature finds that risk mitigation strategies generally improve livelihoods; however whether they are actually effective in reducing risk of households to face livelihood stress due to extreme weather remains unclear. The aim of the paper is to investigate whether risk mitigation is effective in reducing the number of extreme events causing livelihood stress, their severity felt by the household and the actual damage. We use panel data from two provinces in rural Vietnam providing information on about 1100 households in the the years 2003 to 2013, looking at economic shocks due to drought, flood and storm. In a difference-in-difference model with kernel matching the impact of applying risk mitigation measures such as collective action, agricultural diversification and income diversification in 2008 is assessed by comparing the outcomes for non-mitigators and mitigators in the five years prior to 2008 to the five-year period after 2008. The findings are that risk mitigation measures cannot reduce the total number of shocks the households face. However, the number of shocks with high severity is reduced throughout the sample while the number of shocks with medium severity increases for floods and droughts. This leads to the conclusion that risk mitigation measures are capable of reducing the impact of extreme events but not reducing the number of events causing livelihood stress. The impact on total damage relative to household income is expected to be decreased by the application of risk mitigation measures as well.

Keywords: Adaptation, risk mitigation, Vietnam, weather shocks

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Food Security and Livelihood Achievement through Biodiversity Maintenance, Use, and Management — The Case of the Camëntsá Indigenous Community in the Sibundoy Valley (Colombia)

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The Camëntsá indigenous agrarian systems approach is chiefly based on agroforestry systems, which implies two or three components: crops, trees or/and bushes, and animals. Under this productive scheme the Sibundoy Valley's biodiversity is preserved, used, managed, and improved. The biodiversity provides goods and environmental services necessary to meet the household and community demands, including income generation from the production surpluses sales. Among the prevalent goods, abound food, medicine, wood, and fuel. Services comprise biodiversity, pollination, carbon sequestration, nitrogen fixation, and beautiful landscapes.
One-hundred-twenty species were found in the indigenous agrarian systems – home gardens, silvopastoral systems, and monocultures – of the Sibundoy Valley and they have more than 20 different uses. Out of these species, 40.8 % are used as food, 25 % as medicine, and 21.6 % as live fence, with other uses including wood, handicrafts, fuel, aesthetics, construction material, herbs, and shade for crops. Species with one use are the most numerous (62 %); species with more than one use comprise 30.8 %.
The Camëntsá community, from ancient times until now, has been empowered by biodiversity to support their lives, uses, and customs. Exchanges of food, medicine, and trees, along with planting materials of different species and varieties, with Inga, and Amazon native peoples, is one of the causes that led to such a high level of biodiversity in such a particular place on the planet. Since pre-Columbian times, the indigenous communities have done the hard work of collecting planting materials, sowing them within the agrarian systems, choosing the best individuals to grow them, and finally adapting them to the local conditions. Thus far, biodiversity has allowed the communities to achieve food security and livelihoods.

Keywords: Home garden, income generation, Inga, pollination, wood

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The Effects of Green Microcredit on Land Use Practices among Rural Farmers in Sudan? The Battle Ahead

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Although green microcredit is seen as a viable tool being used by NGOs and government institutions to protect and use the natural resources in a sustainable manner, much more needs to be done for the security and sustainability of livelihood. This study intends to assess the effects of green microcredit on land use pratcices in rural Sudan. On top, it tries to answer the question - how farmers would use sustainably the green microcredit (finance for specific activities) to protect the ecological services and to enhance livelihood security? More precisely, the paper also attempts to explore the perceptions of farmers towards green activities that do not involve degradation of natural resource or any chemical fertilisers and insecticides. A survey of 450 households (250 represent credit users and 200 non - credit users) in 10 different localities in North Kordofan State was carried out from August through mid-October, 2014, using structured questionnaire. A multi-stage stratified random sampling technique was used for the selection of sampling. Subsequently, focus group discussions with the key informants in the village communities were also conducted. Descriptive statistical analysis and dynamic non-separable farm household model were applied to analyse the data. The results of descriptive analysis show that 90 % of rural farmers repayed their loans on time, while 88 % of rural farmers have used their loans in green activities. Interestingly, the results of the model simulation demonstrate that, about 92 % of households decided to invest in crop production, of which 23 % and 12 % did so in livestock raising and forest activities, respectively. While only 8 % of households have used their loans for non green activities. To avoid misleading results, a test of auto-correlation, heteroscedasticity and multicollinearity for variables is carried out using relevant commands in Stata software. The study suggests that in order for green microcredit to be an efficient tool for promotion of land use practices, larger and longer-term credit services at lower interest rates should be provided to farmers who agreed to invest in green activities. This could be possible through improving market facilities and providing training to the farmers in remote areas.

Keywords: Dynamic farm household model, green microcredit, livelihood, perception

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Food Security Management of Consumers in Surat Thani Province, Thailand

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Food is the most important factor in life and human survival. Thus, food security is of primary importance in human life. Food crisis and malnutrition affect human security and vulnerability in society. Consumption behaviours, both in rural and urban areas have changed considerably from the past according to economic, environmental and social changes. Proper food consumption behaviour and food security management will lead to self-reliance and social justice. Therefore, the purposes of this research were (i) to study inspiration and behaviour on food security management of consumers in Muang district, Surat Thani province, (ii) to investigate factors influencing food security management behaviour of consumers, and (iii) to investigate the relationship of consumers' inspiration and behaviour on food security management. The population was 171,712 people in Surat Thani province, Thailand. A total of 400 consumers in Muang district were identified by simple random sampling technique for a survey done in 2014. The data collection tool was a closed-ended questionnaire. The frequency, percentage, mean, standard deviation, t-test, One-Way-ANOVA and Pearson's Product Moment Correlation were used to analyse the data.

The results revealed that: 1) the consumers' inspiration and behaviour on food security management was at a good level. The King Bhumibol is an inspirational role model for Thai people and his projects motivate them on food security management. Communication efforts and the provision of information influenced them to be involved with sustainable food chains. The consumers were much concerned about food safety, cleanliness, and nutritious meals. Their food derived predominantly from own production and natural food sources; 2) the level of education, age and marital status influenced the different levels of behaviour on food security management ($p < 0.01$); and 3) the inspiration in food security management of consumers were significantly correlated with behaviour on food security management ($p < 0.01$).

High motivation and inspiration, better knowledge, good attitude and awareness about food security and safety will lead to positive change in behaviour. Therefore, the self-sufficiency principle should be promoted and integrated into every learning subject. Moreover, concerned organisations and communities should set goals and develop plans to manage the food security and safety comprehensively.

Keywords: Consumer behaviour, food safety, food security management

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Utilising Stream-Water and Valley-Land for Commercialising Indigenous Vegetables Production and Livelihoods Improvement in Peri-Urban Kenya

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Kiambu County is among the peri-urban areas within the proposed Nairobi metropolis and a major source of fresh agricultural produce for consumers in Nairobi City. African Indigenous vegetables are currently among the most highly sought after leafy vegetables by consumers due to their nutritional profile, medicinal qualities and a change in attitude towards them. Smallholder farmers in Kiambu produce significant amounts of these vegetables for the city but unlike rural areas, land is a limiting factor for agricultural activities. To the smallholder producers, especially those nearer the city where demand is high, these vegetables have provided a valuable income generating opportunity and high prospects for livelihood improvement. Despite this potential, the vegetable supply remains erratic especially during the dry spells when production is very low and prices correspondingly very high making them unavailable for most consumers. Smallholder producers in the county have adapted to the seasonal gluts by adopting diverse production systems in the high potential areas of the county. To ensure year round supply, smallholders have adopted irrigation agriculture either in valleys along stream banks or by installing motorized irrigation stations along the streams to irrigate vegetable fields away from the streams. Occasionally conflicts have emerged among producers when upstream stations inhibit down-stream water flow. Similarly, valley land leasing has become a common practice among non-vegetable producing land owners and lessors interested in AIVs production. Using both quantitative and qualitative data the paper evaluates how access to irrigation water influences degree of AIV commercialisation and impact on livelihoods of smallholders, sources of water use conflicts and the resolution mechanisms adopted by producers. Additionally, utilisation of valley land is investigated to find out the potential of land leasing on market integration and livelihoods of non-land owners in the land scarce areas such as Kiambu County.

Keywords: Land market, market-integration, scarcity and value, smallholders

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The Effects of Household Definitions on Survey Results and their Possible Implications for Policy Design: Evidence from Tanzania's Maasai

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Household definition plays a crucial role in the nature and outcome of any research based on household level data. While developing and evaluating policy interventions, survey designers and analysts often assume a 'standard' definition that may not fully reflect the local understanding and/or the actual structure of the households under consideration. This may lead to misusing survey data and consequently to misleading conclusions and doubtful policy recommendations. The need for a clear definition is particularly apparent in pastoral societies such as the Maasai of East Africa due to them living in areas with dispersed population, their partial mobility, and the complex family structure involving polygamy.

Considering this background, this study addresses the underrated but highly relevant household definition debate. Based on an intensive literature review, it first discusses different concepts and understandings of a household, particularly in pastoral settings. Second, it uses available data from two Maasai household surveys which were carried out in Tanzania in 2009 and 2012 to econometrically test different household definitions in order to identify possible variations in regression results, results' interpretation or subsequently recommended policy interventions. The effects of modifying this key household characteristic on outcome variables, i.e. a set of welfare indicators (income, TLU ownership, asset value), is assessed by running different regression models and testing the results' sensitivity using likelihood ratio tests, F-test and Hausman test.

Results of the study's analyses are expected to show considerable changes in the socio-economic indicators associated to each household definition, and hence significant variations among outcomes and conclusions obtained from identical household data. Identifying the potentially large variation will highlight the importance of carefully designing household questionnaires with a properly defined variable representing the structure of the families under consideration.

Keywords: Household definitions, Maasai, policy implications, survey data

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Vulnerability of Maize Farming Households to Abiotic Stresses in South Asia: Results from India and Bangladesh

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South Asia is highly vulnerable to climate change with increasing trends in the intensity and frequency of extreme weather events. The region accounts for more than 44 per cent of the world's poor in developing countries. Extreme weather events are more likely to occur in future; exacerbating production risks. Abiotic stresses such as drought and waterlogging are major sources of risk with respect to food security of small and resource poor farmers in rain fed and low lying areas of South Asia.
Maize (*Zea mays* L.) has the potential to alleviate rural poverty; contributing to food security. Susceptibility of maize to abiotic stresses can threaten farmers' livelihood, with the strongest impacts on smallholders with low financial and technical capacity to adapt to climatic variability and change. Incidences of drought coincide with high levels of poverty in maize based production systems in South Asia. Waterlogging affects about 18 per cent of the total maize production area causing an annual production loss of 25–30 percent.
The present study follows a contextual approach for vulnerability assessments. Composite indices are calculated to understand the nature and extent of maize farming households' vulnerability to abiotic stresses in Comilla district, Bangladesh and Panchmahal district, India. Micro-level data from 399 households are utilised to measure the extent of vulnerability as well as households' adaptive capacity to cope with drought and waterlogging. The effects of bio-physical, managerial, and socioeconomic factors are disaggregated to enable an assessment of different vulnerability dimensions.
The results show that bio-physical parameters are major factors influencing vulnerability. Crop management decisions have a significant influence on vulnerability to abiotic stresses. As stress incidences like waterlogging are farm specific, coping and adaptive strategies should be farm specific too. Farmers facing stresses are not undertaking adaptive measures. Changing planting dates to reduce stress exposure, is hardly feasible, as farmers are not willing to compromise on the production of other food or cash crops. Therefore the availability of more abiotic stress resilient maize cultivars could be a viable option to reduce farm households' vulnerability to abiotic stresses and production risks, and to stabilise household income and food security.

Keywords: Drought, maize, micro-level data, vulnerability, waterlogging

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Food Security and Farm Revenues among Smallscale Farmers in Malawi under Changing Climate, Population Growth and Landuse Options

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In Malawi, like in many other sub-Saharan African countries, smallscale farmers comprise up to 80 % of the population and agriculture is often the sole source of livelihood. Due to financial and resource limitations, smallscale farmers are faced with fewer opportunities in choosing or accessing adaptation options, hence being more vulnerable.

In this study we consider welfare as an aggregate measure of food security and farm revenues. Through an integrated climate biophysical and economic modelling process, welfare of smallscale farmers' is analysed over a period of 50 years (2010–2060), under different novel crop management practices against probable scenarios of landuse, population growth and farm input subsidies.

The analysed crop management practices include subsistence system, representing the no adaptation option, conservation agriculture, use of fertiliser trees (agroforestry), optimal fertilisation and intensive farming systems. The study includes all major crops, which represent over 95 % of cultivated land in Malawi. The climate biophysical modelling utilises the Environmental Policy Integrated Climate (EPIC) model to simulate crop productivity under different crop management practices while the partial agriculture sector economic model is developed through the Generalised Algebraic Mathematical Systems (GAMS).

Welfare sensitivity to climate impact is discussed under different management options and scenarios alongside the role played by reproductive health services. We conclude by highlighting a number of probable policy recommendations regarding investments levels on crop management practices, landuse change and reproductive health services that optimise welfare of smallscale farmers in Malawi.

Keywords: Food security, integrated modelling, landuse investments, smallscale farmers, sustainable crop management practices, welfare

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The Correlation Between Household Food Security and Cassava - Constructing an Index to Analyse the Impact of Specific Crops on Food Security

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As cassava is known as an undemanding crop that grows on poor and even tired soils, its cultivation can be expected as a contribution to the food security (FS) of households in poor rural areas. In Tanzania cassava is the main crop in terms of production, reaching more than 5 million tons in 2012.

The aim of this research is to (1) develop a household food security index (HFSI) and (2) to analyse if local cassava cultivation and availability has a direct impact on the FS of people in the Kilosa and Chamwino regions. The research will be based on the FS definition of the World Summit in 1996 that leads to four dimensions: availability, access, utilisation and stability. Subsequently, the hypothesis that households cultivating cassava or with access to it suffer less chronical food insecurity will be verified.

In the context of the Tran-Sec project, conducted by fifteen institutions of Germany, USA, Kenya and Tanzania, an extensive survey has been realised. About 900 households of the regions have been surveyed. The collected data provided information regarding the food status at household level, crop production, consumption, etc. Multivariate statics will be applied, and through a principal component analysis (PCA) variables will be sort out and new indicators (based on PCA) will be obtained. A HFSI that includes all the four dimensions of food security will be designed to fit in the available data. This HFSI will be categorised in temporal food security intensities (ranging from constant FS to constant food insecurity). Thereafter, a cluster analysis will be conducted to realise regional pattern recognition and indicated if FS is correlated with the presence of cassava or not.

Preliminary results indicated that, despite being the main agricultural production in the country, cassava is cultivated in less than 10 % of the surveyed households. The next steps will examine how the cultivation of cassava is correlated to the HFSI. In the sequence, the methodology will be applied to other significant crops of the regions to examine their correlation to FS. Finally, this approach may uncover some roots of food insecurity in the surveyed regions.

Keywords: Crop production, food security, household survey, *Manihot esculenta*

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Family Agriculture and Land Use in the New Ruralities of Sub-humid Tropics in Central America

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The sustainability and resilience of family agriculture is fundamental to the livelihoods of rural communities and the health of rural landscapes in Central America. Family agriculture encompasses a large diversity of households and farming systems. In this region, farming, land-use systems and livelihood strategies are quickly evolving reflecting closer rural-urban interactions-i.e. new ruralities. The aim of this study was to better understand the interactions between family agriculture (income, food security, production orientation) and farming systems within these new ruralities to better identify future options. A short farm household survey was conducted in 2014 with local partners to almost 800 families in five sites in Nicaragua, Honduras and El Salvador. With 14 questions and ca. 40 minutes time, the survey was designed to understand the diversity of farming systems in the region, their main agricultural activities and performance, as well as their main sources and levels of income and food. Results showed that in two sites in Nicaragua where land was still available (average farm size 3 ha) the income of almost half of the households still depended on on-farm activities. In the other sites, average farm sizes drop from 1.4 to 0.7 ha together with an increase dependency on off-farm income. These differences influence the potential risk of family agriculture in terms of income levels and food self-sufficiency. These results also confirm the increasingly rural-urban interaction in family agriculture in Central America. The development of better policy and development programs needs to account for this diversity, as well as the new rurality of family agriculture in the region.

Keywords: Food security, household diversity, off-farm income, rural livelihoods, smallholder farming

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Evaluation of Coping Strategies among African Leafy Vegetable Farmers in Kenya

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Production and consumption of African leafy vegetable (ALVs) has a great potential in mitigating malnutrition as well as being a source of households income. However, production and marketing shocks have adversely made the vegetables to receive little attention in terms of their contribution to household poverty alleviation and food security. ALV producers in developing countries use different *ex-post* coping strategies such as asset accumulation, selling livestock, use of informal networks, seeking help from government, and increasing or shifting labour supply in response to such shocks. However, there is insufficient evidence as to why households choose a specific type of coping strategy. This study, therefore seeks to determine the factors affecting the choice and the extent of coping strategies to production and marketing shocks among smallholder ALV producers in Kenya. The study focuses on rural (Kisii, and Kakamega counties), and peri-urban (Nakuru, Kiambu, and Kajiado counties) areas, which represent different production potentials and proximity to urban centres. A semi-structured and pre-tested questionnaire was used to collect data from smallholder producers through face-to-face interview. Multi-stage sampling technique was employed to select 1232 respondents, which were subjected to a Heckman two-step selection model to determine the factors that influence the choice and extent of coping strategies among ALVs producers. The preliminary results showed that availability of water for irrigation, high-valued market access, individual land tenure and variable representing farmers whose main occupation was farming significantly and positively affected the likelihood to cope with production and marketing shocks while only age was significant with negative effect. With regard to extent of coping with production and marketing shocks, private land ownership, access to credit financial services, high-valued market access, and access to extension services were significant with positive effect while age was significant with negative effect. The conclusion is that the incentives and drivers that are deemed necessary for coping with production and marketing shocks among smallholder farmers needs to be enhanced and improved across all the producing areas. This study therefore recommends that government and other stakeholders should formulate and implement effective policies related to promotion of efficient ALVs production and marketing coping strategies.

Keywords: African leafy vegetables, coping, Kenya, marketing, production, shocks, strategies

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Opportunities and Determinants of Rural Non-Agricultural Employment: Evidence from Ethiopia

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As compared with other African countries where the estimated average non-agricultural participation was 42 % in the 1990's, a lower proportion of the labour force is engaged into non-agricultural activities in rural Ethiopia. Non-agricultural activities defined as all economic activities such as manufacturing, service and mining and extractives except agriculture, livestock, fishing and hunting. The main goal of this study is to identify the opportunities and main determinants of non-agricultural activities of Ethiopia. This study addresses the following specific questions: What are the different non-agricultural opportunities of Ethiopia? Why households are diversifying into non-agricultural activities? What are the determinants of non-agricultural employment?

We employed descriptive statistics and an econometric model for the analysis of this study. The dataset for the study is sourced from Ethiopian rural investment climate survey (RICS) and Ethiopian rural socio-economic survey (ERSS). The study found that the main non-agricultural activities of Ethiopia are manufacturing (brewing/distilling traditional alcohols, grain milling, etc), trade activities (whole sale and retail trade) and service activities (transport, carpentry, repair service, small restaurants, etc). The study also indicated that rural household diversify into non-agricultural activities due to lack of access to agricultural land, low/volatile earnings and social/economic independence.

We also identified the main determinants of non-agricultural employment based on binary probit model. The outcome of that estimation indicated that the main determinants of non-agricultural employment are lack of market opportunities, limited access to credit or finance, poor access to road and transportation, and lack of business training or education. Most of these factors have significant effect on the household's non-agricultural participation. Therefore, the development of rural infrastructure is critically relevant for facilitating rural non-agricultural employment in Ethiopia. Furthermore, policy makers should integrate the promotion of non-agricultural activities in the framework of rural development policies and strategies.

Keywords: Non-agricultural activities/employment

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Food Availability and Acquisition Along the Rural-Urban Continuum of Two Cities in Cameroon

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Although Cameroon stands out as a sub-Saharan country rich in natural resources, the reality of food insecurity still persists. According to UNOCHA, by early 2015, the number of food insecure people in Cameroon stood three times higher than two years before, also seeing an increase in malnutrition rates. This can primarily be attributed to insufficient agricultural production, low education and income levels, and inadequate infrastructure. The research carried out by the LUNA project ("Urbanisation and its impacts on the use of natural resources in Africa" also known as "Livelihoods, Urbanisation and Natural Resources in Africa") in middle-sized cities in Africa aimed at investigating the impact of urbanisation on household food security and nutrition. The town of Bamenda in the Northwest Region of Cameroon and Limbe in the Southwest Region were chosen as study sites because of their rich agricultural background with still existing strong rural linkages and their rapidly increasing population, which create an undeniable rural-urban continuum.

Initial investigations of the first phase of LUNA included a quantitative survey of households throughout the rural-urban continuum of Bamenda, as well as several Focus Group discussions. The extension phase then aimed at a more intensified analysis of household food security and nutrition, especially in the peri-urban realm, through dietary surveys, focus group discussion and transect walks.

Dietary transect walks were used to have a commented, inside view on the effort and time that is needed for weekly food acquisition. Food acquisition turned to be mostly divided into purchase from local food markets as well as products from subsistence agriculture in gardens or farms.

For comparative investigations the project subdivided the rural-urban continuum into three spheres, an urban, peri-urban and rural zone. It could be detected that the time and distance and the connected efforts to acquire food for the household differed prominently between the spheres. But even within the same zone many differences were observed throughout the walks, especially concerning distance to the place of food acquisition (market or field).

Keywords: Food acquisition, food availability, rural urban continuum, stakeholder participation, urbanisation

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New Dimensions of Multidimensional Poverty and its Relation to Shocks: Evidence from African Indigenous Vegetable Producers in Kenya

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The global community is confronted with not only existing challenges of poverty and food insecurity but also emerging ones of climate change and loss of biodiversity. It is clear that the consequence of these challenges has lasting and severe effects on the livelihoods of households especially in developing countries and their economies. It has been shown that shocks such as drought, floods, changes in rainfall levels and variability, and the consequent effects of crop failure are identified as major determinants of poverty dynamics and have a significant effect on the welfare of households in developing countries. Yet, it remains an open question as to how these shocks affect different welfare indicators. There is emerging literature about using multidimensional indicators to measure poverty. Consequently, research on poverty has reached consensus that measurements of poverty has to reflect its multidimensional character by including education, health, assets and other indicators into the conventional consumption poverty measure. Using such multidimensional poverty assessment captures both short and long-term components of poverty. Accordingly, multidimensional poverty measures, composed of different variables, are increasingly being used as reasonable methods of poverty assessment and its application is being tested in different contexts, such as to assess the link between poverty and disability and child poverty and conflict. However, there is little evidence of using multidimensional poverty measures to assess the link between poverty and shocks. Therefore, this study seeks to use new dimensions of welfare indicators to calculate multidimensional poverty using HORTINLEA household survey among rural and peri-urban African Indigenous Vegetable producers in Kenya. We then establish the link between different dimensions of multidimensional poverty to incidence of various shocks. This provides new insights to policy and development interventions as to which dimensions of poverty are vulnerable to a specific type of shock incidence so that informed actions could be undertaken when a specific type of shock occurs.

Keywords: African indigenous vegetables, Kenya, multidimensional poverty, shocks

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Food Security through Integrated Land and Water Management of Smallholder and Family Farmers in Eastern Georgia

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The collaborative research between the Agricultural Faculties University of Kassel, Germany and University of Georgia, Georgia examines the causality between land and water resource management and food security of smallholder and family farmers. Adequate water quality and improved soil quality are critical factors in ensuring food security of smallholder and family farmers. Socio-politically less powerful stakeholders, such as smallholder farmers, could have to bear the negative consequences of land and water as competitive sources, which are exposed to different interests. Smallholder and family farmers are considered as major food producers in Bolnisi municipality, eastern Georgia. Most of them own 1 to 2 hectares under the land reformation program after 1992 and are located as homestead lands. Especially vegetables and fruits are produced in their own fields and these are the main source of family food supplies. As a result of the mining activities in the upstream area of *Mashavera* River and *Poladauri* River, soil and water sources in the downstream area are heavily polluted. As early studies state, irrigated soils are highly polluted by heavy metals including copper (Cu), Zinc (Zn), Manganese (Mn) and Lead (Pb). On the other hand, the intensive application of chemical fertilisers is another factor in Georgia that reduces soil fertility leading to water and soil salinisation. The salinisation of soil and water table cause for the decline of arability of lands and directly impacting the ecosystems and human health. Consequently, the quality of food is reduced by polluted soil and water. Therefore, the social risks of smallholders and family farmers in terms of household food and nutrition security are threatened. This research study is going to analyze the water quality and quantity of irrigation water and its impacts on food production of small-scale agriculture with the land management policy in the area. Furthermore, the research study aims to observe how small-scale farmers could be engaged in the current land and water management system at local level. Implementing a mechanism to raise local awareness of soil and water quality would mean civic engagement at the local level in terms of land and water resource management processes which would lead to the establishment of food security for smallholders and family farmers. Since the research study deals with a pragmatic and complex

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problem that entails both socio-economic and ecological factors, a mixed methods research approach will be followed. Within this mixed-method approach, there will be multi-disciplinary methodological approaches to evaluate particular disciplinary- oriented and transverse factors. The field and laboratory-based water quality assessment will be conducted. Field research methodology encompasses with surveys, qualitative interviews and participant observation, semi-structured interviews and focus group discussions, as well as expert interviews and institutional observation. These qualitative and quantitative data will undergo MAXQDA, SPSS assisted analyses.

Keywords: Civic engagement, land reform, nutritional wellbeing, organic agriculture, river basin, small-scale farm lands, water quality assessment

Livelihood Transformation as Influenced by Socio-Environmental Changes and its Impact on Food Security among Small Producers of the Red Sea Zone of Eastern Sudan

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Eastern Sudan is dominated by semi-arid climate especially along the Red Sea coast and western plains of The Red Sea hills. It is also characterised by low and erratic rainfall. In this area Beja tribes are the main inhabitants, raising livestock mainly camels (*Camelus dromedarius*) as a main livelihood activity, that contributes significantly to income and food security. Camel pastoralism is historically known to be adaptable and greatly linked with the rural livelihood activities. The prevailing land uses and socio- environmental changes have greatly disturbed the existing livelihood pattern.

The study objective was to assess the impact of livelihood transformation on food security and environmental sustainability among the small producers at Red Sea coast.

The methodology assessed recent and past land uses, beside assessment of browsing resources and characteristics including mangrove trees. GPS loggers were used for tracking camels browsing at selected mangrove forests. It also included socio-economic survey using questionnaires among pastoralists within two selected rural clusters, investigating mainly livelihood changes.

The results indicated that, irrational land uses, climate variability and change greatly contributed to disturbance of the rural livelihood of the Beja tribes. Terracing for farming between the coast and western hills has greatly affected the mangrove (*Avicenna marina*) habitat, by blocking of rainfall water running to the sea. Urbanisation as harbor expansion, growing tourism investments and increasing numbers of salt ponds along the coast greatly disturbed livelihood activities that already have witnessed a transformation towards more marginal livelihood activities

The study identified some sustainable livelihood practices that are sustainable and need promotion, while others are unsustainable and need to be managed. Camel browsing on mangrove is not continuous all over the year; since more than 80 % of camels go to the western plains in summer. The increasing market of camel milk motivates more herders' to increase their herds. Decreasing of preferred rangelands plants and the wide spread of mesquite tree (*Prosopis juliflora*) which invaded the area are urgent issues that need handling. Corridors along the coast are needed for browse access. In addition to these, sustainable conservation means and management plans for mangrove trees are required.

Keywords: Camel herding, food security, land use, livelihood, rural livelihood, socio environmental changes

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Contribution of Wild Fruits to Household Income and Food Security among Small Scale Farmers in West Kordofan State - Sudan

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Wild fruits are a crucial source of household income and food security in many rural households in study area mainly during dry season. However, in Sudan general and West Kordofan in particular the contribution of the wild fruits to the household income and food security, is still relatively limited. This study attempts to assess the contribution of wild fruits to household income and food security and to evaluate the factors that influence the plantation and consumption of wild fruits among small scale farmers in West Kordofan State. The data used in this study were derived from field survey that was conducted during the years 2013–2014 in West Kordofan State. Structured questionnaires were administered to 150 farm households, divided into 50 respondents' represents fruit collectors, 50 retailers and 50 respondenting for wholesalers. A cluster random sampling technique was used for the selection of sampling. Subsequently, focus group discussions with the key informants in the village communities were also conducted. The logit regression, descriptive statistics and (SWOT) analysis were used in the data analysis. The results showed, that the contribution of wild fruits to household income was found to be 71 % counting for approximately SDG 2092 (EUR 300). 50 % of sampled households have secured their food from wild fruits collections, especially during the dry season. The results obtained from logit model indicated that the decision of farmers to plant wild fruits trees were influenced by education level of the farmers, gender, lack of awareness, marketing facilities and availability seedlings. Despite the fact that wild fruits collections have a positive and significant contribution to household income and food security in the study area, nevertheless wide threaten was reported by (SWOT) analysis. The study suggests that in order to improve wild fruits there is a need to formulate supportive policies that encourage marketing and pricing. This could be possible through improvement of infrastructure and market channels.

Keywords: Food security, income, logit model, SWOT, wild fruits

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Urban Farming as an Adaptation to Food Security and Climate Change in Nyeri County, Kenya

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Urban farming is proposed as a one of the key solutions to food insecurity especially in the developing countries where high population and declining land sizes have resulted to major food shortages. As land is being converted to commercial land for building residential houses which generate more profit as compared to farming, climate change has compounded the issues of food production under rainfed conditions due to declining rainfall amounts, droughts and floods thus requiring shift to other production innovations such as supplementation of soil water by use of drip irrigation and diversification of crops and farm animals. A study was carried out in selected urban centres in Central Kenya to investigate the type of urban farming, the dynamics and production potential. A total of 60 respondents who were directly involved with crop and/or livestock production in the urban centres were selected. Triangulation transect was used to ensure all farmers within the urban centres were given fair chances during data collection. Preliminary findings indicated that farming within the urban centres was prevalent with over 40 % of the households owning kitchen gardens of various sizes. The most common crops grown were indigenous and few exotic vegetables. A small percentage (12 %) had fruits and flowers, while 60 % of the households kept some form of livestock. There was differentiation on the type of urban agriculture between the urban centres and their suburbs. This was related to the population density, whereby the suburbs near high populated urban centres attracted a high proportion and more diversified form of urban agriculture (both crops and animal production) than low populated town centres. Due to the magnitude of the research data collected there is need to document the system of urban farming in relation to other factors such as economic capacity of the residents and location of the urban centre in relation to demographic growth. Challenges of urban farming need also to be explored in relation to climate variability. The current research results are being studied in order to advice the county government on the possibilities of incorporating and promoting urban farming within the devolved systems of government.

Keywords: Climate variability, food security, fresh vegetables, urban farming

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Tackling Food and Nutrition Insecurity in Tanzania: Farmers Perspectives on Kitchen Gardening as a Sustainable Approach

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Under nutrition and food insecurity are major problems faced by most of the developing countries including Tanzania. Foods with high nutrient content are difficult to find in the poorer rural areas where most people are dependent on staple foods with little diversity. Kitchen gardens play an important role in fulfiling dietary and nutritional needs. This study sought to investigate the perceptions and practices by farmers on how kitchen gardening can be transformed into a sustainable nutrition and livelihood strategy in order to come up with information not only on socio-economic sustainability but also on the environmental sustainability of kitchen gardens in rural Tanzania.

Focus group discussions, key informant interviews, field observations and secondary sources of data were used. The researcher used observation guide to identify some of the issues that could not come out clearly during focus group discussions. The study was undertaken in Idifu village, Chamwino district in Dodoma. A total of 28 farmers were involved.

Only 18 % of households practised kitchen gardening. It was regarded as the activity of women. About 80 % of the respondents did not have indicted budget to buy seeds and inputs for kitchen gardening. About 85 % of farmers indicated it has a potential to be a secondary source of income. Water was a limiting factor in 78 % of the participants. About 80 % of farmers did not posses radios, and 20 % possessed radios but sometimes they lacked money to buy batteries. This constraints the spread of kitchen gardening information through media.

This study confirms that kitchen gardening can be changed into a sustainable nutrition and livelihood strategy in Chwamino district and other similar environments if the farmers have access to training on the sustainable use of natural resources such as water and land and can afford adequate access to resources.

Keywords: Farmers, kitchen gardening, rural, under nutrition

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Alternative Livelihood Strategies of Forest Dependent Ethnic Minorities Within a REDD+ Implementation Area in Bac Kan Province, Vietnam

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Natural forests have played an important role for rural livelihoods in the upland of Vietnam. However, the primary forest area is continuously declining. Forest plantation and regeneration are urgently needed. This study examines alternative livelihood strategies of forest dependent ethnic minorities through a study in Bac Kan province, Vietnam. The data was collected in four communes at Ba Be and Nary districts. Participatory wealth ranking, income portfolio scoring and willing to access methods were applied, followed by a structured household (n=240) survey. Student's t-test and ANOVA were used to test income differences among the groups. The share of forest environmental income in total household income was used to obtain a mutually exclusive choice of livelihood strategies of households.The average forest environment income contributes to household livelihood was 22 %. Livelihoods of the selected households were classified into less, moderate, and highly dependent on forest. Around 51 % of households choose "less dependent on forest" livelihood strategy with 16.5 % of forest environment income on average. With an average forest income share of 26.8 %, 47.5 % households select "moderately dependent on forest" livelihood strategy. There are only 1.5 % households pick "highly dependent on forest" livelihood strategy. The forest environment incomes mainly support current consumption and the dependence on forest differs among households. The poorer households are more dependent on forest than wealthy households. And the level of forest dependence of local people has been reduced overtime. A proposed REDD+ regime provides an opportunity for sub-national actors to address the issue of poverty in resource rich forests regions. The benefit sharing mechanism needs to be framed appropriately and transparently, in order to overcome the livelihood issues in REDD+ implementation area.

Keywords: Bac Kan province, benefit sharing ethnic minorities, livelihood strategies, REDD+

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Informal Agreements Regulating Access to Natural Resources in Protected Areas: A Sustainable Solution? A Case from Western Thailand

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Due to deforestation, a strong focus is being put on establishing protected areas worldwide. Thailand has been following this trend and protected areas are planned to comprise 25 % of the country in future. Thai law forbids any human activity in national parks, hence the establishment of a protected area is often a shock for local inhabitants, as they have to cease using forest resources. Based on data collected in a village in the Sangkhlaburi district in western Thailand, this study explores local approaches to manage coexistence between people and protected areas.

In order to avoid conflicts, a local division of the recently established Thong Pha Phum National Park arranged an informal agreement enabling the inhabitants of a neighbouring village to use forest resources for home consumption. However, this study shows that villagers with and without land ownership may not be evenly affected by these changes of access to forest resources. While the vast majority of landless people strongly depend on forest resources landowners decreased the collection of forest products. Additionally, as landless villagers have a less diverse livelihood portfolio, they have fewer opportunities of occupational change in case of diminished access to natural resources. Since it is most common to gather food we argue that landless villagers might be most vulnerable to sudden changes in the informal agreement. With no change in Thai jurisdiction the sustainability of such an agreement remains questionable, as it is largely based on social- and power relations. Due to the fragile character of this arrangement, villagers are inhibited to legally enforce their interests. This aspect of instability could possibly expose landless villagers to food insecurity in the future.

Keywords: Forest, informal agreement, land tenure, livelihood, natural resources, protected area, Thailand

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Commercialisation of Mopane Worm (*Imbrasia belina*) in Rural Households in Limpopo Province, South Africa

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Non-Timber Forest Products (NTFPs) have been identified as a key source of income for rural households. In South Africa, mopane worms (*Imbrasia belina*) have become an important source of food and cash income for rural people living in or near the mopane woodlands. However, the continued over-exploitation and commercialisation has implications for long term management of the mopane woodlands in the northern parts of South Africa. This study used a cross-sectional dataset collected from a survey of 120 households in Limpopo province in an effort to identify socio-economic factors influencing mopane worm commercialisation and intensity of commercialisation. The Household Commercialisation Index (HCI) and the Double Hurdle Model were used for the analysis. Result shows that about 63 % of mopane worm harvested is sold within a production year which implies high level of commercialisation. The result of the Double Hurdle Model showed that gender, education, household size, quantity harvested, social capital, distance, transportation and information impact on households' decision-making to commercialised mopane worm. Furthermore, household age, gender, education, exogenous income, price, quantity of marketable surplus and transportation are statistically significant factors influencing the intensity of mopane worm commercialisation in the study area. This therefore suggests that, in order to achieve a balance between sustainable harvesting of mopane worm and improving the livelihoods of the rural poor that depends on it for food and income, there is a need for policy makers to focus on the dynamics in household socio-economic conditions. Implications for policy were discussed.

Keywords: Commercialisation, conservation, income, livelihood, mopane worm, NTFPs, rural households, South Africa

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Agroforestry: A Livelihood Strategy of Survival. Implications for Sustainable Development

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The most serious environmental concerns in Sudan are land degradation, desertification and the spread of deserts. About 75 % of the population live in rural areas that account for over 80 % of the total extreme poor. Due to degraded soils, lack of inputs and unfavourable weather conditions, most of the resource-poor farmers grow their crops in degraded soils without inputs such as chemical fertilisers or pesticides. Rainfall is extremely variable in amount and distribution, making rainfed agriculture risky and thus preventing farmers from investing in inputs that enhance productivity.

A rural pilot development intervention meant to alleviate poverty targeting 100,000 small scale farmers in all states of Sudan. The trend is to move from erosion control, to soil quality conservation. Using *Moringa* and *Jatropha* trees as 'fertiliser trees' that capture nitrogen from the air and transfer it to the soil, the need for commercial nitrogen fertilisers can be reduced by 75% while doubling crop yield. The *Moringa/ Jatropha* agroforestry has proven to be a successful model to address the challenges of alleviating poverty, securing livelihoods and economically empowering women, in a successful partnership with local communities, academics, private sectors and national financial institutions. The pilot project utilised an area of 3 feddans (1 feddan = 0.42 ha) in Khartoum North, 5 km North of the capital City of Khartoum with the aim to be replicate the results in all states of Sudan utilising micro finance investments.

The area is enough to be managed by one family and would fulfil the needs of cereal and vegetable consumption. *Moringa* trees are planted along side ridges of the watering canals where vegetables and main cereal crop are planted, while *Jatropha* is used as a life fence. *Moringa* is a multipurpose tree known for nitrogen fixing, grows best in dry sandy soil and is drought resistant; it provides shade, nutritious food, medicine and oil for cooking and other products, and can even purify and clarify water. The leaves are harvested to be sold as green tea and the stripped branches as animal fodder together with seed pods. The seeds are also sold to private sector, or crushed and sold as oil used for cooking and the cakes as animal feed. The model also includes provision of livestock and continuous supply of water. Jatrofa is used as biodiesel, lighting and soap making. Implementation in rural areas will target groups of ten families on 30 feddans where a well will be drilled and shared by the families who are asked to be organised in a farmer association. The project is linked with the Central Bank microfinance in support of the intervention.

Keywords: Agroforestry, carbon sequestrations, poverty alleviation, rural development, small-scale farmers

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Income Alternatives of Smallholders at the Itaparica Reservoir in NE-Brazil

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Irrigation farming is seen as a suitable tool to promote rural development in the semi-arid Northeast region of Brazil. Especially in the last two decades, federal and state-owned authorities established several irrigation projects along the lower-middle São Francisco River to provide local smallholders the opportunity to generate income and consequently, reduce rural exodus. Due to lack of infrastructure and scarcity of irrigable areas, income derived from agricultural activities is, in many cases, still not sufficient to provide the livelihood for smallholders. Thus, they depend on income alternatives outside irrigation farming.

This study identifies and evaluates income alternatives of smallholders in the Apolônio Sales and Icó-Mandantes irrigation projects in the municipality Petrolândia, Pernambuco. It also weighs the alternatives' importance from an economic perspective as well as by the farmers' perspective. Furthermore, potential innovative income alternatives are assessed concerning their economic viability, social acceptance, and practicability. A special interest lies upon Umbu production, the fruit of the endemic xerophytic tree Spondia tuberosa Arruda, on drylands to reduce the pressure on irrigated areas and contribute to a more sustainable land use.

A random sample of 50 farmers were interviewed - 20 interviews were conducted in the rather prosperous community of Apolônio Sales and 30 in Icó-Mandantes. Although being planned and constructed at the same time, the communities differ in many aspects, such as farm size, farmers' networks, education, capital availability, infrastructure, and social and political influence. Additionally, ten experts were interviewed to gain an overview of the socio-economic situation of the smallholders and to analyse other potential income sources. Although most smallholders still consider themselves as farmers and mentioned crop production as their most important income source, only two of the interviewed smallholders gain their living solely with farm income. Especially in Icó-Mandantes, most households relied strongly on non-agricultural income – mainly social benefits and off-farm work of family members. Three promising income alternatives were identified. Umbu production, beekeeping, and fishery may, despite existing limitations, have the potential to improve the middle or long term income situation of the smallholders and help to reduce the pressure on the irrigable land.

Keywords: Alternative land use, income alternatives, irrigated agriculture, Northeast Brazil

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Agricultural Crises and Migration in Rural Areas of Senegal

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The debate on the relationship between environmental degradation, resulting crises in agriculture and migration is gaining relevance. While some have argued that climatic change and deteriorating ecosystems will produce a large number of environmentally motivated migrants, it has frequently been overlooked that, far from being an exception, mobile strategies are and have for a long time been present in the region, as a way to assure food security in the context of a precarious environmental equilibrium. This paper addresses the issue of how agriculture and mobility are combined in contexts of vulnerability, while dedicating special attention to the relationship between agricultural crises and migration in rural areas of Senegal.

Basing on a multi-sited fieldwork in four villages in Senegal and in two migration destinations in Italy and Spain, this paper argues that both agriculture and mobility are part of a system of collective translocal livelihood strategies.

Through remittances, contacts with external actors and transfers of know-how, migrants not only ensure local food security, but also provide direct and indirect support for further activities, such as agriculture. Thus migration is not a way to escape from the home region, but a contribution to local income strategies, a way to permit further family and community members to remain in the village.

Agriculture concurrently maintains a primary role: it guarantees the covering of basic living expenses and ensures alternatives to returning migrants, such as those reentering from migration destinations affected by economic downturns.

In conclusion, this paper argues that migration and agriculture need to be addressed simultaneously, as part of broader and translocal collective strategies.

Keywords: Agriculture, livelihood strategies, migration, mobility, Senegal, translocal

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Analysis of the Rural Development Strategies Based on Ecotourism in Arid Areas (Case Study: Yazd Province, Iran)

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Tourism industry has an important effect on international economy, nowadays. Ecotourism, as one of the most important branches of tourism industry, has great effects on increasing income, job opportunities, and welfare level of native societies. Growth and development of ecotourism in recent years shows that it can be the dominant industry for future decades. Ecotourism is a suitable tool to provide sustainable development in various parts of the world. It can be a proper approach to develop the rural regions of countries. Economic and livelihood improvements of rural regions are achievable by doing particular and scientific researches on ecotourism in near future. Iran has various natural resources, ancient, historical, religious, and artistic attractions. So, in the field of ecotourism, it can be one of the most powerful countries in the Middle East region. One of the most important natural attractions of Iran is the arid area. Therefore, ecotourism management in arid areas is important to improve the native rural population profits. This paper analysed the ecotourism of Yazd province, as one of Iran arid regions, by using SWOT model and QSPM (Quantitative Strategic Planning Matrix). Capabilities, opportunities, and infirmities of this area were surveyed. The results show that appropriate strategies to develop ecotourism in Yazd province include: supporting the private sector investors by providing low-interest loans; establishing expert non-governmental organisations (NGOs); training the native rural population in field of ecotourism industry principals; providing tax deductibility for ecotourism investors; developing the ecotourism infra structures in rural areas; and advertising the attractions of arid areas. It is expected that applying these strategies lead to improve the welfare level of native rural residents of arid areas such as Yazd region.

Keywords: Arid Areas, ecotourism, QSPM, rural development, strategic planning, SWOT model

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Socio-Economic and Environmental Vulnerability in Rural Area: The Case of Eskisehir-Keskin/Turkey

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Vulnerability has been defined as "a human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard" (UNDP, 2004). There are many factors affecting vulnerability. These factors act to undermine the capacity to sustain the livelihood and the production in rural areas. Poverty, poor health, low levels of education, gender inequality, lack of access to knowledge and technological means are the factors which influence social vulnerability. For example, economic vulnerability concerns national economy, prices of commodities and inputs, production and consumption patterns. Environmental vulnerability is related with land degradation, water scarcity, deforestation, etc. The main aim of this presentation is to discuss social-economic and environmental vulnerability of the households for their livelihood and food production in rural areas of Eskisehir province. This discussion depends on the data which were collected through field research held among 75 households in Keskin-Eskisehir/Turkey. Quantitative and qualitative methods are utilised for data collection. The results indicate that the socio-economic structures of the households who make their living from agriculture and stock breeding are highly affected by the risk of desertification which limits both sustainable livelihood and food production. Possible solutions for an enhanced food security will be discussed. This discussion takes into considerations sociological dimensions of enhanced food security. In order to reduce the food insecurity, both micro and macro socio-economic dimensions have to be taken into consideration, such as market conditions, households conditions and gender dimension of production.

Keywords: Desertification, food security, livelihood, socio- economic vulnerability, Turkey

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Measuring Income Dynamics and Poverty Traps Using Multidimensional Poverty Measures

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Existing theories about income dynamics of poor and vulnerable households are increasingly being called into question. Neoliberal growth theory cannot adequately explain why income gaps among the poor and the non-poor (be it households on a micro level or entire countries on a macro level) are increasing. Inequalities have also been on the rise not only within societies of developing countries but also in the OECD world, suggesting the existence of multiple equilibria in the process of economic growth and poverty traps: a self-sustaining cycle of poverty keeping households and potentially entire societies from growth.

In terms of empirical evidence, results have been mixed. The majority of studies do find evidence for the existence of poverty traps; however, some do not. The reasons may be the varying empirical prevalence of poverty trap-like situations across different areas of life, suggesting that, for example, nutritional poverty traps are more significant than education-based poverty traps. However, different study specifications and poverty measurements might also account for the non-converging discourse about poverty traps. More traditional consumption and expenditure based poverty measures do not incorporate aspects of health, education, etc. that would be required to assess the more deeply embedded and long term effects of poverty. The Multidimensional Poverty Index (MPI) appears as a viable alternative but systematic studies within the poverty trap debate have been lacking.

The objective of this paper is to contribute to the above stated discourse by testing the observable implications of the poverty traps theory on an existing multidimensional, socioeconomic household panel data set, the Ethiopian Rural Household Surveys 1989–2009 and thereby adding to the existing empirical base of said debate. Traditional consumption based poverty indicators will also be included as controls so that comparisons between uni- and multidimensional poverty measures will be made.

Keywords: Ethiopia, multi-dimensional poverty, poverty measures, poverty traps

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Effects of Land Redistribution on Land Entitlement and Use in Limpopo Province, RSA

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Four models of the South African land redistribution programme were distinguishable i.e. model A (SLAG: 1995 – 2000), model B (LRAD1: 2001 – 2007), model C (LRAD2: 2008 – 2010) and model D (PLAS: 2006 to 2012). The models differed in emphasis given to social and economic objectives of land reform, which was influenced by the national needs at the time of model conceptualisation and implementation. The earlier model, SLAG, was social oriented while the later models had economic viability as the main objective. This study investigated the socio-economic outcomes during the evolution of the land redistribution programme. Sixty farms that represented evolution models of the land redistribution programme were selected. Socio-economic data were collected from farm representatives by means of semi-structured questionnaires. Additional data were collected from stakeholders through key-informants interviews. In time, land redistribution had decreasing social contributions: There were 57 households benefitting per farm on average during model A with level of participation in land administration and/or use at 20 % and the beneficiary numbers decreased with time to an average of 3 individuals in model D with levels of participation at 100 %. The proportional land usage per farm improved from 60 % under model A to 100 % under model D. The type of land being reformed and planned agricultural sector developments of the area contributed to variations in land use. The evolution affected beneficiary numbers negatively and participation levels positively, confirming the shift from social to economic objective. Other factors had more influence on land use than the evolution of the redistribution programme.

Keywords: Beneficiaries, evolution, land redistribution, land use, Limpopo Province, model

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Knowledge and innovation systems and processes

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Innovation systems and networks

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Looking at Food Security from an Innovation Systems Perspective: First Empirical Insights from Tanzania

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Food security is a prevailing challenge; that is additionally intensified by the impacts of climate change or the increasing limitation of natural resources. Finding innovative solutions which address this challenge is a key concern of Trans-SEC. Within this context, this contribution aims in a first step to explore conditions for food security innovations in Tanzania. We argue that an innovation system framework is appropriate to study those conditions and processes, because it acknowledges the complex nature of innovation processes. This is taken up in innovation systems literature which states that innovations, also in a majority world context, are a result of multilevel- and actor-interactions.

We used the heuristic concept of innovation system research as an analytical framework to assist our understanding of food security conditions and its specific characteristics in Tanzania. The approach enables us to look at innovation in a systemic way; revealing cross-references between system elements and system levels. Furthermore, pinpointing main obstacles, but also factors promoting food security innovations is a major outcome.

The research was conducted using a mixed-method approach. Secondary literature was analysed on a national and regional level, allowing for general system-information and developing an empirical research strategy. Semi-structured expert interviews on national and regional level (with experts from extension, research, farmer associations, NGOs) were conducted. On a village level group discussions with farmer groups were carried out in order to understand how innovation processes take place in practice.

Preliminary results from interviews and group discussions revealed that 1) there is a perceived "gap" between regional and village level, with communication regarding FS innovations between these levels being disturbed. 2) Government and non-government actions need better cross level coordination to have a sustainable impact. Interviewees therefore strongly highlighted 3) a need for institutional innovations besides technical ones that improve communication across governance levels and 4) raised as a problem, that research was mainly donor and not demand driven, which was perceived as a main obstacle by farmers.

Keywords: Innovation conditions, innovation systems, mixed-methods

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Farmers Innovations in Livestock Production Systems in Pernambuco, Brazil

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The Northeast of Brazil is considered the poorest region of the country. The semi-arid Itaparica region in Pernambuco is characterised by irregular precipitations and a long dry season with frequent droughts that lead to crop and livestock losses and livelihood insecurity. Farmer innovations have the potential to promote local development and to improve farm productivity. The objectives of this study were to assess innovations adopted by livestock farmers of the Itaparica region - to reveal their constraints, benefits and potential for further adoption as well as reasons for non-adoption. Semi-structured interviews were applied to 33 innovators and non-adopters in the region - selected based on their active participation in farmer groups. The following farmer innovations were selected: breeding strategies, cultivation of forages, hay and silage production, use of manure and fertirrigation (application of fertiliser into an irrigation system), pasture rotation and alternative methods to control worms. Results indicated that adopters observed mainly benefits such as the improvement of soil fertility due to manure use, increase of feed availability due to forage cultivation and conservation, enhancement of animal health due to use of plant remedies and higher financial returns due to genetic improvement of the herd. Constraints observed by adopters were high implementation costs of fertiirrigation, silage production and genetic improvement, as well as risk of crop losses due to drought and high spoilage losses with silage. Non-adopters were limited to adopt the innovations mainly by the lack of knowledge and land, water shortage, poor financial conditions, and by their farm management systems. The use of raw manure for soil improvement, cultivation of forages, alternative methods to control worms and pasture rotation were considered to have the highest potential for further adoption due to their perceived low complexities, low risks, comparative advantages and replicability at small scale. Fertirrigation, breeding strategies and hay and silage making were found suitable for farmers of semi-intensive production systems. Future adoption is dependent on farmers' motivation and perception of usefullness, efficient extension services, and on resources availability. Effective participatory methods and approaches are recommended to increase awareness, demonstrate benefits and promote learning about promising innovations.

Keywords: Innovation, Itaparica region, livestock production, Pernambuco

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Agricultural Extension Reforms in Ethiopia: What Works and What Does Not Work Well?

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With the aim to improve the income and food security of farmers, the government of Ethiopia has carried out successive agricultural reforms. Following the introduction of the Agricultural Development Lead Industrialisation programme in 1993, major organisational, management and institutional changes have been introduced to the agricultural extension system. This paper analyses the outcomes of the reform initiatives by taking the extension system in Amhara region as an example. In particular, the study assesses the effects of the demand and supply side reforms on service users and providers and on the ultimate extension outcomes (qualities and impact). The main objectives of the study were to: (1) understand what works and what does not work well in the public agricultural extension system; (2) identify knowledge gaps; and (3) employ new analytical tools for the empirical analysis of extension services.
Although there were various studies on the agricultural reforms in Ethiopia, most of these studies are subject to a range of problems including methodological, scope and identification. This paper attempted for the first time to show what works and what does not work well by employing qualitative and quantitative performance evaluation methods. More importantly, the main contribution of this paper is that it quantified the components of the extension reform programs in Ethiopia.
Based on our results, some of the reform programs do not "best fit" into the current extension challenges, and service providers also lack the soft skills, incentives and resources to do their job in the best way possible. These have affected the work motivation and job performances of service providers. Moreover, the planning, monitoring and evaluation system was not effective in assessing from time to time what has been achieved at the farmers' training centres and what remains to be done in the future. Similarly, the partnership and linkages between the different actors was not strong and key actors such as the private sector and universities, research institutes and NGOs were either totally missing or partially available. The policy implication is then: the private sector and NGOs should be encouraged to participate in some of the private nature extension services.

Keywords: Advisory methods, agricultural extension, capacity, farmers voice, governance, impact, management, service quality

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Innovation Platforms at Work: Supporting the Transition to Agroecological Farming in Nicaragua

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How can processes of innovation towards sustainable intensification, particularly among smallholders, best be supported? Farmer-led experimentation and innovation processes are central to increasing food security among smallholders worldwide, especially in the knowledge-intensive realms of sustainable intensification and agroecological farming. Research and development streams have recognised that successful innovation is a co-evolutionary process, in which technological change occurs with related social and institutional change. Territorial Innovation platforms (IPs), consisting of key actors in a territory (eg. farmers' organisations, cooperatives, government institutions, NGOs) have increasingly focused on brokering interactions among actors in the agricultural innovation system (AIS). The 'mixed crop-livestock-tree' IP in Estelí, Nicaragua is an example of such an IP. One goal of the IP is to bring together organisations that work with local smallholders on sustainably intensifying their production systems through agroecological methods. To provide empirical evidence of how such an intervention progresses, this study used quantitative and qualitative methods to explore the composition and activities of the 'mixed crop-livestock-tree' IP, investigating how it performs its functions based on Kilelu et al.'s work on brokering innovation processes. This highlights the importance of brokerage between different AIS actors in co-evolutionary innovation processes, without losing sight of the central importance of smallholders' needs. An analysis of the sub-functions associated with each function demonstrates that the IP has succeeded well in filling the functions network brokerage, innovation process management, and demand articulation. The functions institutional support, capacity building, and knowledge brokering are weakly executed. The scaling up of agroecological practices could be better supported by strengthening the execution of the latter functions, and through a concerted alignment of all functions. Results emphasise that to support the co-evolutionary scaling of innovations, IP functions should be synergistic. This study underscores the importance of functional analyses to highlight obstructions to IPs' satisfying their full potential as brokers in innovation processes.

Keywords: Adoption, agroecology, co-evolutionary innovation, functional analysis, knowledge brokerage

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Social Network Analysis as Tool to Support the Design and Implementation Process of Payment for Ecosystem Services: The Example of Net-Map

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Payment for ecosystem services (PES) can be an approach to combine pro-poor and environmental instruments for natural resource management. Therefore they serve not only for the protection of tropical forests and wetlands, but also for the improvement of social conditions and rural development. However, the design and implementation of PES implies several challenges. Factors like formal institutional components are important, but also the capability to establish a social context conducive to the payment scheme, considering local behaviours and attitudes towards conservation. In consequence, one of the most important factors to be considered when pursuing a successful process is the role played by local stakeholders and their level of commitment. In this paper we investigate how to foster an PES development process and the motivation of the participants supported by social learning. We show how the Net-Map tool, an interview-based mapping tool that helps people understand, visualise, discuss, and improve situations in which many different actors influence outcomes, can serve not only as a tool to assess the stakeholders' relations and their part in the implementation of the PES but also as an instrument for social learning. The tool can be used in three different stages of implementation: fully implemented PES scheme, planned but not yet implemented PES scheme, development of a PES scheme. Based on Net-Map interviews and the analysis of three workshops that took place in Costa Rica on March 2014, we discuss the results for three different case studies: Golf Dulce, Tíerraba Sierpe and Coyolito and conclude about the importance of the tools which lies in the construction of a common sense of the PES-structure, the creation of ownership and the consolidation of transparency and trust amongst the participants as well as the reflection about the existing social capital to be necessary for the implementation.

Keywords: Environmental planning, Net-Map tool, participatory research, payments for ecosystem services, social network analysis, transdisciplinary research

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Ecosystem Services in Southwest China: Local Stakeholders' Priorities

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Land management can only be sustainable if the needs and interests of various stakeholder groups are incorporated in land use planning. As direct participation in such planning is often limited, there is an urgent need for more transparency of other stakeholders' priorities amongst decision-makers. In a biodiversity hotspot such as Xishuangbanna, Southwest China, where strong economic forces favour cash crop monocultures such as banana and rubber with the consequence of heavy degradation, knowledge about stakeholders' perception and valuation of (non-economic) ecosystem services (ESS) is of utmost importance.

This raises methodological questions, particularly in a situation where decision and power structures are nontransparent and cleartop-down-hierarchies in practice are overlaid by highly informal decision structures which are based on personal relations, such as in China.

The SURUMER project, aiming at the development and at least partial implementation of sustainable rubber cultivation strategies, has carried out sociological studies on these issues. The main research questions in this context are:

- What are local stakeholders' priorities of ESS?
- How to identify and value these?
- And how to communicate the findings with decision-makers?

This paper discusses the methods which have been developed for the specific context, preliminary results as well as consequences for future research.

In general, the approach is a triangulation: Qualitative information has been acquired amongst two main groups of actors (village heads and regional bureaus) during informal talks, semi-structured in-depth interviews, meetings and workshops. Quantitative data has been collected in a ranking exercise. The ladder has been adapted stepwise: As a pure list has brought only vague results and problems with ranking such abstract issues came up, later on the ESS have been visualised more clearly and participants were asked to value the importance of each ESS.

The results show that data collected from various sources not only provides an integrated view of the future land-use scenarios, but also increase the credibility of information by means of triangulation. For further analysis it is seen as very important to know and explain the differences between the various local stakeholder groups.

Keywords: China, ecosystem services, priority, stakeholder, sustainable land-use

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Assessment of the Demand Supply Match for Agricultural Innovations in Africa

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This report presents the findings of an independent assessment of the matches for demand for innovations by African farmers and supply of innovations produced by international agricultural research in Africa with focus on food security and climate change adaptation. This was done by collecting quantitative and qualitative information in 17 African countries from 152 farmer organisations, 141 intermediaries, and 91 scientists and 24 representatives of International Agricultural Research stations. The findings were presented and discussed during three regional African workshops and two international workshops in Feldafing and Nairobi.

It was found that the research output of internal research centres is very broad. The direct match with the farmer needs showed a varied picture. While some outputs are highly adapted and also affordable to smallholder farmers, a good proportion of research outputs require higher investments and thus would require credit of additional subsidies by Government or NGOs to promote these innovations on a larger scale. While many innovations promote high yield solutions, farms favour medium low to medium input solutions and demand more solutions to address marketing problems.

A central problem is that most innovations are currently not readily available in the market and they can only be accessed via selected NARS/NAES or the international centres. Among the 109 innovations reviewed closely, 16 were selected as very good matches. This included among others several adapted OPV seed varieties of millet, seed testing and distribution via crowd sourcing, agroforestry systems in evergreen agriculture and micro dosing of fertiliser.

The analysis of collaboration between the various actors in innovation development and diffusion showed that in particular the extension and diffusion function is underdeveloped.

The study was commissioned by GIZ-ITAACC project with a view to promote collaboration between all stakeholders involved in innovation development in Africa. The combination of data collection through interviews and validation at workshops enabled considerable level of learning and interaction among a broad range of stakeholders.

Keywords: Agricultural innovations, extension, farmer needs, food security, innovation platforms, innovation transfer into agriculture-adaptation to climate change (ITAACC), perception, research, up-scaling

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Traditional Use of Medicinal Plants among Local Healers in Bié Province, Angola

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The redistribution of the population during the Angolan civil war forced people to settle in large numbers in small areas, which has resulted in accelerated degradation of vegetation and soil. Families in Bié province are considered the most vulnerable in terms of food security and health. In Angola, the indigenous medicinal plant knowledge has not been systematically studied to date. Our study documented and analysed indigenous knowledge of 10 traditional healers in two localities in Bié province in Angola through participatory observation, semi-structured interviews, transect walks and calculation of following quantitative ethnobotanical indices: the relative frequency of citations, informant consensus factor, informant agreement ratio, fidelity level, cultural value index and Sørensen similarity index. Gender was presented equally among the herbalists (50 % male, 50 % female). Medicinal plant use reports were mostly distributed among the group of gastro-intestinal disorders (84 use reports), and pregnancy/birth/puerperium disorders (49 use reports). A total of 56 plant species distributed among 54 genera and 30 botanical families have been documented. The most represented botanical families encountered were Fabaceae (16 species), Apocynaceae, Asteraceae, Rubiaceae and Euphorbiaceae (4 species). The study has revealed 12 plant species not previously documented for the medicinal use, several of them with considerable local cultural importance: *Scleria induta*, *Vernonia britteniana*, *Oxygonum pachybasis*, *Droogmansia dorae*, *Brachystegia gossweileri* and *Aeschynomene dimidiate* or *Searsia squalida*. The plants with the highest cultural value in our study are commonly used in surrounding countries and Africa: *Securidaca longipedunculata*, *Garcinia huillensis*, *Annona stenophylla*, *Afzelia quanzensis*, *Strychnos cocculoides* or *Eriosema affine*. Trees (34 %) and shrubs (37 %) were the prevailing plant life forms used in the traditional medicine of Bié province. Roots were the plant parts mostly used (70 %) in traditional medicine and collection from the wilderness was extremely prevailing in Bié province in Angola. Therefore, risk of loss of plant resources is increased in the area, also because of common land clearing processes. The study has documented a diverse system of traditional plant knowledge which urges for continuous research in Angola as well as for further pharmacological studies to validate the use of selected medicinal species.

Keywords: Angola, Bié province, Chokwe, medicinal plants, quantitative ethnobotany, traditional healers, Umbundu

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Community-Led Innovations for Sustainable Land Use. Lessons from the Association of Indigenous and Peasant Producers of Riosucio (ASPROINCA) in Colombia

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Despite a long history of sustainable land use approaches in Colombia, a significant dissemination and impact however fail to appear until today. Possible reasons are lack of technical know-how, conceptual failures, economic difficulties and pending operational methodologies. To investigate possible successful implementation and management frameworks, a field research in Colombia focuses community-led initiatives that demonstrate success in implementation and promotion of sustainable land use innovations at small-scale level. With an existence of nearly 20 years, the Association of Indigenous and Peasant Producers of Riosucio (ASPROINCA) draws one example of such a successful community-led initiative that implements domestic biogas plants as one innovation out of their integrative approach towards sustainable land use. The field research analyses how the community-led process was configured and which factors and mechanisms more likely contributed to achieve success. Within the association's socio-economic cover and institutional margin, success factors in social, economic, environmental, legal, educational and technological dimensions are identified and explored. Furthermore especially the role of so-called 'promoters' is analysed: Which factors do characterise a promoter and what is its central aim? How does the promoters programme contribute to the general development of ASPROINCA and which lessons can be applied to other cases? Through expert interviews and surveys in the field, according data is generated and offers an in depth analysis of the case in terms of success and the promoters program. On the one hand, it can be identified that mutual learning between farmers and promoters fosters trust and team spirit and reflects a basic condition for the initiatives success. On the other hand, the rotary fund plays a central role and allows the practical implementation of sustainable land use innovations. Hence, the field research reflects a multi-dimensional and transdisciplinary study that fosters further development of sustainable land use practices in Colombia.

Keywords: Asproinca, biogas, community-led, innovation, promoter, success

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A Net-Map Insight into the Veterinary Service Delivery in Kenya

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Liberalisation of both clinical and artificial insemination services allowed many actors into the livestock service sector in Kenya. The actors include privately practicing veterinary service providers and non-formally trained service providers who have been operating alongside government service providers especially paraprofessionals. These actors operate in the same field, offering services to the same client "the farmer". However, the levels of interactions and the types of interactions amongst them have not been explored. This study aims to contribute to this knowledge gap by identifying the key actors and institutional arrangements for the livestock service sector in medium potential areas of Kenya and the types of interactions among them. Socio-economic data was collected through a household survey of 128 households using a two-stage cluster sampling technique and 30 purposively selected service providers. The Net-Map tool was used to map out the key actors and their interactions in the course of service delivery to farmers. Descriptive statistics revealed that 59 % of all cases were attended by animal health assistants who are the main service providers, with private animal health assistants attending to 38 % of all the cases. The Net-Map analysis revealed the significant role played by the privately practicing animal health assistants and the reporting and referral, which are regulatory mechanisms that have evolved to be in place post liberalisation period. The delivery of some services by non-formally trained paraprofessionals calls for stronger regulatory mechanisms to weed out any form of malpractice to unsuspecting farmers and enhance the level of professionalism in the industry.

Keywords: Animal health, Kenya, liberalisation, net-map insight, smallholder dairy

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Potential Farm to Landscape Level Impact and Adoption of Forage Technologies in Smallholder Dairy Production Systems in Tanga, Tanzania

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Crop-livestock systems in sub-Saharan Africa are complex and heterogeneous with varied production objectives. The lack of sufficient quantity and quality of livestock feed on a consistent basis is often cited as major constraint faced by dairy farmers in the East African region, especially during the dry season. Improved livestock feeding and forages have been shown to contribute to increased livestock productivity while potentially mitigating and adapting to climate change – thus providing an opportunity for sustainable intensification of crop-livestock systems. However, forage technologies will only be adopted to sustainably improve farmer livelihoods, if they contribute to whole farm performance, balancing tradeoffs between multiple impact dimensions including productivity, socio-economics and environment. Adoption and *ex-ante* impact studies can provide information to assist in prioritising and targeting of development investments. This contribution highlights a newly received GIZ small grant which aims at improving livelihoods of smallholder dairy farmers in Tanga region in Tanzania through i) analysing feed gaps of different livestock production systems and identifying bottlenecks and entry points; ii) assessing potential impact of and tradeoffs of forage technologies at farm to landscape scale; iii) exploring adoption potential of these technologies; and iv) raising awareness among stakeholders to improve prioritisation of interventions. Methods include feed assessment and nutritional analysis; forage on-farm trials and agronomic measurements; training farmers and extension officers in establishment, maintenance and utilisation of improved forages; forage crop modelling (CropSyst), multi-objective modelling to explore tradeoffs and synergies at farm and landscape levels (FarmDESIGN and LandscapeIMAGES); participatory expert-based assessment for adoption constraints (QAToCA). The project is well-positioned to put the research outputs into practice through its embededness in the CGIAR Research Program on Livestock & Fish (http://livestockfish.cgiar.org). Stakeholders along the dairy value chain in Tanzania are engaged in Innovation Platforms at village, regional (Tanga Dairy Platform) and national (Dairy Development Forum) levels. These platforms have identified year-round availability of quality feeds among the main bottlenecks for smallholder dairy production. Results from this research project will feed into these platforms, also providing follow-up support in evidence-based decision.

Keywords: Adoption constraints, forage technologies, livelihoods, livestock systems, tradeoff analysis

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Development of a Community-Based Dissemination Scheme for Improved Cowpea Varieties

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Cowpea, a legume originating from Africa has superior heat and drought tolerance and a high nutritional value. It is an important crop for food security, livelihood improvement and cash income of farmers in semi-arid sub-Saharan Africa. However, the local varieties used by small-scale farmers have low yields, and a weak seed sector and extension services contribute to a slow dissemination of suitable varieties and modern cultivation techniques. The new scheme, "Accelerated dissemination system of improved cowpea Varieties via Empowered Communities in Burkina Faso" called "AVEC-BF", was developed to overcome these difficulties. The scheme consists of three components: (1) Establishment of community seed producers (CSP) providing certified cowpea seed. (2) Conducting farmer participatory varietal selection (FPVS) to capture farmer's requirements. (3) Organisating farmers' schools (FS) to introduce improved management practices. By linking these major components within the same village, suitable cowpea varieties selected by farmers and produced by community seed producers will be disseminated among farmers with improved cultivation skills. FPVS activities were conducted with 910 farmers (286 women) in target villages of Burkina Faso in 2010 and 2011. A total of 17 farmer groups received training to establish community-based seed production systems. Approximately 100 ha were newly cultivated for improved cowpea seed production by CSPs, resulting in 46.8 t of certified seeds over 3 years. A total of 1,177 farmers joined FSs focused on improving cowpea cultivation techniques and increasing knowledge of the new varieties. As a result, a total of 2,949 farmers and groups purchased improved cowpea seeds that were recommended by farmers themselves, tripling of the number of people reached by the project. In addition, the expansion of sustained cowpea production promoted improvement of income for farmers and the reclamation of abandoned land in semi-arid region was detected by economic assessment.

Keywords: Cowpea; dissemination scheme; seed production; small-scale farmer

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Rice Farmers Perception on Soil Quality Indicators and Fertility Management in the Volta Region of Ghana: Reconciliation with Scientific Evidence

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It is increasingly understood that for development purposes, local soil knowledge often forms a much better starting point for communication than scientific soil classifications. The Volta region of Ghana is the country's third largest producer of rice, producing about 83,936 MT per annum which is about 17 % of total national production. The government of Ghana has also identified rice as a priority crop in the region for poverty reduction and ensuring food security, thus has formulated policies to boost production. However, rice production which is relatively high in the region and its threat to soil quality, as well as farmers' perception on soil fertility and its management is still not fully exploited. This study will attempt to explore and identify the most important attributes/indicators known and used by farmers in the classification of their soils and how they perceive their soils in relation to these indicators. It will also try to investigate how farmers' perceptions match with scientific measurements and identify common linkages between farmers and stakeholders (i.e. Government, Scientist, development partners) on the management of their soils. The study will employ participatory rural appraisal (PRA) tools such as net mapping, transect walks, and focused group discussion to collect data from rice farmers in the Volta region of Ghana. The study will employ pair wise ranking method to identify the most important soil indicators used by farmers in their field management, Kendall's Concordance test of agreement in the ranks, descriptive statistics to explain farmers level of understanding of the nature of their soils, and finally laboratory soil analyses to examine in how scientific measurements meets with farmers view. Expected results at the end of study would be the production of a mapping matrix on flow of information on soil fertility management between farmers and stakeholders, and concrete suggestions for the development of training manual merging local knowledge of soil quality indicators and fertility management with scientific evidence.

Keywords: Ghana, local knowledge, scientific knowledge, soil fertility, soil indicators, Volta region

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Participatory Soils Mapping in a Semi-Humid Agricultural Landscape in Tanzania

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Smallholder agricultural production systems in Tanzania are faced by increasing degradation of soil resources. Proper management of soils is recognised as a significant pathway to secure food supply levels. Understanding the distribution, potential and constraints of soils within these systems is an important aspect for adaption of innovative soil management options for sustainable food production. Participatory approaches which build on indigenous knowledge of the local farmers have been fronted as the key entry point to ensure the sustainability of innovative technologies. A study was undertaken to establish the indigenous soil knowledge of smallholder farmers in a semi-humid village of Ilakala, Tanzania covering an area of 44 km^2. Focus group discussions were held with seven selected smallholder farmer groups of 7 to 10 people to map the soil resources within the village. Farmers were also asked to identify the indigenous soil types, their major soil constraints, and the key attributes used to distinguish the soil types. A 1:45,000-scale google earth image printed on an A0-paper was used as a visual aid to facilitate the delineations of indigenous soil units. Transects were performed to verify the delineated indigenous soil map units. Representative soil profile pits were established on each indigenous soil map unit. Soil samples were collected from observed horizons in each profile pit for laboratory analysis for scientific correlation of the indigenous soil types. Five indigenous soil types were identified; Kichanga, Tifu-tifu, Mfinyanzi, Wakitope-Mweusi, and Ngunja. The key attributes for distinguishing indigenous soil types were; soil colour, moisture retention, topography, and workability. Poor soil fertility status was established as the key limiting factor for crop production. Tifu-tifu was identified as the most suitable soil type for crop growth and the Kichanga as the least suitable for crop growth. Smallholder farmers are endowed with knowledge of the soil resources within their locality and are aware of suitable management options for increasing their productivity. Therefore, their inclusion in the development process is key to introducing of new innovations to enhance land productivity.

Keywords: Food production, indigenous soil knowledge, smallholder farmers, soil management

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Electronic Smart Subsidies in Agriculture for Food Security in Tanzania

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One of the constraints facing agriculture in Tanzania is low land productivity caused by declining soil fertility, inadequate fertiliser application and use of traditional seeds. In 2003/04, the Government introduced the fertiliser subsidy system, spending a total of TSh 2 billion to purchase 39,387 metric tons of fertilisers. Since then Government investment into input subsidies under the voucher system has increased to TSh 60 billion in 2008/9 and reached TSh 149 billion in 2010/11. However, since the programme started it has been characterised by elite capture and other challenges making it hard for inputs to reach intended beneficiaries in the right amount. Sokoine University of Agriculture designed a research project to explore this problem and recommend an innovative alternative input distribution model. In this model that leverages on ICT, the cash component of the product value is put directly in the hands of the farmers via mobile phones. The advantage of this system is that inputs reach intended beneficiaries in the correct amount and at the right time; aggregate agricultural production will likely increase because growers will have access to adequate inputs; promotion of agro-dealer network in the area; lending to the sector will be derisked as banks will be certain on loan recovery; creation of employment as input redemption centres; billions of money that are currently fraudulently lost will be saved. Ultimately, productivity would increase and food security would be ensured. The success factors of this system include proper registration of target farmers, a strong monitoring and evaluation (M&E) mechanism to ensure that everything is executed as planned and new challenges are addressed, high commitment on the part of top government officials, and the system must be private sector-farmer driven with government playing a supportive role.

Keywords: Agricultural inputs, food security, mobile phones, productivity, smart subsidy

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Use of E-Readers for Improving Agricultural Extension Service Delivery in Ethiopia

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Agriculture is a major sector in the Ethiopian economy. The Growth and Transformation Plan (GTP) puts it as the government strategy to double yields of smallholder producers and achieve a status of middle income country by 2025. For increased effectiveness and efficiency of the intended impact, innovative and cost effective approaches to agricultural extension are mandatory. One way of realising this is bringing the information and communication technology (ICT) tools and means into the extension delivery system and approach. One such tool is electronic readers (e-readers) or e-book readers. The use of e-readers have become widespread in the developed parts of the world and some developing countries. E-reader is a mobile electronic device that is designed primarily for the purpose of reading digital e-books and other publications. The advantage of an e-reader is that it could hold the digital equivalent of many printed books without added mass or bulk making it portable. This paper assesses the potential of electronic readers (E-readers) in contributing to increasing the effectiveness of agricultural extension service delivery in Ethiopia by availing easier access to reading materials and references. The paper assess the attitude of respondents towards using e-readers to refer or read agricultural documents in order to support their extension service delivery and the extent of the use of the device by extension service providers at regional, zonal and district levels. We argue that even though the device has a potential to serve as an alternative means for easier access to information and knowledge, there are other equally important technical, social and institutional factors that need to be considered to use e-readers as tools for extension service delivery.

Keywords: Agricultural extension service, development experts, E-reader, Ethiopia

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Local People's Knowledge about Land Use Activities in the Mahafaly Plateau Region, Southwest Madagascar

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The aim of the presented research is to identify local people's knowledge about land use activities that exists in the Mahafaly plateau region, southwest Madagascar. The purpose is to present current knowledge systems in order to depict possible links between scientific and local (traditional) knowledge on land use practices. Local people in Madagascar are people who live in rural areas of the country. These rural areas are remote and often marginalised, i.e. without sanitation and access to electricity. In the southwest of Madagascar food insecurity is prevalent in times of rain shortfall next to limited water availability. Due to these pressures natural resources become increasingly degraded. People are largely dependent on natural resources in their vicinity and mainly constitute their livelihoods from subsistence agriculture. This and other activities determine their daily life and form people's environmental perception and knowledge. To allow for a concise picture of complex structures a qualitative social science approach is chosen. Analysis focuses on 90 interviews conducted in 2011, 2012 and 2015 with local people living in the Mahafaly plateau region. The content of the interviews deals with land use activities, taboos, rituals and natural spirits. Analysis shows that knowledge systems subdivide into four categories: (1) ecological knowledge, (2) knowledge about the use of natural resources, (3) denominations, and (4) a knowledge-belief interlinkage. Ecological knowledge is closely related to the land use activities agriculture and livestock keeping as well as environmental signs and signals. The knowledge about the use of natural resources relates to house building and fencing, traditional healing, food for humans and animals, and the fabrication of tools. It is noticeable that people in Madagascar use diverse denominations for natural resources, places and water holes. Most of the denominations have a particular meaning and provide a special picture of the object. There is also a close relation between people's knowledge and their believes in god, the ancestors, and supranatural spirits. Belief in rituals and taboos shape people's knowledge systems. These scientific insights into existing knowledge systems are relevant for a better understanding of people's adaptive capacities to ongoing regional pressures such as food insecurity.

Keywords: Knowledge systems, land use activities, Madagascar, Mahafaly Plateau

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Land Use Systems and Food Security in Forest Areas of Ghana: Conflicts, Controversies and Resolution

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Cocoa farming is one of the dominant land use systems in the forest belt of Ghana. The farms are established initially with food crops such as maize, cassava, yam, cocoyam, plantain and cassava, which contribute to both household and national food security. An alternative land use system in the forest belt is gold mining. Recent practices of small scale gold miners who are leasing fields earmarked for new cocoa plantations and destroying already established farms to mine gold has led to conflict among land owners, tenant farmers and miners. The fact is that some young farmers are abandoning cocoa farming to join the mining business which they perceive as more lucrative. Other young farmers are complaining about the sharecropping system operated among cocoa farmers. The result is poor farm management and low yields of both cocoa and food crops leading to high food prices and eventually low access to adequate and nutritious food. This makes the issue of pitching small scale mining against cocoa farming a controversial one. This paper describes the efforts that are being made by a network of cocoa value chain actors, municipal assembly, government and non-governmental agencies to resolve the issues through consultative and participatory approaches. A survey including 483 farmers and small scale miners in three regions (Western, Eastern and Ashanti) of Ghana as well as representatives of 30 relevant governmental and non-governmental agencies sought the opinions of respondents concerning the sources of conflict, controversies in tenure arrangements and factors of success for land use planning that supports and enhances food security. The way forward is for all to act in ways that will further the welfare of people and their communities by creating convenient, equitable, healthful, efficient and attractive environments for present and future generations.

Keywords: Cocoa farming system, food security, Ghana, land use planning, small scale mining

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The Structure of Food and Medicinal Plants Used within Vietnamese Community in Prague, Czech Republic

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Ethnobotany has observed a flourish in the past recent decades. Ethnobotanical study focuses on exchanging, transferring, and appropriating by migrants adapting to new surroundings and changing environments. Always, the first generation of migrants perceived their own food as being traditional and tasty contrary to younger generations which increasingly consume the host country food. It relies on how much their acculturation level is. In the early 1960s, Vietnamese migrated to the Czech Republic and reached a population of over fifty-seven thousand by the year 2013. Vietnam is the most culturally diverse country in South-East Asia and it is home to an enormous diversity of flora and fauna including many endemic species. Therefore, the study of useful plant resources within Vietnamese diaspora in the Czech Republic could bring interesting results and contribute to the international scientific context.

Fifty informants (34 women and 16 men) 21 to 83 years old, living in Prague, were interviewed using a semi-structured questionnaire during January-March, 2015. Pivot table function in MS Excel and Pearson chi-square (X2) test in SPSS IBM 22 were used to carry out descriptive statistics and correlations between the plant usage and demographic variables.

In total, research participants reported 220 plant species belonging to 76 botanical families being used for food (62.7 %), medicinal (5 %) or both food and medicinal purposes (32.3 %). The most represented families were Fabaceae (17 species), Brassicaceae (15), Cucurbitaceae, Poaceae, Rosaceae, and Rutaceae (11 species each). Fruits, leaves and roots were the most represented plant parts used with the proportion of 39 %, 25 % and 15 % of the total number of citations, respectively. According to plant food categorisation, most plant species are consumed as vegetables (63 % of use reports), dessert fruits (24.8 %), followed by starch plants, nuts and pulses (4 % each). The knowledge and usage of food and medicinal plant were examined as dependent variables; the gender, age and duration of living in Vietnam were named as independent variables. In general, there was no significant correlation between these two variable groups. However, some sub-categories of these variables showed individually significant correlations to each other.

Keywords: Ethnobotany, food, medicine, migrants, traditional knowledge

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Transdisciplinarity and participation

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What Can Conservationists Learn from Local Rule Negotiation Processes? National Park Tsimanampetsotse in Southwestern Madagascar

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Known for its highly endemic biodiversity, Madagascar is still in the center of interest of multilateral donors financing nature conservation. In this context, the area of the National Park Tsimanampetsotse has been quintupled while the pastoral area and the use of natural resources for economic, ritual and social purposes were further restricted for the local population. Two management systems, namely co-management for the national park on one hand and community based natural resource management (CBNRM) for the buffer zone on the other hand, have been introduced following the global trend of participatory natural resource management.
The stereotyped approaches of the development organisations often neglect the diversity of interests in groups and local procedures of decision-making. Furthermore, the Tanalana, the biggest ethnic group living in the vicinity of the National Park, have different perceptions of ownership and access to land and natural resources than the conservationists: their concepts of autochthony, gerontocracy and spirituality define rights and property.
For analysing the different management forms a qualitative case study approach was applied based on 160 semi-structured interviews in the periphery of the National Park. By analysing negotiation processes of rules for natural resource use outside the protected areas it becomes obvious that several aspects peculiar to the Tanalana society need to be respected by development agencies if the objective of a bottom-up movement is meant seriously. In particular, it would be important to leave the choice of the type of rules and sanctions to the local people to avoid a donor driven artificial framework for natural resource use.

Keywords: Co-management, community-based management, land management, local rules, Madagascar, national park, participation, SuLaMa

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Small Farmers' Climate Change Adaptation Can Be Accelerated by Citizen Science

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Small-scale farmers in the global south are among the most vulnerable population to the effects of climate change. As effective adaptation will be key to preserving livelihoods, many farmers are adapting their production system to new pressures or options by making choices among locally available agrobiodiversity. Cultivar adjustment is a highly effective adaptation strategy, so facilitating farmers' access to crop varietal diversity can accelerate climate adaptation by strengthening local adaptive capacity.

Traditional plant breeding has had limited impact in marginal environments, in part because it often failed to address farmers' highly specific selection criteria. Efforts of participatory variety selection (PVS) have tackled this issue, but are bound to focus on a limited geographical coverage. In practice, inconsistent attendance to PVS activities often leads to distorted results, non-adoption of selected varieties and thus does not lead to climate change adaptation.

Citizen science may offer a solution. It involves recruiting large numbers of volunteers to help in scientific tasks, including data collection, analysis and interpretation. Citizen science differs from the participatory methods used until now in the agricultural sciences in that it requires less group organisation and involves more information and communication technologies (crowdsourcing).

Using a citizen science approach, small seed packages of promising crop varieties can be disseminated to large numbers of farmers and tested under local conditions. This may lead to a higher *in situ* agrobiodiversity, dynamic adaptation of farming households, and strengthened climate change resilience of rural communities.

We show that "triadic" comparisons between different varieties is a simple and effective way to evaluate the adaptation options and feed information into local seed networks. Farmers are incentivised to participate via planting an individual mini-trial by the access to new varieties and the capacity building involved. Farmers make accurate observations on the varieties' local suitability, which can be used as inputs to variety recommendations in other regions. Women are empowered by the easy participation. Up-scaling of the approach is feasible by building on mobile phone technology and local seed distribution points.

Keywords: Climate adaptation, cultivar adjustment, participatory variety selection

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Participatory Scenario Planning Addressing Uncertainty of Demographic Change in Rural Communities of North-West Ethiopia

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One of the overriding objectives of development is to improve the quality of life of the people. Information about the future population development is key for rural planning decisions relating to infrastructure, land use, land reforms or social service provision. However, in contexts of huge data gaps and low data quality, missing and contradicting knowledge on drivers of change, such as in many developing countries like Ethiopia, the population projections are confronted with much uncertainty. Furthermore, national projections are unrepresentative to smaller geographic scales of rural communities. In such a situation the authors argue that, application of participatory scenario planning as part of transdisciplinary research methods, can support the intersubjective definition of assumptions needed for the quantitative calculation of population projections for rural communities. The approach was successfully tested in three rural study sites in North-West Ethiopia. We present four plausible qualitative scenarios for the demographic development until 2030, were again validated by the members of the rural communities to support the associated underlying assumptions for quantitative demographic projections. The authors concluded that the participatory scenario process captured and integrated contextual knowledge for the demographic assumptions and resulted in more context-specific projections. The collaborative work on the local drives of demographic change between science and society furthermore provided a valuable space for social learning among the local communities on how their decisions, norms and behaviour will drive the demographic dynamics. So that local stakeholders could identify the need for and scope of local mitigation or adaptation measures to demographic change.

Keywords: Ethiopia, participatory research, population projection, rural population change, scenarios, uncertainty

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Factors Affecting the Functioning of Farmer Groups: Perspectives from Three Farmer Groups in Tanzania

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There has been considerable interest in establishing farmer groups based on the assumptions that groups give farmers bargaining power, enable cost-effective delivery of extension services, and empower members to influence policies. However, research has also shown that many groups fail, often due to issues pertaining to social capital such as group cohesion, trust and reciprocity. This research aimed to reveal farmers' own perceptions of factors that affect the functioning of groups in their specific locality.

Working closely with three farmer groups in the Dodoma and Morogoro regions of Tanzania, this study took a Participatory Action Research (PAR) approach. Ten days were spent with each group and activities included creation of a 'group history' and a self-assessment. Members outlined their own criteria for assessing group functionality. In addition, in each case study site at least four semi-structured key informant interviews and two focus groups with non-members took place, to further explore factors effecting group formation and functionality in each community.

Through these activities, key questions relating to how groups started, what motivated different members to join the group, and perceptions about what makes the particular group more or less functional were addressed. Results show that differences in social capital at the community level produce contexts that can enable or constrain group formation processes. Farmers belonging to groups identified aspects of social interrelations such as unity, love and trust as important factors in determining functionality. Focus groups with non-members gave insight into disincentives to joining groups, such as perceived lack of time, resources or community cohesion.

The PAR approach enabled observations of group activities to take place and critical engagement with farmers' characterisations of group functionality. In feedback sessions, videos and preliminary results were presented to each group to stimulate reflection, discussion and new ideas.

The three case studies offered contrasting insights into farmer group functionality and formation contexts. Moreover, differences in perception among different group members and between villages led to a nuanced and multivocal assessment that was attentive to issues of social difference.

Keywords: Collaborative learning, participatory action research, social capital, Tanzania

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The Influence of Trust in the Nicaraguan Learning Alliance on Capacity Development of Members and Other Influenced Groups

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Today, capacity development through innovation systems involves more interactions among different stakeholders than in the past. An innovation platform called "Nicaraguan Learning Alliance (NLA)," founded by ten Non-Governmental Organisations (NGOs) and local institutions, is currently being implemented in Nicaragua. Besides the NLA, governmental institutions and the private sector are also working in the same areas, emphasising the cultural and historical importance of agricultural cooperatives in Nicaragua. Innovation platforms are relatively new, whereby a few tools are available only to evaluate their performance. Cadilhon (2013) developed a conceptual framework to carry out impact evaluation of innovation platforms. This framework is based on the Structure–Conduct–Performance (SCP) model, new institutional economics, and supply chain management and marketing. The main objective of this study is to evaluate the applicability of the conceptual framework, and to understand the interaction between structure, conduct and performance of the NLA network and its participants, with a focus on trust and capacity development. Key informant interviews, focus group discussions and individual questionnaires were used to collect data. The analysis was done using descriptive and factor analysis as well as linear regression model. The qualitative data was used to triangulate and explain the results from the quantitative analyses. The analysis shows that the NLA has been successful in its activities, including capacity trainings. However the NLA-members and their partners were not found to have more trusting relation-ships or better capacity development than the reference group. This can be explained by the wide variety of support to farmers by the public sector, private sector, NGO's and other stakeholders. The conceptual framework can be partially validated: certain structural elements are influencing trust; capacity development is influenced by both structure and conduct. One recommendation from this study is that more interactions between the different stakeholders should be facilitated in order to make the services more sustainable and efficient.

Keywords: Assessment, capacity development, impact evaluation, innovation platform, learning alliance, Nicaragua, trust, value chains

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Enhancing Transdisciplinary Research on Food and Nutrition Security through Innovation Systems Perspective (ISP)

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Food and nutrition security challenges require new sustainable ways of knowledge generation, dissemination, implementation and adaptation. Transdisciplinary research approaches are often applied as appropriate means to address real-world problems by involving non-academic actors into the research process in order to integrate the local knowledge and to create ownership for suggested scientific solutions. Following an evolution of approaches to agricultural research for development which have mostly failed to effectively connect research and non-academic actors, the ISP attempts to learn from past failures and takes a comprehensive view of researchers, farmers, policymakers and other actors whose interactions could lead to successful innovation. In order to understand which actors need to be involved when, which linkages between them have to be strengthened and which institutional and context factors have to be supported to enable successful innovations, this article discerns different elements and stages of innovation processes. Adapting the ISP to the context of horticulture and particularly to the sub-sector of African indigenous vegetables (AIV), it aims to identify research and non-academic actors whose effective collaboration is relevant to improve food and nutrition security through innovation in Kenya. Centering on different actor groups, it analyses the conditions they face in carrying out their functions with regard to innovation in AIV sub-sector in West and Central Kenya. It also highlights determinants for successful innovation, i.e. positive as well as negative factors linked to the political and infrastructural context, the actors' capacities and their interactions. Building on a holistic assessment it discusses several aspects on how to optimise the innovation processes the multi-stakeholder interdisciplinary German-Kenyan research project HORTINLEA (Horticultural Learning for Improved Livelihood and Nutrition in East Africa) aims to support and participate in. The article concludes with recommendations in order to further enhance the practice of transdisciplinary research on food and nutrition security through ISP.

Keywords: African indigenous vegetables, food and nutrition security, horticulture, innovation system, Kenya, transdisciplinary research

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Business Decision Analysis Principles in Research for Agricultural Development

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Most research for agricultural development aims at informing intervention decisions, but the information it delivers is normally insufficient for comprehensive decision support. This is because few research activities manage to adequately consider the complex nature of agricultural systems, which are influenced by a range of ecological, socioeconomic, cultural and political factors. Severe lack of data on most of these factors contributes to the frequent failure of research to supply decision-makers with robust science-based information to support particular decisions.

Since it is not feasible to close all knowledge gaps or to fully capture complex system dynamics in integrated deterministic models, new approaches are needed for supplying decision-makers with usable information. Business decision analysis methods offer a promising way forward, because they have been designed for aiding businesses in decision-making on risky projects with imperfect information and limited research budgets. A key strategy in decision analysis is capturing the current state of uncertainty about particular variables of interest, before any measurements are taken, and using this knowledge for probabilistic simulations of the full range of plausible system outcomes of particular interventions. Exploring the outputs of this procedure allows identifying high-value variables, whose measurements would most improve certainty about how a decision should be taken. These then emerge as priorities for further investigation. Having the research process guided by such analysis facilitates efficient allocation of research funds and helps researchers focus their efforts where they are most useful.

Application of these principles is demonstrated with three case studies: 1) probabilistic participatory modelling of the business case for a water pipeline in northern Kenya, 2) use of Bayesian Networks for targeting water interventions in Tanzania and 3) analysis of the nutritional implications of replacing homegarden-based small-scale farming in Uganda with larger scale commercial food production. In all cases, robust guidance on decision-making, or at least on data collection needs or prominent intervention risks were possible without expensive long-term data collection. The principles of business decision analysis offer one of the most promising approaches to meeting the challenges of system complexity and data scarcity that appear ubiquitous in agricultural development.

Keywords: Applied information economics, Bayesian Networks, holistic modelling, transdisciplinary modelling, uncertainty

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Transdisciplinary Research on Community-Based Environmental Management: Who Is In and Why?

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In community-based environmental management (CBEM), the role of communities is emphasised in bringing about change for an improved management of natural resources to support ecosystem services provision and secure local livelihoods. CBEM approaches are known to differ widely and understanding the composition of CBEM actors and their distinct roles in the governance of natural resources can offer valuable insight in what works best under which circumstances. In this study we investigated a transdisciplinary research project in which partners from research and practice collaborated closely to investigate different CBEM approaches in Latin America. Transdisciplinary research usually is understood as a research strategy that dissolves and spills over disciplinary boundaries to take a holistic view on a certain issue that requires integrating, and, more importantly, unifying scientific knowledge of several disciplines for problem-solving. Beyond, transdisciplinarity is also understood as a research strategy that transgresses scientific disciplines altogether to include the practical and everyday knowledge of stakeholders affected by the problem into the research process. In such a way, transdisciplinary research becomes capable of engaging with different ways of knowing the world, generating new and often more relevant knowledge for understanding a certain phenomenon. In our study we asked project partners, both from research and technological development (RTD) as well as from practice, in particular from civil society organisations (CSO), about their motives to get engaged into transdisciplinary research, and also about the perceived benefits but also possible drawbacks. The analysis was based on a survey conducted among all involved RTD and CSO partners with 27 individual survey participants. Results of the survey highlight their motivations for engagement and the specific contributions of different partners to the research process also in terms of the quality of the research outcomes.

Keywords: CBEM, civil society organisations, collaborative research, Latin America, research and technology development, transdisciplinarity

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Participatory Impact Assessment to Improve Food Security of Smallholders in Rural Tanzania

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Food security remains a major challenge in sub-Saharan Africa. Sustainable agricultural development is fundamental to food security and poverty alleviation, notably in developing countries. Many development initiatives focus on the enhancement of smallholder production and productivity because the majority of poor people in developing countries live in rural areas where agriculture is the main source of livelihood. However, the consequences of these development initiatives are often manifold; i.e. besides having intended effects also causing non-foreseen impacts. Therefore, there is a need to assess development strategies/projects prior to implementation to reduce the risk of possible negative impacts and to allow for adjustments if necessary. This can be done by applying *ex-ante* sustainability impact assessment. The theoretical discourse on sustainability impact assessment emphasises the following: equal integration of all three sustainability dimensions, active involvement of stakeholders at every step of the assessment process and a focus on exchange and learning among the involved stakeholders. We developed an *ex-ante* impact assessment approach, based on the FoPIA (Framework for Participatory Impact Assessment) method that is applicable to a small-scale farmer's level in the development context. The adapted FoPIA we applied to assess sustainable upgrading strategies along the farmer's food value chains in order to improve food security in rural Tanzania. We present the different methodological steps of this framework and we present results gained from its application at four contrasting case study villages in Tanzania; in the semi-arid Dodoma Region and in the sub-humid Morogoro Region. Strengths and shortcomings of the adapted FoPIA method are discussed. We conclude that FoPIA was capable of identifying local stakeholder preferences, in setting priorities of development measures and for providing a stakeholder-inclusive analysis of possible opportunities and risks connected to the proposed upgrading strategies.

Keywords: Food security, impact assessment, smallholder farmers, sustainability, Tanzania

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Building a Climate Resilient Production of Primary Export Commodities in Ethiopia: Policy and Institutional Options

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Agriculture is the largest employer, main source of livelihood and foreign exchange for Ethiopia (contributing 43 % to GDP, 50 % to export and 80 % to employment). The impact of climate change on agriculture is an issue of great significance to the lives and livelihoods of millions of poor people who depend on agriculture for survival. Although agriculture by its very nature is more climate-change sensitive than other sectors, not all agricultural commodities and social groups are equally vulnerable. Climate change poses a particular threat to certain commodities and social groups, especially to those that have low institutional capacity with unclear roles, weak linkages and social structures. The study aims to build institutional capacity for developing and implementing adaptation interventions that minimises climate change impacts on primary export commodities in Ethiopia.

To this end, the study used an interactive scientific dialogue through an established platform that involves key stakeholders representing policy makers, researchers, civil societies, private sector and most vulnerable communities along each step of project activities. The platform creates opportunities for stakeholders to actively participate throughout the project process in a science-based interactive dialogue. The findings from the research components including climate modelling, value chain analyses, institutional and economic analyses feed into adaptation analyses and are discussed at the platform. This allows stakeholders to discuss the consequences and develop the strategies at various levels to respond to the changing situation. Using quantitative and qualitative information collected at field level, the empirical research assisted in identifying solutions for discussion at the stakeholders' platform; which incorporated various adaptation options. On the basis of adaptation scenarios, which consider technical, economic, social and institutional measures, and their interactions, the platform undertaken participatory analyses and identified roles and responsibilities for the process of adaptation. Finally, a governance structure is developed that governs the roles and responsibilities of key stakeholders to work towards achieving a common goal of addressing the anticipated climate change impact through implementing the identified adaptation strategies, and thereby, build a climate resilient production of primarily export commodities in developing countries.

Keywords: Adaptation strategy, climate change impact, developing countries, governance

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A Decade of 'onehealth' and 'ecohealth' in South East Asia – An Inventory and Perspectives

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South East Asia (SEA) is a hot spot for diseases emergence as demonstrated for HPAI and SARS. To address challenges on disease emergence in livestock and human such as urbanisation, agriculture intensification, land use changes and others new integrated approaches have been increasingly introduced to the region to facilitated collaboration across disciplines, groups and stakeholders. Those approaches include the 'ecohealth' (EH) and 'onehealth' (OH) concept, both focusing on integrated research but having a different history and characteristics. The EH approach was pioneered over the last decades by the International Development Research Centre, Canada (IDRC). The OH concept builds up on Schwabe's One Medicine and is currently institutionalised by the World Organisation for Animal Health (OIE) and FAO. To promote EH in the region, ILRI implemented an EH capacity building project (EcoZD) funded by IDRC between 2008 and 2013. The project targeted six Southeast Asian countries. In each country an across-disciplines research team was formed and implemented an EH case study aligned with capacity building on transdisciplinary research. In a subsequent step, 'onehealth-ecohealth' resource centres were established in three universities/institutions in Thailand, Vietnam and Indonesia. For this paper we also screened selected other OH/EH initiatives implemented since 2004 in SEA for their focus and impact. Most initiatives emphasised on capacity building others mainly on research or both. Challenges are various and complex, such as 'loose' or overlapping definitions of OH/EH, cultural barriers, silo thinking, lack of qualitative research skills. While the use of integrated research has been successfully demonstrated in case studies (e.g. for Brucellosis in Yunnan) donor dependency, limited impact assessments of the added value of used integrated approaches and coordination gaps among the various initiatives remain a challenges and need more attention in the future.

Keywords: 'Onehealth', inventory, perspectives, South East Asia, 'ecohealth'

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Identifying Agricultural Knowledge Gaps Between Farmers and Scientists – A Case Study on Perceptions and Knowledge on Arabica Coffee Pests and Diseases and its Management Along the Slopes of Mount Elgon

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For the development of sustainable crop pest and disease management strategies the importance of integrating farmer's perceptions and knowledge has been recognised by the scientific community. However, the gap between indigenous and scientific knowledge still constitutes an obstacle for both, the problem identification related to plant health and the constraints for the adoption and implementation of management solutions, particularly in the context of smallholder farming in developing countries. In this paper we present a case study on coffee production in Uganda, a sector depending mostly on smallholder farming in the face of increasing and simultaneous socio-ecological pressures. The objectives of this study were to (i) examine farmers' perceptions, knowledge and management of Arabica coffee pests and diseases (CPD) and to relate management practices to socio-economic and topographical variables as well as the vegetation structure of the production systems; (ii) to contrast obtained results with perceptions and information from scientists, extensionists and field observations, in order to identify gaps in knowledge and information flow and to discuss potential causes for constraints facing both, farmers and scientists. Data were acquired from coffee farmers and experts of the Ugandan coffee sector by means of interviews and workshops. 150 farmer households, managing coffee either under sun, shade trees or bananas and spread across an altitudinal gradient in Mount Elgon region were semi-randomly selected. Field sampling of the most important CPD was conducted on a subset of 33 plots. The study revealed the following findings: (i) Farmers were able to visually recognise CPD but did not know the difference between insect and pathogens. Pesticide use was not related to farmers age, education level or gender, but the collaboration with extensionists. (ii) Although perceived incidences across the altitudinal range were partially consistent between farmers and experts, results indicate a crucial gap between what farmers know and what is known by scientists and extensionists in terms of CPD recognition and management, as well as the role of shade trees. (iii) Results from experts and field observations on the impact of shading on CPD revealed existing discrepancies to be considered in research and recommendations for improved coffee management.

Keywords: Arabica coffee pests and diseases, farmers perceptions, integrated pest and disease management, knowledge gaps, participatory research

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Disseminating Efficient Irrigation Technologies: The Egerton Campus Experimental and Demonstration Site

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Within the frame of a joint research project between African and German Universities and research institutions with focus on sub-surface irrigation an experimental and demonstration site for comparing sub-surface irrigation methods in terms of water productivity, yield and impact of different water qualities was installed in 2014 at the Egerton University campus in Kenya.
A first farmers' field day was organised in December 2014 where local farmers, administrations from county water authorities and church support unions where invited to the University Campus in Njoro / Kenya. With great interest and fruitful discussions the invited group had a guided tour to the demonstration site where sub-surface irrigation techniques were installed in a greenhouse and in open field.
The techniques comprised clay pot irrigation, sub-surface drip irrigation, irrigation via plastic water bottles and innovative membrane irrigation, representing a wide range of sub-surface irrigation methods currently used in Kenya and worldwide. Their common features are installation beneath soil surface and water supply directly in the plant rooting zone. These main advantages lead to water savings up to 70 % in comparison to surface irrigation. All applied sub-surface irrigation techniques operate with low pressure provided from water tanks near by the plots, and can be easily adopted by local farmers.
A next project step is conducting a workshop with local farmers to disseminate installation, operation and maintenance procedures of sub-surface irrigation techniques and water harvesting methods.
The described demonstration site will also be used for research purposes to compare the installed sub-surface irrigation techniques in terms of water consumption, yield and water use efficiency. Resulting data will be available by the end of 2015.
All activities are coordinated by the Kassel University, Department for Agricultural Engineering in the frame of the ComASI project - A Comprehensive Analysis of Sub-surface Irrigation in SSA for an optimisation and adoption of an environmental friendly irrigation practice - financed by the German Federal Office for Agriculture and Food (BLE) as part of an ERA-ARD (European Research Area for Agricultural Research for Development) program.

Keywords: Demonstration site, dissemination, efficient irrigation, sub-surface irrigation

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Multistakeholder Platforms for Sustainable Food Value Chains in Tanzania: A Space for Empowerment and Effective Engagement

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To address the challenges facing the agriculture sector and natural resource management, the multistakeholder platform (MSP) approach is increasingly being embraced by research and development actors as a framework aimed to bring together multidisciplinary and heterogeneous actors to address problems of common interest. MSP approach aims to enhance effective interaction and engagement of stakeholders to join hands together in setting strategic directions, identifying complementarities and developing joint actions. The approach helps to create a space for empowerment and active participation of multiple stakeholders intending to search for solutions to common problems. Recently, the MSP approach was adopted by a consortium of researchers from different institutions in Germany and Tanzania who are implementing a multistakeholders food value chain project aiming to innovate upgrading strategies to safeguard Food Security using technology and knowledge knowns as "Trans-SEC project". Stakeholders in Trans-SEC project include farmers (and pastoralists), processors, millers, stockiest, traders, middlemen, transporters and consumers, policy makers, extension officers, service providers, NGOs and churches etc. The engagement process in Trans-SEC project happens through interviews, workshops, focus group discussions, trainings, testing and assessing food value chain UPS that take place during the implementation of various planned activities. Through stakeholders' involvement, it has become apparent that stakeholders have different perceptions across case study sites, at district, regional and national levels. In order to achieve an effective involvement, there is need for good facilitation skills to allow interaction of actors while considering age, gender, status, skills, and personal background. However, farmer groups which have been formed to implement each UPS in the case study sites are still very week, hence need continuous monitoring so to enable then play their role efficiently.

Keywords: Food security, food value chain, multistakeholder platforms, multistakeholders engagement processes

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Willingness to Pay for Value-Added Solid Waste Management System among Cassava Processors in Nigeria

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Cassava (*Manihot esculenta* Crantz) is one of the most important staple food crops processed and consumed in different forms in Nigeria. Environmental pollution from solid waste increases with increasing production and processing of cassava. Past studies showed that over 55% of waste produced from cassava processing are disposed in dumping sites, creating both environmental pollution and negative health impact on the population in the neighborhood of cassava processing facilities. Improved waste management systems for making value-added products such as mushroom, feed and organic manure from cassava waste hold promise for environmental preservation and income generation for the smallholders. A survey of 403 cassava processing enterprises was carried out using structured questionnaires to identify different forms of cassava waste management systems and potential benefits to adopters of various forms of improved management systems. Descriptive statistics, contingent valuation and Logit model based on the cumulative probability function were used to determine the willingness of the processors to pay for improved waste management system and analyse the factors influencing processors' willingness to pay. Women constitute largest population of smallholder cassava processors and generate largest amount of cassava solid wastes. The mean willingness to pay for acquiring new knowledge on improved waste management technologies was US$3/person. However, more than half of the respondents were willing to pay for acquiring new knowledge on the improved waste management, while other were on willing though they showed great level of interest in acquiring the new knowledge. It is expected that public expenditure to empower processors to use technologies for converting cassava solid wastes to value-added products will lead to lower cost and higher social benefits to the population (lower exposure to toxins and additional income to the smallholders, less pollution of the air, rivers and underground water, etc) compared to the current waste disposal methods.

Keywords: Cassava, pollution, smallholders, solid waste, value-added, willingness to pay

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Incorporating Nutrition and Health in a Technology Adoption Impact Study: The Effect of Improved Seeds on Food Security in Ethiopia

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Despite the remarkable progress made in the past two decades, a large share of Ethiopians are still frequently food insecure. In view of the country's fast growing population and the exploitation of land area, the intensification of agricultural production is considered crucial to meet the increasing demand for food and to serve as a growth engine for the whole economy. The Green Revolution in Asia has set an example for how such growth can be achieved: through the adoption of new agricultural technologies including high yielding seeds of staple crops. However, the nutritional quality of the agricultural output has long been neglected in favour of its quantity fostering malnutrition with all its consequences for health and ultimately labour productivity.

This paper contributes to the technology adoption and impact assessment literature investigating the impact of partial adoption of high-yielding seeds on smallholders' food security status. Acknowledging the widespread problem of malnutrition, we focus on the nutritional dimension using different dietary diversity indicators. We first develop a theoretical and conceptual framework linking agricultural production, food security, nutrition, and health in the context of technology adoption and then implement it in an econometric model.

Second, using household data of 398 Ethiopian farmers collected in 2014, we assess the impact of adopting improved seed varieties on dietary diversity. We estimate the effect by employing a two stage procedure and thereby overcome the endogeneity problem of technology adoption and food security. Technology adoption is modeled and exemplified by the share of land allocated to high yielding seed varieties, hence allowing for the option of partial adoption.

Our results could not prove a significant impact of the level of technology adoption on food security, thus rejecting the Green Revolution paradigm, i.e., increased food security through new technology in the research area. Since livestock ownership, non-farm diversification, social capital, access to credit, and gender had a significant and positive effect on food security, a policy focus in these areas appears to be of greater importance for the improvement of dietary diversity than the promotion of improved seeds.

Keywords: Dietary diversity, Ethiopia, food security, improved seeds, technology adoption

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Adoption of Multiple Sustainable Agricultural Practices and its Impact on Household Income: Evidence from Maize-Legumes Cropping System of Southern Ethiopia

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Severe land degradation in Ethiopia has threatened agricultural productivity and livelihoods of the poor. The use of a wide range of sustainable agricultural practices at plot level has been promoted as a package of technology to increase productivity per unit area of land while preserving and enhancing the natural resource base. However, in most rural area, farmers adopt a mix of practices rather than all available practices. Understanding the determinant of adoption of multiple practices and its impacts on outcome variable is essential to design appropriate policy options for wider adoption process. Thus, this study analyses farmer's choice of combination of improved maize variety, legumes crop and crop residue retention and evaluates its impact on maize net income using detailed household and plot level data collected from Boricha and Loka Abaya districts. Multinomial logit and endogenous switching regression models were employed. The result indicate that socioeconomic factors, access to information and credit institution and plot characteristics are found to be important determinants of adoption of multiple sustainable agricultural practices. For example, access to market information, extension services and credit are found to be significant variables that positively determine simultaneous adoption of multiple practices. Besides, in contrary to most previous work the probability of adopting multiple practices is higher on rented plots than owned plots. Important policy implication here is that fixing appropriate length of period for land renting could be as essential as private land ownership right to manage land resource in a sustainable way. Regarding the effect of adoption, adopters of sustainable agricultural practices in any combination earn higher maize net income than non-adopters. The results also indicate that adoption of multiple practices as technology package provides modestly higher net income than adopting each practice in isolation or in any mix. Total production cost is found significantly higher with adoption of each alternative package. This implies that multiple sustainable practices as package of technology is capital intensive and require relatively higher initial investment cost. This may call for the need and expansion of credit access while promoting multiple sustainable practices in resource constrained communities of rural Ethiopia.

Keywords: Multinomial endogenous regression, multinomial logit, sustainable agricultural practice

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Simulated Willingness of Farmers to Adopt Fertiliser Micro-Dose and Rainwater Harvesting Technologies in Semi-Arid and Sub-Humid Farming Systems in Tanzania

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As a continent which is full of potential and abundant natural resources, Africa is in a better position to feed its people. Productivity of African agriculture falls below the global average mainly due to limited use of productivity enhancing technologies. In Tanzania, smallholder farmers are operating without fertiliser on fragile soils in rain-fed areas. Nutrient mining and soil-moisture stress are the main limiting factors of increased crop productivity in the semi-arid and sub-humid dry-land areas of Tanzania. Fertiliser micro-dosing (MD) and rainwater harvesting through ridges (RWH) appear to be appropriate technologies to replenish the nutrients and improve the soil moisture for increased crop production. It nonetheless remains unclear whether these technologies can themselves easily be adopted by smallholder farmers in Tanzania. Our findings raise important issues as to whether these technologies are really adoptable to poor smallholder farmers.

There have been very limited efforts to make predictions about adoption and diffusion of new technologies in agriculture. This study attempts to assess the willingness of farmers to adopt MD with and without ridges RWH. Data and information used was obtained from a baseline study, participatory *ex-ante* impact assessments and simulation exercises. Our cross-section analysis mainly relies on the use of ADOPT (Adoption and Diffusion Outcome Prediction Tool) and ScalA-FS for understanding sustainability, prioritising and sequencing as far as technology adoption is concerned. The simulation reveals the *ex-ante* impact of selected technologies, the peak adoption rates, the likelihood for reaching peaks and the possible time for reaching those adoption peaks. Our findings propose the best ways to be opted by technologies users, while considering factors affecting adoption during research planning, implementation and testing of the farm level technologies.

Keywords: ADOPT, adoption, farm innovation, fertiliser micro-dosing, prediction, Tanzania

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Conservation Agriculture in Zambia — An Invention Fast Becoming an Innovation: Assessing Pre-Conditions for Farmers' Adaptation and Adoption Behaviour

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In spite of reported obstacles to a wide scale adoption of conservation agriculture (CA) in sub-Saharan Africa, recorded results in some regions across the continent contradict the expectation of a negative trend. Zambia is one example where increased progress of CA adoption has been witnessed in the past years. The recent development, challenges previous pessimistic forecasts to the possibility of a wide scale adoption and diffusion of CA in the entire region argued by most authors. Emerging success stories equally deviate from the postulations of most studies that have projected CA as an example of a poorly adapted and adopted innovation in Africa with little hope for scaling up.

While most past studies on CA adoption in Africa have focus on failed cases, so far, not much attention has been given to the emerging pockets of success in countries like Zambia amongst others. Failure to analyse success cases has only helped to minimise chances of further up scaling of existing best practices/lessons which could benefit as well as accelerate wide scale adoption.

This contribution attempts to fill this knowledge gap by applying the QAToCA approach through focus group discussions complemented by semi-structure qualitative expert and farmers interviews to assess reasons behind a positive CA adoption trend in Zambia. There is a close examination of pre-conditions for its recorded success rate compared to other areas in the region. Specifically, this study 1) assesses the given institutional, socio-economic and cultural frame conditions which have boosted CA adoption in Zambia and, 2) systematically identifies the still-existing hindering factors for a wider CA adoption beyond the case study region.

Results highlight 1) positive institutional influence, 2) systematic approach towards CA promotion – encouraging a step by step adoption, 3) mobilisation of a strong marketing dynamics around CA, as main reasons behind Zambia's success story. Results can help promoters of CA in and out of the region to reflect on their activities and to eventually adjust or redesign them based on a more explicit understanding of where problems and opportunities are found.

Keywords: Adoption, conservation agriculture, pre-conditions, QAToCA, Zambia

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How to Increase the Adoption of African Indigenous Vegetables by Kenyan Small-Scale Farmers?

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African indigenous vegetables (AIVs) have high nutritional values and most of them can be grown with very few inputs and under more difficult climate conditions. While AIVs are widely cultivated in sub-Saharan Africa for subsistence and home consumption, only 3 % of the farmers in Kenya have AIVs currently included in their production portfolios. However, the growth of the domestic horticulture market and the wide variety of AIVs offer substantial possibilities for market development. Kenyan urban end-customers and domestic supermarket chains increasingly ask for AIVs. This could motivate small-scale farmers to increase their production of AIVs, and not only for subsistence, but also for income generating purposes. In fact, some AIVs like pigeon peas have already shown to increase income and reduce poverty when cultivated as a cash crop. However, AIVs are considered as poor people's food and are thus not adopted as cash crops by small-scale farmers. Lack of knowledge about cultivation, processing and marketing could play a role as well. This study aims to explore which factors motivate small-scale farmers to integrate AIV as a cash crop or for subsistence farming in smallholders' livelihoods. The analysis is based on primary data from 1,175 rural and peri-urban small-scale vegetable producers in Kisii, Kakamega, Nakuru, Kiambu and Kajiado in Kenya. In a two-stage cluster analysis, households are divided into 4 groups characterised by different levels of AIV cultivation and consumption intensity. A multinomial logit regression is then used to determine the influence of households' assets on deciding for certain AIV usage intensity. Results show that households in the peri-urban areas with relatively high amounts of land and a high share of off-farm employment are more likely to specialise in AIV production as a cash crop. Rural households with relatively high income and asset endowments, however, produce AIVs only for subsistence on a small share of their land and focus on other crops for generating income. Rural households with relatively low income and land holdings tend to employ most of the little land they have for AIV farming, while producing almost no AIVs for cash.

Keywords: Adoption, african indigenous vegetables, AIV, food security, livelihood

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Co-Creating Knowledge to Address the Challenges of Cereal-Crops' Pests for Food and Fodder Production: Case of Push-Pull Technology Implementation in Ethiopia

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Farming systems are under constant pressure to innovate to meet food and feed demands. In the Ethiopian case, agriculture is characterised by low productivity with average grain yields of about 1.2 t ha^{-1} or less. These losses are attributed to factors such as lack of an integrated scientific and practice knowledge base, farmers socio-economic conditions to environmental constrains such as *Striga* weed, stemborers and low soil fertility. A knowledge systems perspective which gives more attention to the interaction between researchers and other stakeholders for learning about the existing, generating and putting new agricultural knowledge into productive use to address these challenges is often lacking. In this study push-pull technology (PPT) was used as a boundary object to provide an opportunity for learning, collaboration and interaction across science-practice knowledge cultures with aim of co-creating new knowledge to address cereal crops pests and other related farming challenges. PPT is a multi-functional innovation platform that addresses concurrently cereal production constraints of stemborers, Strigaweed, low soil fertility and soil moisture retention while at the same time producing high quality fodder. In this strategy cereal crop is intercropped with a stemborer moth repellent fodder legume, *Desmodium* (the push), together with an attractant trap plant, Napier/*Brachiaria* grass (the pull), planted around maize-legume intercrop. Participatory trans-disciplinary action research approach was used with the involvement of researchers, extension professionals and farmers in Bako Tibe, Jimma Arjo and Yayu districts of Ethiopia. The process provided an opportunity for engagement of researchers and other stakeholders from understanding the problem, joint planning, implementation and evaluation of the performance of PPT. Data was collected from 12 focus group discussions, 30 key informant interviews, surveys and participant observations. The study lasted 8 months from August 2014 to April 2015. The stakeholders from various disciplinary and experiential orientations learned PPT based on common concepts of yield improvements, soil erosion and pest control. New research and practices about the pest control was learnt such as chemical free reduction of stemborer infestation,using inter and trap crops as fodder and soil conservation, extracting and marketing of *Desmodium* seeds as forest conservation measure, creation of new markets for green-maize and fodder production for indoor livestock feeding.

Keywords: Co-creation, Ethiopia, knowledge, pest control, push-pull technology, trans-disciplinary

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Will Farmers Buy and Apply Aflatoxin Control Biological Agent? A Willingness-to-Pay Approach in Northern Nigeria

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A biological product for controlling aflatoxin infestation of crops in the field was developed and registered under the name "Aflasafe^{TM}" in Nigeria. Aflasafe only ensures quality products and has no effect on yield. The product was introduced to farmers for adoption at a minimum cost of N1500 per hectare. A study was carried out to determine the role of information on farmers' willingness to pay (WTP) for the product to eliminate aflatoxin on their maize and groundnut farms in Kano and Kaduna states in Nigeria. A multi-stage sampling technique was used to collect primary data from 492 farmers comprising of contact and non-contact farmers. Data were analysed using descriptive statistics and Logit model. The results indicate that the most critical element is information to ensure farmers adoption and purchase of the product. A significant number of the contact farmers in Kano (80.7 %) and Kaduna (89.9 %) states had a willingness to pay bid value of $\geq$N1,500. In case of non-contact farmers only 17.6 % from Kano state and 44.9 % from Kaduna states were willing to pay this minimum cost. Most of the non-contact farmers (>60 %) pointed out that lack of information on awareness, usage and effectiveness of Aflasafe was the major constraint to adoption. In modelling factor affecting the WTP using Logit model, seven of the independent variables were positively significant, among these were 'contact with extension agent'($p < 0.05$); and 'contact with the producer of Aflasafe' ($p < 0.01$); both increased likelihood of willingness to pay for Aflasafe. The study then suggests proper dissemination of information on aflatoxin and the relevance of Aflasafe to farmers both in training and on fields. Also there is a need for the development of market with a premium price for aflatoxin free quality maize to reduce the relative price of Aflasafe application.

Keywords: Aflasafe, aflatoxin, bio-control, Logit model, multi-stage, WTP

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The Potential of Legume Adoption in Upland Maize Fields: A Case Study in Northern Thailand

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This study investigates the biophysical and socio-economic constraints to legume production as well as the economic potential of integrating legumes in maize-based cropping systems in upland areas of northern Thailand. Thailand has experienced a tremendous growth in the maize sector due to increasing demand for maize grains from the livestock and poultry industry. Subsequently, massive expansion of maize farming area has been observed in Thailand, especially in the northern region. The prevailing high-external-input development pathway is constraining for capital-poor smallholders and risks driving them into debt. The introduction of nitrogen-fixing legume crops into the maize-based cropping systems could complement or replace inorganic fertiliser inputs. However in reality, the adoption of such practices by smallholder maize farmers remains low. A comparative study between a maize monocropping system and a maize/legume relay intercropping system was carried out in two villages located in Nan and Chiang Mai provinces. Farmer surveys, participatory rural appraisal tools and key informant interviews were the core methods of the study. The results show that both cropping systems have equal profitability, although the maize yield in the maize/legume relay intercropping system was lower than in the monocropping system. The low selling price was the most cited deterrent from introducing legumes by the non-adopters. In contrast, the high selling price, ease to grow and harvest, low start-up costs and ability of legumes to improve soil fertility were the four main criteria that determine the adopters' choice of legume species. Among the four cultivated legumes (ricebean, groundnut, cowpea and lablab bean), ricebean fulfilled all the criteria for the choice of legume species. Based on the results of this study, it appears that there is a potential to integrate ricebean in the non-adopters' fields. The results of the present work also suggest that switching from a maize monocropping system to a maize/legume relay intercropping system could be a low-cost pathway to intensification that would minimise the use of nitrogen fertilisers. This study identifies the adoption constraints experienced by upland maize farmers and may inform agricultural policy makers as well as development practitioners to define their strategies for promoting legume adoption.

Keywords: Adoption constraints, legume integration, relay intercropping, selection criteria, smallholder farmers

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Improved Rice Variety Adoption, Land Use, and Food Security: Empirical Evidence from Rice Producers in Ghana

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Improved varieties are developed and disseminated to increase productivity and food production. Despite this, major technological challenges and yield gaps in Ghana persist. Most staple crops such as maize, rice, and sorghum yields are generally less than half of economically realistic yields. Due to scarcity of land, improved varieties are expected to ensure intensification of available land resources, while increasing food availability. There is however limited information on the causal relationship between improved varieties and land use on one hand, and improved varieties and food security on the other hand. To contribute to this literature gap, this study seeks to examine the effects of improved rice varieties on land use and incidence of food security among cross-section of 820 households of rice farmers in Ghana. It will construct land intensification index and incidence of food insecurity for adopters and non-adopters. Since adoption of improved varieties is potentially an endogenous decision in a typical farming system, regression procedures that account for the potential bias will be employed. This will require the examination of the existence of endogeneity using Hausman's test. Available options including instrumental variable regression models and endogenous switching regression models will be explored.

The expectation is that land use intensity is decreased by adoption of improved rice varieties. Through increased productivity and production, food security incidence among adopters is expected to be high. Given these expectations, possible recommendation would be the need to continuously sensitise farmers on the importance of improved varieties and how they effects their livelihood and wellbeing.

Keywords: Food security, improved varieties, land use, northern Ghana, rice

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The Role of Household Wealth Status on Agricultural Technology Adoption among Smallholder Farmers in Ethiopia

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The adoption of agricultural technologies in developing countries is mostly connected to farmers' economic ability to access new technologies and to potential risks associated to them. Empirical evidence shows that household wealth and technology adoption are non-linearly related and that households react differently towards technology adoption based on their level of wealth. However, in the context of Ethiopian smallholder farmers, the impact of household wealth status has not been adequately covered in the literature, especially those on adopting agricultural innovations. Therefore, this study addresses this knowledge gap by assessing the role of households' wealth on the adoption of agricultural technologies in Ethiopia. The study's approach to addressing the adoption-wealth relationship considers Ethiopian farmers living in different agro-ecological zones and possesses different levels of wealth. Primary data covering 400 households were collected within a 2014 technology adoption survey is base of this study's analysis besides secondary data collected from various relevant sources. Principal Component Analysis (PCA) is employed to generate a wealth index based on the International Wealth Index (IWI), which is an indicator measuring wealth based on consumer durables, housing characteristics and access to public utilities. The index allows categorising the sample into different wealth groups for which the technology adoption behaviours are investigated. Further, Probit and Tobit models are employed to identify the determinants and intensity of technology adoption among the farmers in the study area. While the adoption decision is expected to be significantly and positively affected by land endowment, access to credit, access to extension service and wealth; it is expected to be significantly and negatively affected by the cost of the technology and the associated risks. Based on the research findings, the study attempts to draw conclusions and provide recommendations on specific policies and programs that may increase farmers' motivation to adopt productivity enhancing new technologies.

Keywords: Ethiopia, smallholders, technology adoption, wealth

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Hidden Benefits to Small Scale Farmers from Payments for Ecosystem Services (PES) Projects in Africa. A Case Study from Lake Naivasha, Kenya

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Payment for Ecosystem Service (PES) schemes have been the subject of many studies that look at the effectiveness of nonstate governance of natural resources. The bulk of work on PES is focusing on quantifying economic benefits to service providers, but very little has been done on investigating softer benefits, such as capacity building and information access. Using a case study from Kenya the present paper is assessing farmer motivations to participate in PES schemes.

In the Naivasha PES project the participating farmers gain a number of benefits as payment for more sustainable farming practices. The benefits are either materials or capacity development. The materials vary from small vouchers for farming tools or chemicals, to plant seedlings, i.e. multipurpose grasses, tree and fruit tree seedlings. The capacity development-part is training in sustainable farming practices.

According to our interview results the PES farmers report tangible changes to their livelihoods after joining the PES-program. The PES-farmer perceptions were that their milk and crop production had doubled since the start of PES. Even the newest PES-farmers reported a 50 % higher milk and crop production. Over half of the PES-farmers indicate a higher level of erosion control in comparison to pre-PES situation. Also around a third of the PES-farmers mentioned the positive impact of more trees on farm and the improved soil fertility as a positive change. It is interesting however, that by a large margin the PES-farmers were able to mention more indirect benefits compared to the No-PES-farmers. These indirect benefits were: increased soil fertility, erosion control, shade and fodder for animals.

The farmers overall reported a high level of satisfaction to the PES-programme and a higher level of well-being due to the PES-program. They felt more confident with their farming practices, had better control over their environment and farm production. In general, the farmers felt more empowered. 100 % of the farmers said that they will continue with the PES-land use practices after the PES-project ends.

Keywords: Benefits to farmers, erosion control, farmer livelihoods, farmer training, payments for ecosystem services (PES)

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Stated Preference of Smallholder Farmers for Improved Cookstoves in Malawi and Mozambique

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Solid biomass is the main energy source for cooking in many developing countries. Beyond that consumption rates of firewood and charcoal are high, because most households use inefficient devices for cooking. Stresses on ecosystems caused by consumption of biomass could be mitigated by a comprehensive adoption of improved cookstoves. Development partners and NGOs disseminate improved cookstoves in sub-Saharan Africa since more than 20 years. However, their adoption rate in rural areas is still low. Market information could be used to identify first adopters and develop comprehensive adoption strategies for improved cookstoves.

As there are no or only disturbed markets for improved cookstoves in rural areas, we investigated the demand side of an improved cookstove market by conducting stated preference approaches in Dedza District, Malawi and Angonia, Mozambique. We implemented both a choice experiment and an analysis of the willingness to pay for the locally produced clay stove ("Chitetezo Mbaula") as well as a factory-made and imported metal stove.

Our results reveal that networks, which increase the information and knowledge transfer in rural areas are very important for the adoption of improved cookstoves. Especially, membership in a women´s group had a positive impact on the preference of the improved cookstoves over the traditional three-stone fire. Personally experienced negative consequences from the use of traditional cooking devices and unsustainable biomass consumption, which we measured in occurring of respiratory diseases in the family and the amount of time necessary for collecting firewood, also contributed to a positive perception towards improved cookstoves. Additionally, we found evidence for the mental accounting hypothesis for remittances. Income received from relatives or friends, which is often transferred with conditions or information, is more likely to be spend on purchasing improved cookstoves.

Keywords: Choice experiment, improved cookstoves, Malawi, Mozambique

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Impacts of Fuel Efficient Improved Cooking Stove on Biomass Collection and Consumption in Rural Ethiopia

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Access to modern energy is critical for achieving almost all the Millennium Development Goals. Lack of proper access to modern cooking energy sources leaves the use of improved cook stoves (ICS) indispensable option particularly in rural areas of Africa South of the Sahara (SSA). This is because it can substantially improve cooking efficiency and plays positive role in improving the socioeconomic conditions of rural households. However, research to estimate the empirical impact of ICS on biomass consumption, labour use for collection and health is scanty. This paper attempts to uncover the rate and determinants of rural households' adoption of fuel efficient cooking stove and its impact on wood biomass collection and consumption based on two rounds of data collected in four districts of Ethiopia. We used a diff-in-diff approach to estimate the empirical impact of ICS. The findings showed that wood constituted the major source of fuel for cooking with disproportionate burden on women for its collection. Within the two surveys the uptake of ICS increased by more than two folds. The adoption of ICS has reduced the amount of biomass consumption for fuel and the time required for collecting fire woods. Such benefit is believed to contribute to climate change mitigation and livelihood improvement endeavours of the country. But the impact on household level health remained insignificant. We find different set of determinants for early (households adopted in 2012) and late (households adopted in 2104) adopters. Early adoption was influenced by better education of the spouse, higher household income, lower adult size, and higher family size. But late adoption was influenced by female headship, better spouse education, and spouse primarily engaged on domestic care. The study also showed many households who adopted the ICS have perceived positive attributes of ICSs that indicate the potential for sustained use of the stoves. Based on these findings we draw important policy implication on strategies to scale-up and capitalize the impact of improved stove.

Keywords: Adoption determinant, household energy, impact evaluation, propensity score matching

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Land Use, Agrobiodiversity and Smallholder Rubber Farmers' Risk Perception: A Case Study from Xishuangbanna, China

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Natural rubber plantation, especially smallholder rubber plantation, has been rapidly expanding in Xishuangbanna during the last three decades, triggering profound changes in land use and reducing agrobiodiversity. Although rubber expansion has improved smallholders' income this development carries risks due to the possibility of price decline and environmental degradation. Due to high profits of rubber farming during the recent past, many smallholder rubber farmers in Xishuangbanna have given up their traditional multiple cropping systems and specialised in rubber farming. This paper hypothesises that a major factor that determines the land use strategy of smallholder farmers is their perception of riskiness of rubber farming. Farmers with a higher risk perception are more likely to diversify land use and less likely to specialise in rubber.

To test this hypothesis, we use cross-section data of some 600 rubber farmers in Xishuangbanna. Individual risk perception was measured by a score that expresses the decision maker's subjective assessment of the riskiness of rubber farming. As methodology we use four econometric models, namely Probit, Tobit, Poisson and Seemingly Unrelated Regressions (SUR). We introduce instrumental variables to control for endogeneity. Our results show that farmers with a higher risk score are more likely to plant other crops in addition to rubber, including food crops. Results also indicate that land use strategies are associated with ethnicity, household wealth, off-farm employment, land tenure status, altitude and the household's experiences of rubber farming. Overall, this study can provide a better understanding of smallholder rubber farmer's decision making with regards to land use. Potential entry points for improving agrobiodiversity in rubber-based land use systems can also be identified.

Keywords: Crop diversification, land use, risk perception, rubber, Xishuangbanna

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Factors Influencing Towards Adoption of Organic Fruits and Vegetable Farming Practices: A Comparative Analysis in Karnataka, India

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The organic food sector in India has experienced important growth during recent years. Despite the growth potential, the area under organic farming is very negligible. Indian smallholder farmers are facing challenges to enter and stay in the organic food sector, as well as to derive benefits from this growth in a sustainable way. In this context, the aim of this study was to investigate factors influencing the adoption of organic fruits and vegetable farming practices by smallholder producers in Karnataka. The source of information used was generated through face-to-face interviews with 200 smallholder farmers, among which 100 were organic farmers and 100 conventional farmers. Collected data was analysed by using descriptive statistics and factor analysis methods. Results revealed that younger farmers, affiliated with institutions, counting on higher education, better training, and extension contacts, and having smaller farms are more likely to adopt organic farming. Also, results from the factor analysis showed that issues of cost and benefits, health consciousness, marketing and environmental aspects are the primary factors influencing farmers' decisions on adoption of organic farming. All the four factors together explained 69.5 percent of the total variance in the case of organic farmers. Whereas, in case of conventional farmers all factors together explained only 46.7 percent of the total variance. This research results may help to improve policy interventions targeting smallholder farmers and stakeholders oriented towards organic agriculture development by designing appropriate strategies to promote organic farming in Karnataka state, India.

Keywords: Factor analysis, Karnataka, organic farmers, organic fruits and vegetable

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Adoption of Sustainable Intensification Practices in Northern Ghana

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This study aims to assess the adoption of sustainable intensification practices (SIPs) and analyse its contribution to farmers' income. It is based on the data collected from 1284 households residing in 50 rural villages of northern Ghana in 2014. The data enabled us to capture variations in applying sustainable intensification practices at plot level which has also increased the number of valid observations to more than 2500. Seven sustainable intensification practices were considered in our analysis namely, inter-cropping, crop rotation, organic fertilisers (mainly manure), soil conservation practices, inorganic fertilisers, improved seeds, and pesticides (including herbicides). A multivariate probit (MVP) model was estimated using a simulated maximum likelihood method to assess the integrated adoption of multiple SIPs. Moreover, we used a multivalued semi-parametric treatment effect model (MVTE) to estimate the effects of adopting multiple SIPs on three productivity indicators i.e. gross return (GHC/ha), gross margin (GHC/ha), and returns to labour (GHC/person days) in maize production. The MVP regression result shows that multiple factors explain the adoption of SIPs including plot characteristics, resource endowments, access to information, and demographic factors, though the degree and direction of influence varies among the type of SIPs. Moreover, it shows that the adoptions of the SIPs are interdependent and that most farmers adopt agricultural practices as a package but not as a single technology. Such a mechanism of adoption has helped farmers exploit potential complementarity among the technologies which is visible from the results of the MVTE model. The MVTE estimation shows that mean maize gross income monotonically increases as one goes from no adoption of SIP category through to adoption of four or more SIPs. The results associated with gross margin and returns to labour are a bit different, however. In these cases, the results reveal that complementarity was important in reducing the loss due to bad weather in stead of enhancing gains.

Keywords: Adoption, Ghana, multivalued treatment, sustainable intensification

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Adoption of Improved Livestock Disease Management Practices and Food Security: Evidence from Small Scale Cattle Farmers in Rural Togo

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Keeping livestock especially cattle continue to play significant roles in the livelihood strategies of the resource poor and landless rural households. Notwithstanding, livestock disease especially the African animal trypanosomosis (AAT) remains one of the most important impediments to increased livestock production and productivity in sub-Saharan Africa. AAT is characterised by chronic illness, loss of weight and in extreme cases death. It also reduces the productivity of bulls that may constrain staple crop production. The methods these farmers adapt to manage AAT is expected to have a trickledown effect on their long run food security status. Using a representative data of 448 randomly selected small scale cattle farmer households in northern Togo, this study investigated the adoption of best bet AAT management practices in particular integrated rational drug use (RDU) strategy. Using propensity score matching techniques, we analyse the impact of adoption of rational drug use as a best bet AAT management practices on food security and poverty. We find that adoption of best bet AAT management practices has a positive and significant impact on being food secure. On the other hand, we find that adoption has a negative significant impact on the probability of households falling below the food poverty line by between 17–27 percentage points.

Another interesting finding in this paper is the fact that the impact is found to be heterogeneous across households. We find larger impacts of adoption for the households within the lower quantile of per capita income with the impact decreasing up the per capita income quantiles. This finding also supports the hypothesis that technology adoption improves the livelihoods of poorer households more.

Keywords: Adoption, consumption, food security, impact, trypanosomosis

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Assessing the Welfare Impact of Biochar as a Soil Ameliorant on Urban Farmers in West Africa

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Low soil fertility and high population growth rates have increased the incidence of food insecurity in Africa, particularly in sub-Saharan Africa. Urban agriculture, which supplies 60–90 % of the fresh vegetables consumed in West African cities, is also threatened by continuous conversion of farmland to settlements, thus aggravating the incidence of food insecurity. To enhance resource use efficiency in urban and peri-urban agriculture, UrbanFood^{Plus} (UFP), a research project funded by the German Federal Ministry of Education and Research (BMBF) under its programme GlobE (Securing the Global Food Supply), aims to assess the effectiveness of biochar to increase agricultural output in the West African cities of Tamale (Ghana) and Ouagadougou (Burkina Faso). As using biochar as a soil amendment is an uncommon practice among farmers so far, this study sets out to assess the welfare implications of adoption of this new technology from the perspective of urban producers through an *ex-ante* impact evaluation. Household-level data were collected through the administration of a structured questionnaire. Following a spatial, GIS-based sampling procedure, 168 open-space farmers in Tamale and 237 in Ouagadougou were randomly selected for interviews. In addition, focus group discussions with farmers were held in both cities. Study results indicate that on an average landholding (size: 650 m^2 in Tamale; 1740 m^2 in Ouagadougou), farmers will incur an initial costs of US$265 and US$707, respectively, to incorporate biochar in Tamale and Ouagadougou in the counterfactual situation. On-going field experiments suggest a significant, biochar-related yield increase for vegetables that are typically produced by urban farmers. These results are used to simulate the net welfare effect of biochar application from the perspective of urban farming households, considering the costs related to technology adoption. The focus group discussions highlighted farmers' difficulty in accessing organic and other soil ameliorants. Thus, markets for farm inputs, including biochar, need to be enhanced to sustainably meet the growing food needs of the population.

Keywords: Biochar, BMBF GlobE, food security, UrbanFood^{Plus}, welfare

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Distribution Experiment and Estimation of Willingness to Pay for Improved Bean Seeds in Madagascar

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Madagascar is facing exacerbated poverty and food insecurity especially in rural areas due to low agricultural productivity, low household incomes as well as climate hazards. Malnutrition is prevalent and calories are mainly obtained from staple food such as rice and cassava which leads to widespread hidden hunger. In 2013, in the framework of an ongoing research project in the province of Fianarantsoa, seeds from an improved variety called "Morombe" for the bean *pois du cap* (*Phaseolus lunatus*) have been distributed to households. Adoption of the beans could contribute to a less extended lean period between rice harvests and to a more diversified diet with higher nutritional quality and/or higher agricultural incomes since higher yields might increase selling of the beans.

To analyse the adoption process, we used a randomised treatment control design in which 168 randomly selected households out of the total panel of 354 households were receiving the beans. Of those receiving, 99 randomly selected households were given information on how to store, plant and cultivate the beans.

Existing panel data since 2009 is used to supplement the data on treatment and control households at the time they received the seeds and one year later. Via the contingent valuation method the willingness to pay (WTP) for these improved bean seeds was investigated by asking respondents to state how much they would be willing to pay for improved bean seeds. A regression analysis is applied in order to analyse the variables influencing the WTP.

Adoption is rather low since the variety has not been cultivated in the area before, 55 per cent of the 168 households that received beans planted them. Preliminary results show that the WTP for improved bean seeds is higher than the price of beans purchased on the local market. This might arise from the fact that households were explained the benefits of improved bean seeds like higher yields, no need to sort seeds for cultivation, higher resistance against pests, diseases and drought. Determinants for the WTP are expected to be wealth, willingness to take risk, education and if the households received bean seeds and information.

Keywords: Food security, hidden hunger, improved bean seeds, Madagascar, pois du cap, willingness to pay

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Understanding Influencing Factors to the Spread of Conservation Agriculture (CA) in Sub-Saharan Africa Following the Qatoca Approach: Results from Seven Case Studies

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In order to achieve main objectives of development in Africa (i.e. poverty reduction, food security and sustainable natural resource management), measures to stabilise and increase soil productivity need to be taken without delay. Many studies have argued that the above objectives cannot be achieved under conventional tillage-based agriculture - held accountable for soil degradation and continuous decline in crop yields. Conservation agriculture (CA) based on minimal or no-tillage is increasingly seen as a promising alternative for highly productive and sustainable farming.

In spite its reported benefits, CA adoption rate in sub-Saharan Africa (SSA) compared with other continents have remained extremely low. While literature on adoption constraints is abundant, comprehensive, holistic frameworks and tools for explaining and targetly supporting adoption are still lacking.

This contribution demonstrates how a recently developed Qualitative participatory expert-based Assessment Tool (QAToCA) complemented by selected key informant interviews and structured field observations was applied in seven case studies across Malawi, Burkina Faso, Zimbabwe, Tanzania and Kenya, to 1) determine relative adoption potential of CA, 2) assess institutional, socio-economic and cultural influences on its adoption potential and, 3) identify site-specific hindering and supporting factors to its adoption potential in SSA.

Results show: 1) cases with high adoption potentials explained mostly by positive institutional factors, and lack of alternative options - especially in dry and water limiting areas e.g. the case of northern Burkina Faso where farmers have no option than to adopt the locally adapted CA practice – Zai farming.

2) cases with low adoption potentials attributed mostly to unstable and less secured market conditions and strong competition of CA with livestock over residue.

Critical concerns for long lasting adoption in SSA calls for more innovation systems orientation towards supporting CA adoption amongst smallholder farmers within which attention should be focus especially on 1) addressing emerging needs for new input and output market outlets, 2) adapting CA to the existing management structures of adopting farms and, 3) taking into consideration, the hidden sensitive gender issues between men and women in small scale family structures, 3) further developing a supportive political and institutional frame condition at village and regional levels.

Keywords: Adoption, conservation agriculture, influencing factors, QAToCA, sub-Saharan Africa

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Intensity of Technology Adoption and its Determinants in the Gambia: The Case of New Rice for Africa (NERICA)

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The New Rice for Africa (NERICA) varieties have been disseminated in all the rice production regions of The Gambia. However, a review of the available literature on the adoption rate of such varieties shows no studies assessing their adoption intensity in The Gambia. Hence, this study focuses on bridging such a gap by estimating the adoption intensity of NERICA and its determinants in The Gambia based on a country-wide panel data from 515 randomly selected rice farming households. Tobit regression model is used to identify the factors influencing adoption intensity. The results of our analysis show that 41 % of the total rice area in the country is under NERICA cultivation. The findings on factors influencing adoption intensity suggest that farmer's residence in villages which have been part of initial dissemination of NERICA varieties, contact with the National Agricultural Research Institute, practice of upland rice farming, household size, and access to credit in kind impact positively the farmers' allocation of land to NERICA varieties. On the contrary, being female decreases the likelihood of allocating land to NERICA. Based on these findings, this study recommends that decision makers should focus on improving farmers' access to NERICA seeds via further involvement of local agricultural institutions. This makes use of the closeness of such institutions to farmers in rice growing villages and can further allow identifying key local farmers, who can be labelled as certified NERICA seed producers. This will go a long way in assisting the country to be self-sufficient in rice production.

Keywords: Adoption determinants, adoption intensity, NERICA, Rice, The Gambia

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The Impact of Improved Chickpea Adoption on Household Welfare in Ethiopia

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Chickpea is an affordable source of proteins and nutrients for poor households and improved varieties have a high value with potential for export. We analyse the impact of improved chickpea variety adoption on household welfare in Ethiopia utilising three rounds of panel data (2008, 2010 and 2014) collected in three districts of Ethiopia covering 607 households. The decision to adopt improved varieties is potentially endogenous on household welfare and other observed or unobserved characteristics. We therefore compared the welfare outcomes of poor adopters and non-adopters to analyse whether households with similar resources experience different outcomes. Moreover, based on their adoption history households were allocated to five categories (adopters / non-adopters, late-adopters, dis-adopters and mixed) to compare welfare characteristics before and after adoption. We further addressed the problem of selection bias by estimating fixed effect panel models for the welfare regressions where expected (predicted) values of improved chickpea planting serves as an instrument for observed values. Finally, by disaggregating the panel analysis of poor versus better-off households we tested whether improved chickpea adoption is pro-poor. We established that adoption of improved chickpeas has increased from less than 50 to 80 percent of the total sample and 90 percent of chickpea growers, with improved chickpea contributing up to 25 percent of total household income. Improved chickpeas had higher net returns to both land and labour when compared to local varieties, based on higher productivity and prices. Accordingly, we found that improved chickpea adoption, as captured by both an adoption dummy and the land allocated to improved varieties, has had a strong positive impact on income per capita, assets and livestock ownership. Several wealthier households dis-adopted as they graduated to crops or off-farm activities with higher returns. First time or late-adopters, however, greatly benefited from adopting improved chickpea varieties. Our analysis thus confirms the importance of improved chickpea adoption for poverty and provides support for policies targeting poverty alleviation in rural areas.

Keywords: Ethiopia, household welfare, improved chickpeas, technology adoption

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Identifying the Potential of Ghana 'pona' Yam for Geographical Indication (GI) Labelling

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Consumers worldwide demand more unique origin products featuring a ´connect´ with the ´landscape' and land use systems producing particular qualities. Ghana is endowed with a diversity of tangible and intangible, bio-geo-physical and socio-cultural and traditional landscapes that have influenced the quality, reputation or other characteristic of several differentiated agricultural food products in specific areas giving them the potential to qualify for geographical indications (GI) labelling. However, this enormous potential has not been tapped - in the same way the EU gain billions of Euros per annum from agricultural origin food products registered with protected GIs.The custodians of such potential GIs products therefore languish in abject poverty.
This paper presents preliminary results from VALOR – a research project investigating conditions under which Ghanaian origin food producers can add value by incorporating territory specific cultural, environmental and social qualities into marketing, production and processing of unique local, niche and specialty products.
Cases are investigated of the prospects for Ghana to leapfrog perhaps into exports of GI products, and certainly into allowing smallholder farmers to create employment and build monetary value, while stewarding local food cultures and natural environments and resources, and increasing the diversity of supply of natural and unique quality products and so contribute to enhanced food security.
'Pona' Yam from the Ghana Savannah Regions is one of the product cases investigated and provides for in-depth case study, as ´landscape´ products incorporating ´taste of place´. Framework conditions for producers creating or capturing market value as stewards of cultural and landscape values and environments and institutional requirements for such creation or capturing to happen, including presence of export opportunities, are discussed in this paper. A political ecology approach combined with the sustainable livelihoods framework provides guidance to the understanding and analysis of the research issues.

Keywords: Geographical indications, Ghana, Pona yam, smallholder farmers, unique qualities

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Household Pork Consumption Behaviour in Vietnam: Implications for Pro-smallholder Pig Value Chain Upgrading

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Pork represents more than 70 % of meat consumption in Vietnam, and pig production provides livelihood for more than 4 million small farmers in the country. Understanding pork consumption behaviour is thus important for upgrading the pig value chains in Vietnam. The study is conducted with 416 households in Hung Yen and Nghe An provinces. The results confirm that pork is the most widely eaten animal source food in Vietnam (about 24.7 kg per capita and year), consumed by more than 95 % of the population of different ages and gender. A household spends about USD 30 monthly for pork, accounting for 13 % of total food expenditure. Meanwhile, other types of meat appear to be weak substitutes to pork. While consumers select market outlets for pork based on cleanliness, trust in sources, and the absence of disease in pork sold, 99 % of them still buy meat in traditional, wet markets. This, coupled with the fact that meat quality is not traceable in the value chain and only 3 % of respondents trust in their regular meat supply, implies that the pig value chain, especially the formal/modern retailing sector in Vietnam, has not yet gained consumer trust. Given saturated pork demand with more than 95 % of respondents planning to sustain or decrease their pork consumption, it's unlikely that pork consumption behaviour will significantly change for the majority of Vietnamese consumers. Several potential implications are drawn for upgrading the pig value chains: (i) Organizing small farms into groups applying good practices that allow meat to be traceable and certified by trusted institutions; (ii) Developing a quality assurance system that can be feasibly established under smallholder conditions, and complies with minimum quality and safety standards tailored to Vietnam's context, (iii) Strengthening capacity to collect appropriate market information to provide pig producers, particularly smallholders, reliable meat demand and supply forecast to better serve their target consumers; and (iv) Improving cost and quality competitiveness in pig value chains. These are important considerations especially when Vietnam becomes deeply integrated into the global and regional markets when the Trans-Pacific Strategic Economic Partnership Agreement is officially put into practice.

Keywords: Pork consumption, smallholder market, value chain upgrading

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Reducing Food Security Conflicts through Protection of Potential Agricultural Geographical Indications in Kenya

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Agriculture in Kenya is characterised by low and declining productivity, poor market access and information asymmetry, environmental degradation, and vulnerability to changing and unpredictable climate, among others. This is made more complex by the increasing demand for land mainly for real estate development. Increasing pressure on agricultural land constitutes a major threat to food security especially among smallholder rural communities. Kenya is in the process of developing the Geographical Indications law to protect its origin products. Enhancing market access through protection of origin products as geographical indications has the potential of increasing household incomes, enhancing social inclusion, raising environmental sustainability and alleviating rural poverty. Geographical indications provide consumers with information on product quality and producers with market information.

The study was conducted to scope agricultural origin products that have the potential to be labelled as geographical indications and the possible impact of the standards. The field study, conducted in 2014 and 2015 in different parts of Kenya, involved review of relevant literature, interviews with key information experts in the various agricultural subsectors, as well as groups of producers, traders and consumers. Snowballing was used to determine who to interview in order to get additional useful information. The research identified at least twelve potential agricultural products ranging from export crops like tea and coffee, to locally sold products like Tilapia fish, mangoes and goats, and products of industrial value including *Artemisia* and pyrethrum. In most of the sub-sectors, information asymmetry especially on the part of producers and lack of product differentiation led to sub-optimal marketing. Lack of proper market structures and producer collective action in the highly perishable product markets, like mangoes and fish, led to exploitation by traders. This minimised the benefits that would accrue to producers as result of prices paid for their "unique" agricultural products leading to use of unsustainable practices. Agricultural origin products exist in Kenya that can improve the food security situation through sustainable practices. However, in laying out the geographical indications policy, the formal and informal institutions and rules that influence market structure, information and prices need to analysed and their negative effects minimised.

Keywords: Geographical indications, institutions, markets, smallholder farmers

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Carbohydrates Content at Different Maturity Stages of African Leafy Vegetables

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African indigenous leafy vegetables (ALVs) play a significant role in food security and poverty eradication in sub-Saharan Africa (SSA). Compared to exotic vegetables, ALVs have higher contents of vitamins, minerals, dietary fiber, phytochemicals, antioxidants and medicinal properties. Despite the high values of AVLs, post-harvest losses remains $> 50\,\%$ due to various pre-harvest and post-harvest constrains leading to massive losses along "the field to consumer" chain. Physiological maturity is one of the major factors that highly influences shelf life, phytohormones and nutrients such as carbohydrates and carotenoids contents. Photometric and enzymatic measurement of carbohydrates (glucose, fructose, sucrose and starch) was conducted at 30, 75, and 90 days after planting (d.a.p) in nightshade (*Solanum scabrum*), spider plant (*Cleome gynandra*), amaranthus (*Amaranths cruentus*) and cowpeas (*Vigna unguiculata*). Results indicated the level of carbohydrates to be higher in 30 d.a.p, (170 μg/mg dry weight of the nightshade leaves) than in 90 d.a.p (60 μg/mg dry weight of the nightshade leaves). Higher levels of carbohydrates were observed in Nightshade and cowpeas compared to those of Spider plants and amaranth's. Furthermore, carbohydrates levels were higher in younger leaves (180 μg/mg dry weight in nightshade) than in the older lower leaves (80 μg/mg dry weight) of the same plant in 75 d.a.p. However, storage of vegetables in higher temperatures (24°C) resulted to low starch and high sucrose levels indicating the effects of temperatures on carbohydrates breakdown. Carbohydrates are important in post-harvest processes such fermentation. Determining the right development stages with optimal nutrients levels and longer storability will be a great milestone in solving problems of postharvest losses. Further experiments are going on in Kenya, as well as cytokine measurements, and the results are expected to guide us to determine optimal development stages for harvesting ALVs.

Keywords: African leafy vegetable, carbohydrates, carotenoids, post-harvest

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Improving Yield and Carotenoids of African Leafy Vegetables by Use of Agricultural Nets

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African leafy vegetables (ALV) are not only important sources of minerals but also have medicinal values. However in the open field production, crops suffers from insect pest and diseases and unfavourable weather that severely reduce yield and quality. The present study aimed to evaluate the impact of agricultural nets (agronets) on yield and quality of ALV to ensure livelihood and food security, especially for urban and rural farmers. The ALVs used in the study were vegetable amaranth (*Amaranthus cruentus* L.), Ethiopian kale (*Brassica carinata* A. Braun) and Spider plant (*Gynandropsis gynandra* L). The ALVs were harvested 8 weeks after planting. The experiment was laid in a randomised complete block design with three replications. The treatments include ALVs covered with agronets and open treatments (control). The following parameters were analysed: total carotenoids, lutein, lycopene, ß-carotene, chlorophyll a, chlorophyll b, as well as dry weight, whole plant fresh weight and leaf weight, leaf number and plant height. The results revealed that ALVs grown under agronets had significantly better growth and yield as indicated by more leaves with higher leaf area. The whole plant weight and dry weight was also promoted by agronets. Furthermore, agronets significantly improved carotenoid and chlorophyll contents in the three studied AVLs. Vegetable amaranth grown under agronets resulted to 34 % increase in total carotenoids, while chlorophyll a and b increased by 29.5 %. In Ethiopian kale grown under agronets an increase in chlorophyll b (90 %) was observed, whereas in covered spider plants the chlorophyll a content increased by 62 %. These findings not only show great potential for using agronets in the production of ALVs but also for improving their quality compounds which may in turn contribute to enhance food security for urban and rural African farmers

Keywords: African leafy vegetables, agronets, amaranth, carotenoids, chlorophyll, crop yield, quality

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Characterisation of the Secondary Metabolite Pattern of Vegetable Amaranth

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Vegetable amaranth represents one of the most consumed African leafy vegetable. However, there is a multitude of species cultivated for human consumption and little is known about the various secondary plant metabolites in these vegetables. Phenolic substances as well as saponins belong to the groups of potentially bioactive constituents described so far. Scientific data on the precise chemical nature of these compounds in vegetable amaranth are lacking, however, this is mandatory for an evaluation of the potential health impact of vegetable amaranth on humans. Therefore, the aim of the present work was to characterise the saponin and (poly)phenol pattern of selected amaranth species (*A. hybridus, A. hypochondriacus*, *A. cruentus*). Methanolic extracts of the leaves were analysed by HPLC-DAD-MSn for structural information and quantitative data. The main flavonoids detected in field grown *A. cruentus* leaves were rutin, 120 – 280 mg/100 g; quercetin-3-glucoside, 30 – 50 mg/100 g; and nicotiflorin, 5 – 8 mg/100 g all calculated as flavonoid equivalents in DW. Even more abundant were esters of cinnamic acid derivatives accounting for approx. 650 mg/100 g DW. Only half of these cinnamic acid derivatives could be assigned to e.g. esters of coumaric or ferulic acid and aldaric acid whilst the most abundant compound still needs to be isolated and identified. The saponin pattern was qualitatively analysed and compared between all three amaranth species. In *A. hybridus* and *A. hypochondriacus* high amounts of saponins were detected whilst in *A. cruentus* leaves only trace amounts were found. In *A. hybridus* and *A. hypochondriacus* more than ten different saponins of the oleanan-type (triterpensaponins) could be tentatively identified, whereof six have never been described in amaranth before. Amongst these, at least one derivative possessing significant hemolytic activity could be isolated. Amaranth leaves contain a heterogeneous pattern of phenolic substances and saponins. Many of these substances are chemically and biologically poorly characterised. Moreover, the pattern is strongly dependent on the species, implying that certain species are more nutritious than others. As a consequence a more comprehensive structural identification and biological activity investigation is needed for a thorough evaluation of the potential health impact of vegetable amaranth on humans.

Keywords: Amaranthus species, food analysis, hemolysis, phenolic substances, saponins

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Enhancing the Stability of Probiotic Bacteria in Fermented Milk Fortified Using some Food Additives

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The present investigation studied the effects of some dates palm (date-paste) and olive oil on the viability of bacterial starter cultures (*Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus*) and probiotics (*Lactobacillus rhamnosus* and *Bifidobacteria breve*) in fermented milk during manufacture and storage period. Date-paste and olive oil were added to fermented milk at different concentrations as follows; 1, 1.5 and 2 % for date-paste and 0.5, 1.5, 2.5 % for olive oil respectively. Changes in chemical and viable total bacterial count of fermented milk were monitored during manufacture and storage at 4°C for 30 days. Data showed that the incubation time that was needed to reach pH 4.5 was considerably affected by the added ingredients. Also, the drop in pH or the increase in acidity of this fermented milk was dependent on the added ingredients and the percentage of supplementation. Results indicated that addition of date-paste and olive oil improved the viability of probiotic starter culture and the microbiological properties in the treated samples in comparison with control. The survival of probiotic bacteria in all treatments which were in viable counts remained at $> 10^7$ cfu g^{-1} after 30 days of storage at 4°C. Moreover, addition of dates palm-paste improved the viability and stability of probiotic starter culture than olive oil especially during storage and the total viable counts were 7.1, 7.4, 7.7 and 7.5, 8.0 and 8.1×10^{-7} for olive oli and dates-paste at the end of storage, respectively. Coliforms, *E. coli* bacteria yeasts, and moulds were not detected in tested samples.

Supplementation of the fermented milk with 2 % date-paste and 1.5 % olive oil improved the rheological properties and reduced the curd and syneresis rate was in the range of 34 to 47 %.

Sensory evaluation showed that fermented milk fortified with 2 % date-paste and 1.5 % olive oil recorded the highest score and overall acceptability than the other treatments.

It is suggested that the fermented milk of acceptable quality and high total probiotic bacterial count during storage can be made from milk supplemented with adjusted concentration from date-paste and olive oil, which could guide the dairy industry in developing new probiotic dairy products and food safety.

Keywords: Dates and olive oil, fermented milk, fortification, microbiological quality, probiotic bacteria, stability

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Impact of Hormic Doses of UV-C on Postharvest Quality of Vegetable Amaranth (*Amaranthus cruentus* L.)

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The diet of many rural and recently urban and peri-urban inhabitants is made up of largely African leafy vegetables (ALVs) whose nutritional and medicinal value is well appreciated. Currently, the magnitude of postharvest losses of ALVs in Kenya can reach up to 50 %. UV-C has been used as a germicidal agent for water and surface disinfection including postharvest management of pathogens in fruits and vegetables due to its capacity to affect DNA of microorganisms. Low doses of UV-C irradiation can trigger favourable physiological reactions in biological organs such as fruits and vegetables which can lead to the improvement of shelf-life and storability as well as increase of health promoting components in fruits and vegetables. The objective of the study was to evaluate the effects of postharvest applied UV-C irradiation (254 nm) on weight loss and characteristic plant compounds such as carotenoids, chlorophyll and protein of vegetable amaranth (*Amaranthus cruentus* L.). Eight weeks after sowing, vegetable amaranth leaves were harvested and immediately subjected to UV-C at 1.7 kJm^{-2} and 3.4 kJm^{-2}. Non treated plants served as control. Thereafter, leaves were stored at 5°C (85 % rH) for 14 days and 20°C (85 % rH) for 6 days. The experiment was laid in completely randomised design with three replications. Results obtained indicated that postharvest treatment of vegetable amaranth with UV-C contributed to significantly reduce weight loss and enhanced carotenoid, chlorophyll and protein content at hormic UV-C doses (1.7 kJm^{-2}). The findings of the present study therefore indicate the use of UV-C as a postharvest treatment technology that is relatively affordable and easy to apply for improving quality of ALVs, which might be a promising step in enhancing food security.

Keywords: Carotenoids, chlorophyll, indigenous African vegetables, postharvest treatment, protein, UV-C

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Improving Carrot (*Daucus carota* L.) Fruit Storability by Edible Coating Containing Aloe Vera Gel and Essential Oil from Sesame Seed

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The increasing interest and research activity in edible packaging have been motivated by both increasing consumer demand for safe, convenient, and stable foods and also awareness of the negative environmental impacts of non-biodegradable packaging waste.

The aim of this study was to improve carrot fruit storability by testing the effect of edible coating containg *Aloe vera* gel and essential oil from sesame seeds. The three experimental coatings were: *Aloe vera* gel (AVG), sesame oil (SO), mixture of *Aloe vera* gel and sesame oil (MAVGSO). The following parameters were measured: weight loss, ascorbic acid content, pH, total soluble solid, firmness and microbial qualities. The carrot were stored for seven weeks at ambient temperature. Prior to storage, the carrot samples were surface sterilised using 100 mg L^{-1} sodium hypochlorites. Results showed that edible coatings was effective in extending the shelf-life of carrot when compared to untreated control in the following order: MAVGSO $>$ AVG $>$ SO $>$ Control. Results revealed that coatings hindered the growth of microorganisms significantly ($p < 0.05$).

Development and evaluation of this indigenous and biodegradable edible coatings will help in prolonging the shelf-life of fruits and vegetables, thereby ensuring food security, poverty reduction and wealth creation in alignment with the objectives of United Nations Millennium Development Goals and Agricultural Transformation Agenda (ATA) of the Federal Government of Nigeria.

Keywords: *Aloe vera* gel, biodegradable, carrot, edible coatings, sesame oil

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Season Effect on Fatty Acids Composition of Desert Camel Meat (*Camelus dromedarius*)

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The present work was designed to study the effect of slaughter season on fatty acids composition of the desert camel Longissimus thoracis (LT) muscle. Desert camel calves (n=30) were fattened by local camel herders in Sudan and slaughtered in different seasons of the year: winter, summer and autumn, ten camels each. The results showed that the average of total lipids was 11.7 g/ 100 g fresh muscle. No differences among seasons were observed in fatty acids composition. Slaughter season did not influence Myristic acid (14:0) which was 5.2 % (average of three seasons). Camel LT muscle contained 52.2 % SFA, 35.8 % MUFA, 11.6 PUFA and 0.5 % CLA, respectively. The total MUFA was higher in summer season as compared to other seasons. Similar results were obtained, the ratio of 18:2 n-6/ 18:3 n-3, n-6/ n-3 as well as UFA/ SFA were significantly influenced by slaughter season ($p < 0.05$). The concentration of conjugated linoleic acid trans11, cis9 18:2 (CLA) was 0.5 %, however no differences among seasons were observed. CLA content and the percentages of trans11, cis 9 18:2 isomer are relatively high. Slaughter season significantly affected the n-6/ n-3 ratio of camel LT muscle ($p < 0.05$). This ratio was within the recommended values for the human diet which indicated that camel LT muscle has a high nutritional value throughout the year. The predominant fatty acids in camel LT muscle were Palmitic acid (16:0) and stearic acid (18:0) as saturated fatty acids (SFA), 18:1Δ9+10 cis and 18:1Δ11 cis as monounsaturated fatty acids (MUFA) and LA; 18:2n-6 as polyunsaturated fatty acids (PUFA) indicating the high quality of fatty acids.

Keywords: Desert camel, fatty acids, lipids, slaughter season

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Acoustic Characteristics of *Acanthoscelides obtectus* (Say) (Coleoptera: Bruchidae) on Common Beans *Phaseolus vulgaris* L. (Fabaceae)

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Acanthoscelides obtectus a multivoltine bruchid beetle, is a serious pest of common bean *Phaseolus vulgaris* L. (Fabaceae) in the tropics and subtropics. It is difficult to detect the presence of *A. obtectus* because it is cryptic and spends most of its developmental time inside the bean seeds. Their presence being almost imperceptible except for neat circular emergence holes created by the last instar larvae as they exit as adults. Because early detection of this pest using inexpensive acoustic means can be achieved, laboratory experiments were conducted to estimate the acoustic characteristics of the larvae and adults of *A. obtectus* on stored common beans. Spectral and temporal features of recorded sound signals recorded in an anechoic chamber were analysed. The larvae displayed continuous low amplitude impulses with periods of successive peaks and bursts. In contrast, the adults displayed lower amplitudes of impulses with less distinct peaks. In addition, spectrograms associated with the larvae had more high energy regions as compared to those of the adults indicating that movement by the adults is generally associated with low energy sound produced during mating and oviposition. Contrastingly, spectrograms of larvae were characterised by higher energy due to the feeding, locomotion, moulting and pupating especially during eclosion and as the new adult emerges from the infested seed. Analysis of impulse and burst rates revealed that rates of noise impulses in larvae and adult sounds varied significantly. The rates of bursts, rates of impulses and the impulses per bursts for the larvae and the adults were significantly ($p < 0.05$) different. Overall, the larvae and adults of *A. obtectus* produced varied acoustic signals that could be harnessed to acoustic sensor development. The use of acoustic sensors for real-time detection of *A. obtectus* infestation in stored common beans in sub-Saharan Africa will contribute to hunger and poverty alleviation.

Keywords: *Acanthoscelides obtectus*, acoustic characteristics, bursts, common beans, Impulses

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Tanzanian Food Origins and Protected Geographical Indications

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Geographical indications can aid in transforming the Tanzanian agriculture-dependent economy through tapping the unique attributes of their quality products like soil, taste colour – and so indirectly contribute to food security through valorisation of non-market values or creation or strengthening of market values.

Consumers worldwide demand more unique origin products featuring a ´connect´ with the land use systems producing particular qualities. Tanzania has demonstrated capacity to tap into the organic world market and has untapped potential for harvesting market value from geographical indications indications - in the same way EU gain billions of Euros per annum from agricultural origin food products registered with protected geographical indications.

This paper presents preliminary results from VALOR – a research project investigating conditions under which Tanzanian origin food producers can add value by incorporating territory specific cultural, environmental and social qualities into marketing, production and processing of unique local, niche and specialty products.

Cases are investigated of the prospects for Tanzania to leapfrog perhaps into exports of geographical indications products, and certainly into allowing smallholders to create employment and build monetary value, while stewarding local food cultures and natural environments and resources, and increasing the diversity of supply of natural and unique quality products and so contribute to enhanced food security.

Rice from Kyela, coffee and sugar from Kilimanjaro, are some of the product cases investigated and provides for in-depth case study, as ´landscape´ products incorporating ´taste of place´. Framework conditions for producers creating or capturing market value as stewards of cultural and landscape values and environments and institutional requirements for such creation or capturing to happen, including presence of export opportunities, are discussed.

Keywords: Food origins, food security, protected geographical indications

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Choice of Sweet Peppers: Investigating Factors Affecting Taiwanese Consumers' Purchase Decision Using Best-Worst Scaling Methodology

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Consumers' food purchase decision is rarely formed by a single product or process attribute. Rather, consumers' choice is determined by a combination of different characteristics - search, experience and credence attributes – as well as by particular features of the decision-making environment such as the shopping location or recommendations given by significant others.
This study accounts for this complexity of consumers' food choice by applying best-worst scaling (BWS) methodology in a street-intercept web survey in Taiwan for fresh sweet peppers. Nine very different factors able to influence consumers' decision making for sweet peppers were tested in an experimental setting. The nine attributes (country-of-origin; production methods; chemi-residue test; price; shopping location; visual appearance; sense-of-touch; package size and recommendations given by an important person) included in the analysis had been identified in a pre-study. Overall, 481 respondents participated in the study. Respondents faced four choice tasks, each with five attributes.
A mixed logit model was applied to quantify the importance of the attributes for consumers' purchasing behaviour. Latent class analysis allowed uncovering heterogeneity inherent in the food preferences among Taiwanese consumers. Three segments emerged from the analysis: the largest group of health-perceptive buyers (51.9 %) represents consumers that reveal a strong focus on the displayed information regarding production methods and chemi-residue test (credence attribute), but care less for price. The exterior seekers (27.9 %) show a strong importance for the tactile sense and visual appearance of the sweet peppers (search attribute), with price being as well an important attribute for them. The origin-orientated buyers (20.2 %) perceived the country-of-origin information (credence attribute) to be most relevant.
This study sheds light on the importance of different product and process attributes as well as environmental factors on consumers' purchase decision for sweet peppers. Results show the high relevance of origin- and health-oriented cues, and thus of credence attributes, for consumers' food choice. However, there are also some consumers placing a strong emphasis on sensory-oriented cues of a product. The preference heterogeneity detected in the study can be used in customized marketing and trading, in order to offer differentiated products in line with consumer preferences.

Keywords: Best-worst scaling, consumer preference, latent class analysis

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Iron Concentrations in Roots and Edible Organs of African Indigenous Vegetable Species

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Iron (Fe) deficiency is among the 10 leading human health risks causing "hidden hunger" in sub-Saharan Africa. Iron concentrations and bioavailability are often higher in leafy vegetables than in staple crops like maize and sorghum. Therefore, increasing food diversity through vegetable production and consumption is an option to mitigate Fe deficiency.

The aim was to quantify Fe uptake and distribution between roots, stems and leaves in selected African indigenous vegetable (AIV) species, and to compare species responses to different rates of Fe supply.

Plants of five leafy AIV species (African night shade *Solanum scabrum*, amaranth *Amaranthus cruentus*, cowpea *Vigna unguiculata*, spider plant *Cleome gynandra*, Ethiopian kale *Brassica carinata*) and a standard species commonly grown in Kenya (kale *Brassica oleracea acephala* group) were grown in nutrient solution at three rates of Fe supply (sub-optimal to induce Fe deficiency responses, optimal for growth, supra-optimal to test if Fe density in edible organs can be enhanced by additional Fe fertiliser application). Leaf chlorophyll content (SPAD-meter) and pH of the nutrient solution were measured at regular intervals to quantify shoot and root responses to Fe deficiency. At harvest, biomass and mineral nutrient concentrations were measured separately for roots, stems and leaves.

The species markedly differed in their early root responses to Fe deficiency. Whereas in amaranth, proton extrusion from roots was significantly increased at low Fe supply compared to medium and high Fe supply, in spider plant and kale proton extrusion was not influenced by Fe supply. Fe concentrations in the plant dry mass strongly varied among plant organs and decreased in the order roots >> leaves > stems. In all organs, Fe concentrations were significantly affected by species. Concentrations in shoots varied from 17 (Ethiopian kale) to 39 mg Fe kg^{-1} dry mass (amaranth) at low Fe supply, and from 42 (Ethiopian kale) to 127 mg Fe kg^{-1} dry mass (cowpea) at high supply respectively

Responses of Fe density in edible plant organs indicate that the potential for increasing the nutritional value of leafy vegetables by Fe fertilisation (biofortification) is largest in cowpea and spider plant.

Keywords: Biofortification, hidden hunger, iron deficiency responses, rhizosphere

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Cadmium Uptake and Distribution to Edible Organs in African Indigenous Vegetables

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Cadmium (Cd) is toxic to humans. The most important source for dietary intake is consumption of plant products, whereby Cd concentrations in leafy vegetables are particularly high. In peri-urban areas, soils are often contaminated with Cd. Thus, recommendations to increase vegetable consumption should consider species-specific uptake and allocation to edible plant organs. Cadmium uptake and distribution within plant was compared in various species to derive recommendations for vegetable production on contaminated soils. Four African indigenous vegetable species (African Nightshade *Solanum scabrum*, amaranth *Amaranthus cruentus*, cowpea *Vigna unguiculata*, spider plant *Cleome gynandra*), and a standard species commonly grown in Asia (Pak Choi *Brassica rapa chinensis*) were grown in nutrient solution at three Cd-concentrations: 0.1 (low), 1.0 (moderate) and 2.5 μM Cd (high contamination). Biomass and mineral nutrient concentrations were measured in roots, leaves, stems and lateral branches.
Growth was little affected by Cd supply with the exception of amaranth and cowpea. In these species, growth of shoot organs was substantially reduced at moderate and high supply. Growth depression was associated with low leaf iron concentrations indicating Cd-induced iron deficiency. In all species Cd concentrations were higher in roots than in shoot organs, which is in accordance with xylem loading being an important barrier for Cd distribution within plants. At moderate and high supply, Cd concentrations in shoot organs strongly differed among species. Concentrations were particularly low in cowpea, and high in amaranth and African Nightshade. Low Cd concentrations in shoot organs of cowpea were associated with low apparent uptake and translocation rates of Cd from roots to shoots. At all rates of Cd supply, Cd density in edible organs was significantly influenced by species. Cadmium density was particularly low in cowpea and Pak Choi. Based on a vegetable dish of 250 g fresh mass, best choice of species reduced Cd intake by 0.1 mg at low supply (amaranth versus African Nightshade), 0.7 mg at moderate (cowpea versus African Nightshade) and 1.7 mg at high Cd supply (cowpea versus amaranth). Best choice of vegetable species can considerably reduce Cd intake by humans.

Keywords: Cd contamination, cd toxicity, dietary intake, leafy vegetables, peri-urban horticulture

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Comparison of Chemical Composition of Goat Milk from Farms and Individual Households in Khartoum State, Sudan

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Goat was one of the first animals to be domesticated and it remained a popular animal serving the needs of man all over the world. Goat milk is one of the milk sources that is characterised by an economical, nutritional and medical importance, especially for children who suffer allergy from the cow milk. Since goat milk has a high importance as a source of nutrition for poor communities, the present study was conducted to evaluate some of the physio-chemical properties (fat, solids not fat (SNF), density, protein, lactose and acidity) of goat milk. Samples were collected in Khartoum State, Sudan during winter and summer seasons. Fifty samples of raw goat milk were collected from both farms and individual households (25 each). The average fat content, SNF, protein and lactose of goat milk samples were higher during winter season (5.11±0.2 %, 9.3±0.07 %, 3.6±0.03 % and 5.0±0.04 %, respectively). Similarly the average fat and SNF were higher in milk samples obtained from dairy farms (5.4%±0.4 % and 9.1±0.0 %, respectively). The fat, lactose and acidity of goat milk samples were significantly ($P \leq 0.01$) different in goat milk samples collected from different sources. The acidity of goat milk samples was higher (0.15±0.0 %) during summer. Moreover acidity and density of goat milk samples collected from different sources and during different seasons showed high significant ($P \leq 0.001$) differences. The present study concluded that generally goat milk is of good compositional quality during winter season and that goat milk revealed high content of protein and lactose for the samples collected from individual households compared to those from dairy farms. Hence this study recommended the improvement of goat production in order to utilise its milk because of its nutritional and economical significance.

Keywords: Compositional quality, farms, goat milk, households, seasons, Sudan

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Food and Herbal Remedies Consumed in Manila, The Philippines

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The Philippine islands are extremely vulnerable to hurricanes. It is also a country that possesses a high prevalence of poverty and frequent socio-political stresses. Food security and health care are major concerns in Manila, where most households rely on herbal medicines and informal fruit and vegetable trade to solve their health and nutrition needs. Current contribution presents the results of a survey conducted by the Portuguese Tropical Institute in early 2015. The main objective of this research is to compile the species of fruits, staples and medicinal plants consumed in Manila and to compare them with the plants mentioned in early Spanish colonisation manuscripts. The survey totaled fifty semi-structured interviews to three categories of informants, following the format of previous investigations on the same issue, elsewhere in Asia and in Latin America. Results show that there is predominance in consumption of Asian species, particularly in herbal medicine. Due to the importance of the Chinese community, in terms of wealth, trade, and number, Chinese medicinal flora is especially sought. In fact, they settled on these islands long before the Portuguese Magellan officially discovered those (1521) at the service of the Spanish kingdom. Nevertheless, there is still preference for a few popular Old World species introduced by the Europeans, such as grapes (*Vitis vinifera*), mint (yerba buena as in Spain), or tusilago (*Tussilago farfara*), and native American plants as yacón (*Polymnia sonchifolia*), guava, guayabano (*Annona muricata*), and corn, which trade route was initiated from New Spain (Mexico) through the Pacific in the sixteenth century. Hope is to contribute to the study of medicinal flora in the Philippines, which has frequently dual consumption as food.

Keywords: American, Asian, European, flora, food, medicine, Philippines

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Evaluation of Fruit and Vegetable Consumption as Phytonutrient Potential in Lebanon

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Fruits and vegetables (FV) are known to contain considerable amounts of vitamins and minerals in addition to phytonutrients and bioactive compounds having many positive health effects in the prevention of diseases such as cardiovascular illnesses, cancer, etc. Therefore, it is crucial to evaluate the FV consumption as sources of phytonutrients of the Lebanese population. A cross sectional analysis of 390 Lebanese individuals aged between 20 and 65 years old located in six Mohafazat (Beirut, Mount Lebanon, North, South, Nabatieh and Bekaa), was conducted. Sociodemographic, lifestyle, eating behaviour, food frequency questionnaire (FFQ) and awareness information were collected through a questionnaire specifically adapted for the purpose of the study. Statistical analysis was carried out and multivariate models were used in order to evaluate the association between fruits and vegetables consumption and different independent factors. The FV consumption among the Lebanese population was acceptable compared to the international recommendations. Regarding vegetables, 38.5 % of the Lebanese respondents, showed a high level of consumption versus 37.98 % having a low level of consumption. Related to fruit consumption, 38.08 % Lebanese respondents consuming high levels of fruits compared to 36.54 % of the Lebanese respondents, showing a low fruits intake. Furthermore, it was observed that the majority of the study population was highly aware of the importance of phytonutrients in FV and were willing to consume these food items more and more, 49.23 % of the Lebanese population. The FV consumption was the most associated with the area of residence, age, education level, work, salary ranges, weight loss diet, physical activity, smoking, supplement intake the monthly amount of money spent on food and consumptions of starch, dairy products, meat, herbs and juices. The findings stated that the consumption of FV in Lebanon is acceptable, even though it is affected by several socio demographic and lifestyle factors. Future governmental or national programs and interventions could be settled to encourage and increase the FV consumption among all the population age levels and areas of residence.

Keywords: Awareness, bioactive compounds, fruit, health, phytonutrients, vegetable

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Assessment of Chemical Characteristics of Pupuru Analogue from Breadfruit Enriched with Tigernut

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The promotion of some underutilised crops cannot be overemphasised as they have potential economic and nutritional benefits resulting to solving the problems of food insecurity and malnutrition. In this work, an imitation of pupuru (cassava – based food) was produced using bread fruit (*Artocarpus atilis*) and enriched with flour produced from tigernut (*Cyperus esculentus*) at different proportions (90:10; 80:20; 70:30 and 50:50 of breadfruit : tigernut). Control sample from cassava was also produced following the traditional method.

The results obtained indicated higher protein content in the samples from breadfruit than pupuru from cassava. The protein content values of the samples were significantly different ($p \leq 0.05$) and ranged from 2.75 to 3.73 %, with 100 % breadfruit having the lowest value while breadfruit with 50 % tiger nut substitution had the highest value. The pupuru made from cassava mash (control) had a protein value of 1.70 % which is lower than that of the composite flours. The crude fiber content value ranges from 1.38 % for pupuru made from cassava mash to 5.11 % for breadfruit : tigernut composite flour with ratio 50:50. For magnesium and copper there was a steady increase up to 70:30 substitution. Substitution does not affect calcium content of the composite flour significantly. Sensory evaluation rated the taste of the control sample better than the rest, followed by the 100 % breadfruit pupuru flour, while the flour produced from breadfruit pupuru substituted with 10 % tiger nut was least rated. The texture of pupuru flour produced from 100 % cassava had the best rating, while the flour from breadfruit pupuru substituted with 40 % and 50 % tigernut flour was least preferred by the panelists. The breadfruit pupuru samples containing tigernut at varying proportions except the one with 10 % and 20 % tigernut had texture attribute similar to the pure cassava pupuru flour. The result from this work has demonstrated the potential of breadfruit in the production of pupuru analogue which must be harnessed to prevent overutilisation of cassava.

Keywords: Breadfruit, chemical composition, pupuru analogue, tigernut

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Is it Possible to Influence Chemical and Technological Attributes of Eland Meat by Enriched Diet?

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The eland (*Taurotragus oryx*) is a cattle sized African antelope commonly hunted for its meat with excellent farming potential. Unfortunately published meat attributes are limited. Therefore, the influence of enriched diet on the chemical and technological meat parameters of farmed eland was studied. Ten young bulls were divided into experimental (n = 5) and control group (n = 5). Diet of experimental group was enriched with feeding granules for period of 8 months. Both groups were fed with mixed diets based on maize, lucerne silages and cereal straw. Musculus triceps brachii (TB), m. semimembranosus (SEM), m. pectoralis profungus (PP), m. longissimus thoracis et lumborum (LTL) were dissected from slaughtered elands and analyzed. The enriched diet increased crude protein content ($p = 0.0251$), total fat content ($p = 0.0291$) and dry matter content measured on drying scales with infra-red radiator ($p = 0.0284$). The interaction between diet and muscle shoved differences only in total fat content ($p = 0.0007$). The difference between muscles was proved ($p < 0.0001$) for crude protein content, total fat content, dry matter content, pH value, water-holding capacity (Grau and Hamm's filter paper press method, cook losses), colour and tenderness, measured as Warner-Bratzler shear force, all regardless on diet. Differences between the muscles were found regardless on diet between more valuable cuts (LTL, SEM) and less valuable cuts (TB, PP). The diet influenced chemical attributes, such as protein, total fat and dry matter content, but did not affect technological attributes, such as pH, meat colour, WHC and tenderness.

Keywords: Chemical attributes, eland, meat, nutrition, technological attributes

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Evaluation of Essential Oils as Biocide in Cucumber from Farm to Consumer

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To enhance and maintain food security, agricultural systems need to be screened to increase application of environmentally fertiliser and pesticides. Key benefits of essential oils are to progress food security without further polluting soil and water resources. The present study was conducted to investigate the effects of 5 essential oils (0, 500 and 1000μll^{-1}) including pepper, garlic and onion, thyme, cumin and savory as fungicide on food safety and pathogen disease of cucumber in comparison to common fungicide carboxin - Thiram. The first treatments were done by seed soaking in volatile oils for three days; for control, seed soaked in ‰2 concentration of Carboxin -Thiram. Followed sowing, seeds were irrigated by the same treat from germination to forth leaf development stage. Germination percentage, percent survival, seedling height, and diameter were evaluated at 8 weeks. During growth season, cultural practice was performed when necessary by bio-fertilisers and bio-pesticides. Followed fruiting, the first fruits and soil were evaluated to investigate the amount of fungicide and pathogen residues. The growth rate of the pathogens was partially or completely inhibited by all the essential oils at concentrations up to 500 μll^{-1}; they were not different from the fungicide. Garlic and onion, thyme, and cumin essential oils showed fungicidal effect on soil-borne pathogens at the concentration 500 μll^{-1}. However, pepper and savory oils, at a concentration 1000 of μll^{-1}, were lethal for this pathogen. The persistence of antifungal activity was different among essential oils. Therefore seedling survival ranged from 80 to 95 %, although in the control, it was 30%; with increasing essential oils concentration germination percentage and seedling survival significantly increased. Observations revealed alteration in the residues of essential oils and fungicide was present in fruits and soil. Essential oils had significantly less residues incidence in fruits and, improved fruit safety, however the residues of fungicide was detectable in the fruits belonging to seed treated with fungicides. These results were also observed in the soil samples. Findings suggest that essential oils possess strong inhibitory potential against pathogens that could be recommended as a potential source of biological fungicide in order to produce safer and healthier product.

Keywords: Cucumber, essential oils, food safety, fungicides

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Health, nutrition and food security

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Essential and Toxic Minerals in Leafy Vegetables from Open Air and Supermarkets in Nairobi

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Deficiency of macroelements such as calcium (Ca) and microelements like zinc (Zn) is widespread in sub-Saharan Africa, particularly among the poor, for which diets are strongly based on staple crops like maize and sorghum. Increasing diet diversity through African indigenous vegetables (AIV) might be an option to reduce hidden hunger caused by mineral deficiency. In addition to mineral deficiency, toxicity of heavy metals like cadmium (Cd) and lead (Pb) is another important health risk which is closely related to dietary intake of plant products. Vegetables may be contaminated by toxic elements through superficially adhering dust on edible surfaces or root uptake from soil and internal distribution to edible organs.

In this study, essential and toxic elements were measured in edible plant organs of vegetables sold on markets in Nairobi to assess potential health benefits and risks associated with consumption of AIV.

Fresh samples from AIV (*Solanum scabrum*, *Amaranthus cruentus*, *Vigna unguiculata*, *Cleome gynandra*, *Brassica carinata*) and a standard species commonly grown in Kenya (*Brassica oleracea acephala* group) were collected from ten open air and five supermarkets in Nairobi. Before mineral analysis, the edible parts of the vegetables were washed either with distilled water to remove minerals associated with externally adhering soil and dust, or 1 % nitric acid to remove minerals associated with epidermal cell walls, or not washed at all. Essential (e.g., Ca, magnesium Mg, iron Fe, Zn) and toxic (e.g., Cd, Pb) mineral elements were measured.

The results showed that mineral element concentrations were similar in samples from open air and supermarkets, with the exception of Pb concentrations which were markedly higher in open air markets, indicating contamination by traffic. In 10 % of all samples Cd concentrations exceeded 1 mg kg^{-1} dry mass indicating that vegetables may be an important source for dietary intake. Iron concentrations were very high. Washing with water or nitric acid strongly reduced Fe and Al concentrations, indicating that high Fe concentrations were mainly due to external contamination. Concentrations of Zn and Mg were very high in amaranth suggesting that this species is a particularly valuable source of these essential elements.

Keywords: Heavy metals, hidden hunger, iron, nutritional value, peri-urban horticulture, surface contamination, zinc

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Don't Forget about the Children — Latent Food Insecurity in Rural Cambodia

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When measuring food insecurity in rural Cambodia we find that common indicators such as the Food Consumption Score (FSC) or the Coping Strategies Index (CSI) do not reveal great problems with food insecurity. However, anthropometric data for children under five and caloric intake for adults indicates that malnutrition, stunting and nutrition deficiencies are widespread. This finding is somewhat puzzling. This paper therefore aims to measure and compare different food security indicators along with more complex measures including weight-to-height ratios and caloric intake. Further, we analyse food consumption patterns and cultural habits that explain the prevalence of malnutrition in rural Cambodia. The data set consists of 600 randomly sampled households from Stung Treng, located in the North of Cambodia. Our results suggest that households in Stung Treng are indeed able to meet their basic food security needs as indicated by the different food security indicators throughout the year. But while food diversity is relatively large, the quantities consumed are small and caloric intake mainly stems from rice. Given that the majority of the households are engaged in manual labour related to crop and livestock production, caloric intake per person is found to remain at the lower bound of sustaining the individual's strength. Children below five are found to suffer from stunting and malnutrition. Despite the increase of caloric intake in the last decade, rice and fish remain the main source of food. Further, we find that people are not aware of malnutrition and deficiency issues since for them having enough rice means that they are food secure. Thus, due to its cultural dimension it will be difficult to change people's diet and food consumption pattern. In order to improve the situation it is important that policy makers are aware of the latent food insecurity, especially for children, in rural Cambodia.

Keywords: Anthropometrics, caloric intake, food security, rural Cambodia

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Improving Infant and Young Child Feeding Practices through Nutrition Education with Local Resources — Results from a Longitudinal Study in Malawi

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Main causes for undernutrition are a diet poor in quality and quantity, feeding practices, and hygiene. Programmes emphasise on affordable ways for improving diets for low-income families. Food security is considered essential for any improvements in diets. A longitudinal study was conducted in Malawi looking at feeding practices as well as growth of children below two years. At baseline 6–9 months old children and their caregivers participating in a nutrition education (NE) programme of FAO were invited. The recruited children were matched by age (days) and sex with children living in an area without NE (control). The intervention, nine nutrition education sessions plus one graduation ceremony, included topics on hygiene practices, breastfeeding, composition and consistency of complementary food and cooking demonstrations. The sessions were carried out by trained volunteers twice a month based on locally adopted teaching materials. The children and their caregivers were visited by the longitudinal study team every three months for a total period of 12 months to assess current infant and young child feeding practices and household food insecurity using the household food insecurity access scale (HFIAS; 0= food secure – max 27= highly food insecure). At baseline (prior to the NE) the mean age of the children was 227 days, all breastfed (n=149). In the intervention area the prevalence of children receiving a minimum acceptable diet (MAD) doubled from 42 % to 88 % after three months and reached 92 % one year after baseline. The rates in the control area doubled as well from 22 % at baseline to 52 % three months later but did not increase further reaching 56 % one year after baseline. In the intervention area, the mean HFIAS was at baseline 6, increased to 7 six months later, and dropped to 2 one year after baseline. The values in the control area were always 1–2 points higher. The food insecurity level changed from baseline to 6 months later in both areas equally. However, the caregivers in the intervention group managed to improve and sustain the improvement of the children's diet after the nutrition education despite changes in food security.

Keywords: Food security, infant and young child feeding, nutrition education

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Food Habits Matter: Investigating the Consumption of African Indigenous Vegetables in Kenya

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Kenya is confronted with a paradoxical situation of malnutrition: on the one hand hunger is still prevalent within the Kenyan society with 24 % of the population being undernourished; on the other hand an increasing number of the population is suffering obesity and "hidden hunger". In order to overcome malnutrition in Kenya recent studies emphasise the relevance of African indigenous vegetables (AIVs), which are nutrient rich and contain medicinal value. Although AIVs are an important component of households' diets in Kenya, AIV consumption is still low. Thus, this paper aims at investigating the factors that influence consumption of AIVs in Kenyan households.

This paper presents first research results of the HORTINLEA subproject "Meal Cultures in Market Trends and Consumption Habits". The paper starts from the assumption that place-based practices of food production and preparation, symbolic meanings of food as well as social relations of power frame the consumption of food. Referring to the concept of "Meal Security" we argue that it is necessary to take account of socio-cultural aspects of food practices when analysing food security.

First findings of the study reveal that the consumption of AIVs differs due to place-based, ethnic and gendered practices of food production and preparation. The paper starts with, firstly, presenting the conceptual framework of the social embeddedness of food habits and meal cultures. Afterwards, the main research results will be presented. The paper will, for instance, show that food habits and meal cultures are significantly affected by the gender division of labour: provision, preparation and serving AIVs is mainly women's work. Consumption of AIVs is negatively affected by the time-consuming preparation processes, like plucking, washing and cooking. Finally, the paper will draw conclusions on how to link the concept of meal security to issues of food and nutrition security by analysing contexts at household level, which may not be visible at first glance but significantly influence the acceptability and accessibility of leafy vegetables.

Keywords: African indigenous vegetables (AIVs), food habits, gender, meal security

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Food Plant Diversity in Homegardens and its Contribution to Family Nutrition – A Case Study from Rural North-Eastern Bangladesh

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Child stunting and anemia amongst children and young mothers as indicators for malnutrition are on alarmingly high levels in Bangladesh as vitamins and minerals from fruits and vegetables are often insufficient in rural diets. Homestead food production may be a promising way to combat malnutrition, considering the high crop diversity and potential year-round production in homegardens. However, little data exists on crop diversity in homegardens in many parts of Bangladesh and its contribution towards nutrition security of farmer families.

This study aimed at assessing the effect of food plant diversity in homegardens on dietary diversity and nutritional status (wasting and stunting) of young mothers (< 30 years) and their children (< 3 years). Environmental factors, socio-economic characteristics of the households and challenges for intensifying food production were identified, alongside the effects of socio-economic factors on dietary diversity.

In rural north-eastern Bangladesh, 64 households with homegardens were randomly selected and all food plants (fruits, vegetables, spices, staples and stimulants) inventoried in each homegarden. Socio-economic household data and information about homegarden management and used plant species were collected with interviews, and a 24 hour dietary recall applied to mothers and children.

A total of 82 food plant species were found in the surveyed gardens with a mean of 18.1 species per homegarden (range 4–45 species). Dietary diversity for women (WDDS) was low (mean 3.7, range 1–7) and homegarden produce contributed only little to the women's diets. As the survey was performed in the vegetable growing season (December-January), even lower dietary diversity and higher micronutrient deficits most probably exist during the rest of the year. As much as 53.3 % of the surveyed children were stunted and 8.6 % were wasted. Multivariate linear regression analysis showed that socio-economic factors such as wealth and size of paddy land had a larger impact on dietary diversity than the number of food plant species grown in the homegarden.

The potential for intensifying homegardening was apparent, so that agricultural interventions in the area would have to raise awareness for dietary diversity in the households, enhance homegardening skills and reduce seasonal gaps in the year-round food supply.

Keywords: Dietary diversity, fruit, homestead, malnutrition, stunting, vegetable

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Local Dynamics and Perceptions of Food Insecurity among Agroforestry Family Farms in Ethiopia

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About 80 percent of the Ethiopian population depends on small-scale family farming. Family farms account for more than 95 percent of the agricultural production of the country. Agroforestry plays a significant role for family farms particularly in South-West Ethiopia. The "Comprehensive Food Security and Vulnerability Analysis" (CFVA) published by the Ethiopian Central Statistical Agency and the World Food Program in 2014 defines almost half of the Ethiopian family farms as 'food insecure'. Findings like this determine policy making and agenda setting for (rural) development strategies and programmes in Ethiopia. Upon this backdrop, this paper shows findings of a study on local dynamics and perceptions of food insecurity among agroforestry family farms in Yayu area, Oromiya Region, South-west Ethiopia. It is based on household interviews conducted as part of the transdisciplinary research project "BiomassWeb – Improving food security in Africa through increased system productivity of biomass-based value webs". The studies' results contest different food security conceptualisations by providing evidence on the strong and complex dynamics in food insecurity magnitude and quality, as well as showing what Ethiopian family farmers actually understand under 'food insecurity'.

Most interviewed farmers define food insecurity as a situation in which not all members of a household can eat three times a day. According to this definition, 100 percent of the interviewed farmers said that food insecurity is a problem in their village. 79 percent considered their own household as food insecure. However, this is characterised by strong seasonal and yearly variabilities. The average months in which a household defines itself as food insecure are 3.3 months per year, basically the time before the (main) rainy season.

Keywords: Agroforestry, Ethiopia, food insecurity, Oromiya Region

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Farming for Food Security: Probabilistic Simulations of Farm Contribution to Nutrition in Southwest Uganda

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Southwestern Uganda's population density, 64 people per square kilometer, is less than half of the national average, however a high growth rate and low average age are likely to exacerbate land scarcity, poverty (per capita GDP 500 USD), and food insecurity. The region is ideal for farming, with fertile soils, 1500–2000 mm annual rainfall, and mean annual temperature range of 12.5–30°C. Uganda's agricultural authorities aim to utilise this strength and industrialise farming systems away from the common traditional homegardens, currently the source of most food. However, robust science-based information to support this decision is lacking. Here we used decision analysis methods for probabilistic simulations of food nutritional implications based on homegardens and the proposed changes.

We compared total nutrient outputs of two scenarios: 1) 102 homegardens (HG) multilayered diverse banana plantations intercropped with fruits and vegetables, based on extensive field work; 2) Ugandan agricultural authority plans (UA) dominated by grains, tubers, Tooke bananas, and legumes. Land area for food production in HG was around 95 %, whereas, UA used 100 % by removing homes and roads, or as little as 75 % with area lost to commercial non-food products. Yield estimates were based on HG observed yields and reports with UA yield increases of 5–60 % with chemical fertilisers. Crops were categorised by food group with nutrient contribution based on yields.

Monte Carlo simulation with 10,000 model runs revealed that, while industrialising farming systems may be a win in terms of energy and some nutrients, homegardens should nevertheless be maintained for key important nutrients. UA significantly outperformed HG in protein production by 50 %, calories, carbohydrates, thiamine and zinc by 40 %, fiber by 30 %, thiamin by 20 %, and folates by 13 %. HG significantly outperformed UA in production of vitamin-C by 170 %, calcium 60 %, riboflavin 40 %, vitamin-A 30 %, beta-carotene and vitamin B6 20 %, total lipids 2 %, and iron and niacin by 10 %. HG also had folic acid and vitamin B12 whereas UA had none.

Partial least-squares regression of Monte Carlo output indicated that gathering more data on the annual yields of roots and tubers would most improve certainty about the nutrition contribution of HG and UA scenarios.

Keywords: Decision analysis, homegardens, Monte Carlo, probabilistic simulation

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Food Consumption Pattern and Micronutrient Adequacy of Cassava Value Chain Households in Guinea Savannah Area of Nigeria

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Monotonous starchy staples that are mainly energy-dense and poor in micronutrient content are common in food insecure areas. This contributes micronutrient deficiencies which impede the health and productivity of individuals, households and communities. A dietary assessment study was carried out in selected communities of Oyo and Kwara States, Nigeria (Guinea Savannah zone). This was to assess and compare the food consumption, dietary diversity and dietary pattern of cassava value chain households (CVCH) and non-cassava value chain households (non-CVCH). Household sizes ranged from 2–20 with mean of 8 members. CVCH constituted 87.1 % and 72.0 % of all households in Oyo and Kwara States, respectively. The most frequently consumed staples and modes of consumption were: yam (18.7 %) - pounded; maize (17.7 %) – plain gruel; cowpea (16.8 %) – steamed pudding; wheat (14.8 %) – bread; rice (9.3 %) – plain boiled; cassava (8.5 %) – fermented flour dough; sorghum (6.6 %) – plain gruel; cocoyam (5.6 %) – boiled; sweet potato (5.2) – boiled; and millet (2.5 %) – plain gruel. The weekly frequency of cassava consumption was significantly higher in CVCH (9.2 %) than non-CVCH (6.1 %). The minimum number of food groups consumed was 3, the maximum was 10, the mean household dietary diversity score was 6.8 $\pm$1.1, with no significant difference between CVCH and non-CVCH. Two major dietary patterns were identified among the households: root/tuber-based and grain-based and these explained up to 58 % of the total variance in the diet of the households. The findings show that both cassava value chain and non-cassava value chain households in this study subsist on a fairly monotonous diet with limited diversity. This indicates a vulnerability to micronutrient deficiencies because such diets are often inadequate in micronutrient supply. There is therefore the need for food security and nutrition intervention activities involving dietary diversification to improve micronutrient intake among this population.

Keywords: Cassava, dietary diversity, dietary pattern, household foods, value chain

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Peri-Urban Neighbourhoods and Access to Food: A Case Study Conducted in Tamale, Northern Ghana

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Given the ongoing urbanisation processes in West Africa and the emerging importance of food and nutrition security in rapidly growing cities, this study investigates characteristics of peri-urban neighbourhoods and food access in Tamale, northern Ghana.
The study uses a comparative approach by looking at urban (n=1), peri-urban (n=3) and rural (n=1) neighbourhoods. It further compares food access patterns in two different seasonal time frames of the year in order to identify seasonal variations.
The food related infrastructure of the sampled neighbourhoods was studied through neighbourhood mappings. Within the same neighbourhoods, a random sampling approach was used to carry out a household food access survey.
Results reveal that peri-urban neighbourhoods are heterogeneous in terms of food access, as they resemble both the urban and rural comparative values. The two central Tamale markets are the most important food source for the majority of food products in all urban and peri-urban neighbourhoods, then followed by neighbourhood hawkers. In peri-urban neighbourhoods, backyards play an important role in household vegetable supply during the rainy season. Especially during dry season, all studied neighbourhoods have limited access to fresh and healthy foods, such as fruits, vegetables and meat, within the defined neighbourhood boundaries. The data further reveals influential factors on household decision making in terms of purchase patterns and food provisioning. The costs of food and household financial capabilities appear to be the most important influential factors regarding food access patterns. Further, seasonal price fluctuations have a strong impact on the diversity, frequency and quantity of the obtained and consumed foods. During the dry season, prices for most food products are high and the availability and accessibility for some seasonal food products is limited. These results indicate a seasonal drop in dietary diversity and hence, a potential nutrition insecurity.

Keywords: Food and nutrition security, food markets, neighbourhood mapping

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Biosecurity Measures in Meat and Milk Value Chains: A Study in Bura Sub-County, Kenya

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Livestock value chains are an important source of employment, income and nutrition in developing countries. Increasing income has led to high demand for animal source products.

Zoonotic diseases pose a public health risk to people producing, handling, processing and consuming animal products; with value chains creating a contact networks for transmission. Biosecurity measures constitute a cheap, integrated approach and affordable way of disease control from farm to fork as advocated by the concept of 'OneHealth' and 'EcoHealth'.

This research used mixed methods - qualitative and quantitative methods. A semi-structured questionnaire was used to test knowledge, attitude and practices of value chain actors. Sampling techniques used included snowballing and convenience sampling in markets days as no register of actors existed, aiming to reach as many actors as possible. Participatory mapping exercises were utilised to map activities and biosecurity measures in the value chain and evaluate occupational risk, biosecurity measures adopted and drivers of adoption. This was complemented with key informant interviews conducted with key actors including government institutions employees.

Results indicate low knowledge of diseases, symptoms and biosecurity measures among value chain actors reflected by low adoption of biosecurity measures. Poor handling of food products exist, which increases the risk of contamination and at the same time exposes actors' to diseases. There is non-enforcement of laws, inadequate extension services, governance challenges and low institutional support for actors to implement and adopt biosecurity measures. Qualitative analysis or risks highlighted many gaps that need to be addressed urgently.

Risks associated with milk and meat safety hazards require a cooperative approach of the value chain as a whole (from farmers, meat processors and consumers to government authorities) as a lapse at any point of the value chain (inspection, processing, distribution and meal preparation) poses a risk to human health as well as environmental and animal health.

Keywords: Biosecurity, informal livestock value chains, one health, zoonoses

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Reduction of Animal-Product Consumption to Counter Environmental Degradation and Food Insecurity in the Tropics

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The scarcity of natural resources in light of the world's rising population has been the subject of many studies about the world's food supply. The extension of agricultural land use and the intensification of agriculture are discussed as a necessity to be able to produce enough food worldwide. These, however, conflict with the principles that underlie the conservation of resources like soil, water or biodiversity as well as climate stability. Based on scientific literature we contend that food security and the conservation of natural resources are not contradictory *per se*. This putative competition would not exist if more crops were produced for direct human consumption rather than for feeding livestock. Our view is that the alleged necessity to intensify agriculture is a result of the enormous energy losses during the production process of animal-based human food. To achieve the urgent need to balance agriculture and environmental assets, human consumption of animal products needs to be restricted to certain limits. We offer this suggestion against the background of the current high level of meat and dairy consumption in industrialised countries and its growth worldwide. In this conference contribution, socio-economic reasons for and ecological consequences of the high consumption level of animal products in the tropics are presented. The findings are based on examinations including a review of scientific literature and a systematic meta-analysis. Results show that animal production and thereby intensive agriculture is linked to resource depletion and food insecurity by several causal connections. Contributory factors include e.g. deforestation and greenhouse gas emissions. Biodiversity loss as a result may lead to, *inter alia*, an increased vulnerability to climate influences, and thus to food insecurity. Moreover, food security is threatened by the above mentioned competition for land. Additionally, it can be shown, that among others, the deep cultural integration of animal products is retarding the process of transformation to a sustainable, predominantly plant based diet. Efficient instruments to accelerate this process seem to include the improvement of school education, the use of role models to appeal for a plant-based diet, as well as certain politico-economic measures. These results invite further empirical examination.

Keywords: Animal-product consumption, behaviour change, biodiversity loss, climate change, environmental degradation, food insecurity, meat consumption

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Children of Drought: Rainfall Shocks and Early Child Health in Rural India

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Identifying the long-run effects of *in utero* and early-life conditions has become an important research topic in economics. Since the seminal work by Almond (2006), a growing literature finds that *in utero* exposure to adverse environments may negatively affect the health and educational attainment later in life.
The hypothesis that the *in utero* period is the most critical period in a person's life was first posited by David J. Barker, a British physician and epidemiologist, who argued that nutritional deprivation of pregnant women are transmitted to the fetus leading to impaired fetal development with long lasting consequences that continue to persist after birth and even through adulthood.
This paper exploits the plausibly exogenous variation in rainfall to examine the effect of *in utero* exposure to a rainfall shock on health outcomes of children in India. We study the medium-term effect of drought in the year before birth (*in utero*) and in the year of birth on the health outcomes of children younger than 60 months living in rural India. About 70 % of Indian working population rely on agriculture directly or indirectly for living and their income is highly volatile due to erratic monsoon rainfall as agriculture is highly rainfed in India. Droughts are common phenomena in India. Given the dependency of rural lives on rainfall, a negative rainfall shock in a year is likely to affect the household income due to reduction in agricultural production as well as food availability which in turn may affect the maternal and fetal nutrition.
We show that exposure to droughts *in utero* is associated with lower weight- for-age z-scores and increased probabilities of being underweight. However, *in utero* exposure to drought does not seem to affect the anemic status of children. Our results also indicate that drought in the year of birth is also an important predictor of health. We also find evidence of heterogeneity in the effects of drought on child's health.

Keywords: Fetal origins hypothesis, India, rainfall, undernutrition

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Quality Assurance and Preservation of African Leafy Vegetables Considering Technological and Health Aspects for the Reduction of Food Losses and the Improvement of Health and Nutritional Value, Storability and Food Safety

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African indigenous leafy vegetables (ALV) play a significant role in food security of smallholder farmers in rural and urban/peri-urban areas. Currently, the magnitude of pre- and postharvest losses of ALVs in Kenya can reach up to 50 %. Losses are attributed to inadequate conditions during production and to rapid decay of products during transport, storage and marketing. Inadequate postharvest handling and facilities for storage and transport, inappropriate processing methods for product preservation, insufficient hygiene conditions in the markets and poor infrastructure aggravate these problems, causing massive losses along "the field to consumer" chain.

In many parts in Africa, subsistence smallholder farmers cannot afford construction of expensive cold storage facilities, thus after harvesting ALVs, simple methods are applied. Alternative technologies such as on-farm evaporative coolers, modified atmosphere packaging and postharvest treatments need to be explored for adoption. The commonly used, local preservation methods (blanching, solar-drying, fermentation), however, still result in significant loss of nutritional product quality and in microbiological contamination. Thus, one major aim in subproject 4 and 5 of the HORTINLEA

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consortium (Horticultural Innovations and learning for improved Nutrition and Livelihood in East Africa as part of the BMBF "GlobE - Global Food Security" program) is to identify and characterise quality losses during the entire food supply chain (from smallholder farmer to consumer) and to improve product quality, food safety and storability by adopting affordable production, harvest techniques, postharvest treatments and processing technologies, as well as implementing emerging technologies for optimising transport and storage conditions under unfavourable conditions.
Moreover, it is largely unknown in which quantities compounds relevant for a healthy human nutrition (e.g. vitamins, minerals, secondary plant metabolites) are present in ALVs. In order to link potentially beneficial effects to secondary plant metabolites, extracts as well as isolated and chemically characterised substances are subjected to biochemical *in vitro* assays. Additionally, the impact of agronomical practices and harvesting stages on the chemical composition of ALV will be studied. All these aspects contribute to the understanding how significant improvements in the nutritional status of the sub-saharan population can be obtained by the optimisation of processing and postharvest treatments of indigenous ALVs inKenya.

Keywords: Vegetables

Linkage Between Drinking Water Supply and Irrigation under Multi-Use Water System in Rural Ethiopia

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In rural Ethiopia, irrigated agriculture has complex interaction with drinking water supply and sanitation services. Separate sources for drinking water and agriculture uses do not exist in several areas. Due to limited availability of safe drinking water, majority of rural population relies on unimproved water sources, including rivers, irrigation water from canals and dams, ponds, streams, and unprotected springs which are easily polluted by human and animal feces. Irrigation water might serve as an option to increase the availability of water for domestic uses and saving water collection time and energy. Drinking water quality and quantity can easily become affected through agricultural practices and poor quality of irrigation water for domestic purposes may be harmful for health due to the present of disease-causing pathogens. Hence this linkage is often overlooked and understudied. Considering the limited studies on the linkage between domestic water and agriculture, this study shed some light on the agriculture-water nexus using state-of-the art econometric methods. For this study, a household survey has been conducted in rural area of Fogera and Mecha districts of Ethiopia from February to June 2014. More than 454 agricultural households were randomly selected using a stratified multi-stage cluster sampling technique. Drinking water sample quality testing has been conducted and anthropometric measurements such as height and weight were also collected for children under-five years of age.
Child and nutritional and health status is measured by z-scores and the prevalence of diarrhea in the preceding two weeks before the survey, respectively. The self-reported prevalence of diarrhea for children of under five years is 16 %. The prevalence of underweight and stunting based on the anthropometric measurement results for under five children is 27 and 40 % respectively. Although there is no systematic variation in the prevalence of diarrhea between irrigating and non-irrigating households, malaria incidence is much higher in households living in irrigating villages as compared to households living in non-irrigating village. Controlling for socio-economic variables, the estimation results show that household water quality, per capita water consumption, basic latrine, hygiene score and distance to irrigation water sources are highly associated with child diarrhea and nutrition outcome.

Keywords: Agriculture, health and nutrition, rural Ethiopia, water quality

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How to Catch 'Low-Hanging' Fruits and Vegetables in Uzbekistan?

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Fruit and vegetables are essential components of a healthy diet thanks to their macro- and micro-nutrient content, and their adequate consumption could help prevent major non-communicable diseases. The natural and climatic conditions in Uzbekistan provide ample opportunities for the development of fruit/vegetable production. Unfortunately, consumption of such healthy food is constrained by its seasonal and spatial availability and considerable price differences throughout a year. The purpose of this complex research is to study how healthy is the current diet of Uzbek people in terms of seasonal fruit/vegetable consumption and its macro- and micro-nutrient content. The research aims also to explore existing constraints and opportunities to improve year-long availability of fruit/vegetables as a key determinant of healthy diet. Econometric analysis of population data allowed to study various interactions related to healthy diet at individual level. Multi-stage stratified cluster sampling approach was utilised to conduct a household survey in summer 2014 and the repeat survey in winter 2015 with sample size of 200 households in five districts of Tashkent province. Functional and institutional analyses of fruit/vegetable value chains allowed qualitative studying of the existing constraints and required policies. A sample size of 100 $^{\text{fruit/}}_{\text{vegetable}}$ farms in five districts of Tashkent province was selected randomly, disproportionally for conducting structured interviews which took place in winter 2014. Based on the research results, interseasonal price variation and the inability of households to smooth their annual fruit/vegetable consumption manifest themselves in seasonal variation in macro- and micro-nutrient intake. Intake of important micronutrients as a result of fruit/vegetable consumption is very low even in summer season. Consumption of energy-dense (often, less healthy) food still prevails in Uzbek diet, which can be partially explained by culture. Among the main problems of efficient fruit/vegetable production are output market failures, input market failures, institutional bottlenecks, and degraded natural resources. Recommended policy changes include reduction of state bureaucracy and abuse of power, shift from planned system to market-oriented system, removal of export restrictions, better marketing research, knowledge capacity development, investment in new equipment, technologies and infrastructure (indoor production, storing and processing), development of agricultural extension services and effective work of associations.

Keywords: Fruit and vegetable consumption, healthy diet, nutrition

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Scaling-Up Nutrition: Implementing Potentials of Nutrition-Sensitive and Diversified Agriculture to Increase Food Security: A Research Framework

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Food and nutrition security is still one of the most pressing challenges to constantly growing populations in sub-Saharan Africa. The nutritional situation in Tanzania has only slightly improved in the last decade despite high rates of economic growth. The share of the population with insufficient available calories for consumption was found to be higher than 20 % and stunting prevalence of 40 % in children <5 years are reported. To improve the nutritional status of Tanzania's local poor, the Scale-N project funded by the Federal Ministry of food and agriculture aims to safeguard food and nutrition security by supporting the development of diversified and sustainable agriculture.

Scale-N will perform in regions with highest need: the semi-humid Morogoro and the semi-arid Dodoma region. The participatory research design of Scale-N targets the above problems by applying a holistic integrated approach while using and linking to the existing analytical research framework Trans-SEC. This framework aims to enhance local food security by participatory testing of innovations across various sectors of the food value chains (FVC).

The research concept of Scale-N includes the following steps: (1) local stakeholder involvement will be set up from the beginning as an integral part of most analytical steps (2) in depth analysis of the nutritional status of the local population and access to the sanitation and health care (3) an integrated in depth analysis of nutrition value chain components to identify and inventor nutrient dense plant derived foods with regard to sustainable resource management and production conditions (4) participative field testing of most promising nutrient-dense plant-derived foods and processing techniques (nutrient-sensitive innovations) (5) local implementation of nutrient-sensitive innovations focusing on knowledge transfer and (6) disseminations and policy implementation.

Keywords: Nutrition security, sub-Saharan Africa, Tanzania

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Morphological Diversity of Spider Plant (*Cleome gynandra* (L.) Briq.) Accessions from Different Countries in African

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Spider plant (*Cleome gynandra* (L.) Briq.) has the African recipe taste for potential nourishment of local community based on its diverse use-values. The diverse uses range from nutritional (high value of vitamin C & A; minerals-Mg, Zn, Ca; protein, fat and fibre) and medicinal. As well it reduces risks of degenerative diseases like cardiovascular diseases, some cancer types, inflammation and age-related disorders. However, there is scarce and sparse scientific information on the plant diversity for use in crop improvement and is a potential area for research. Morphological characterisation and evaluation of 255 spider plant lines developed by single plant selection from 32 accessions obtained from AVRDC-The World Vegetable Center, East and Southern Africa (AVRDC-ESA) was conducted in 2014 in Arusha, Tanzania. The materials were assessed in on-station field experiment at AVRDC-ESA, 1290 m a.s.l, 4.8° N latitude and 37°E longitude. Five advanced lines were included as checks. The experiment was laidout in an augmented design of five blocks. The check lines were arranged in a randomised complete block design, and each was assigned to a plot in each block at random. The 255 test lines were available only once in the experiment assigned at random. A number of quantitative and qualitative data were collected. The materials were evaluated by seven female and six male farmers from around the research centre for their yield, quality and desirable horticultural traits. We present within and among accessions morphological diversities based on quantitative and qualitative traits data collected. We also present traits associations with leaf yield and among each other. The paper identifies promising lines for yield, quality and desirable horticultural traits for further evaluation and use in germplasm development programs and especial studies.

Keywords: Characterisation, germplasm development, indigenous vegetables, morphological traits

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Processing of agricultural products into food and fuel

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Impacts of Biofuel Production on the Food-Energy-Water Nexus in Malawi

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The growing pressure on natural resources worldwide requires a profound understanding of the intrinsic links between food, energy, and water and the conflicting impacts of development policies on all three sectors. While the expansion of biofuels is promoted to reduce poverty and enhance energy security, tradeoffs regarding water through irrigation or food security through land displacement could outweigh the benefits. This paper is the first to simultaneously assess the effects of biofuel production on food, energy and water security through the implementation of a comprehensive modelling framework. Sugarcane and ethanol sectors are integrated into a recursive-dynamic computable general equilibrium (CGE) model of Malawi. Different sugarcane production technologies concerning farm size and irrigation intensity are simulated to measure changes in energy and food security. To evaluate effects on water, the CGE model is linked to a new crop model that calculates water requirements of crops based on historic climate data. A micro-simulation module analyses policy effects on poverty. Higher availability of ethanol from sugarcane undoubtedly enhances energy security. Due to extreme land scarcity in Malawi, land displacement for sugarcane production leads to crowding out of other crops. Contrary to findings of many other studies at the global level, we find that not food crops but traditional export crops are displaced due to an appreciation of the exchange rate from increased ethanol exports. Food security increases through higher food availability, lower food prices, and higher incomes. Positive effects on food security are highest if sugarcane is produced by smallholder farmers under irrigation. Even without irrigation, smallholder farmers realise income gains and reductions in poverty. Since sugarcane is a very water-intensive crop, both rainfed and irrigated sugarcane production for ethanol lead to an enormous rise of exports of virtual water from Malawi. As irrigation water is exclusively taken from surface water, an expansion of irrigated sugarcane is likely to decrease water levels of rivers and thus water security in Malawi. These complex effects stress the importance of an integrated assessment of food, energy, and water security to identify both synergies and tradeoffs of development policies.

Keywords: Biofuels, food security, Malawi, poverty, water

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Fostering the Use of Banana and Plantain Fibers from Agricultural Residues for Improving Income Generation and Food Security in Ghana - How to Construct an Example Project

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As for the limited availability of resources worldwide, it is and will continue to be increasingly important to make use of renewable resources. Next to the rising food demand, especially the growing demand for plant based materials, including textile fibers for clothing, will require suitable strategies to improve efficiency so as to ensure sustainability in the emerging bio-economy. Currently, cotton fibers and various synthetic fibers provide the main supply for the textile industry. In order to meet the increasing fiber demand expected for the coming decades, it will be necessary to put more emphasise on developing alternative plant based sources for the textile sector.

In this article we investigate how banana and plantain residues could be incorporated into an example fiber value web and thereby offer income alternatives to Ghanaian smallholder farmers. By relying on a so far underutilised resource, an economic benefit can be expected without compromising food security. Using secondary information and key person interviews, we assess the framework conditions like opportunities, institutional requirements, and potentially involved stakeholder, which need to be considered when attempting to set up a practical example. In this context, our key focus is the use of the whole plant biomass and thereby target the most efficient use of agricultural and other inputs in banana and plantain cultivation.

Our results indicate that there is a substantial interest of private (German) enterprises to make use of the high quality long fibers contained in banana and plantain pseudostems. Using suitable, low-tech equipment, the fibers could be extracted and processed in the rural producer areas, and then offered to textile producers at various levels: local, regional, or international. If targeting export, it appears to be highly important to ensure certain quality standards, quantities and reliability of supply. Overall, we conclude that there is a significant potential for local farmers and private enterprises to achieve mutual benefits. Consequently, spill-over effects are likely to lead to a more general economic development of rural areas. Case specific, however, there is still need for identifying suitable varieties as well as developing contacts and collaborations between stakeholders.

Keywords: Banana fiber, Ghana, plantain fiber, value web

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Post-Harvest Challenges and Economic Consequences – Focus on Rwanda

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Post Harvest Losses (PHL) are estimated between 15–22 %. Agricultural activities contribute to 34 % of share of the GDP, the GNI per capita using PPP is $1450 according to World Bank data of 2013. PHLs are due to poor post-harvest processing of agricultural products, when valued in monetary terms reflect a tremendous loss in the economy. Such a situation does not only reduce the national income but also it generates a problem of malnutrition in population, 43 % of children are subjected to malnutrition.

Both government and private institutions need to invest much effort in research and extension toward improving and modernizing post-harvest facilities to attain more efficient market infrastructure and distribution channels.

in this research we evaluate PHLs of maize, beans, and rice as the pillar of Crop Intensification Program (CIP) initiated by Ministry of Agriculture (MINAGRI. We evaluate the economic impact caused by PHL by quantifying price discounts which small farmers face when selling damaged cereals and the target the establishment of a postharvest model that can tackle postharvest losses.

we use quantitative methods and qualitative methods, interview, and algorithm that operates on a set of postharvest loss profiles and seasonal data in order to evaluate PHL. The double-hurdle model and standard regression models are also used to identify the level of impact of grain damages to evaluate the economic loss caused by these damages.

PHL reduction and management enhances food security and increases the value of agricultural production on the market thus enhance welfare and contribute to Poverty eradication. PHLs reduction contributes to the land use by reducing land and natural resources invested in food production as more food can reach the final consumer.

Keywords: Double hurdle model, economic appraisal, food security, post-harvest losses, regression model, Rwanda, storage technology

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Experimental Analysis of the Thermal Behaviour of a Dual Solar - Biomass Tunnel Dryer Type "Hohenheim" for Aromatic Plants

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Colombia has an important production potential of a wide variety of aromatic plants that find extensively use in the pharmaceutical and cosmetic sectors. However the currently industry of aromatic plants is incipient with a production concentrated only on fresh product. The drying process inhibits the growth of microorganisms and the decomposition process of the plants resulting in reduction of losses of harvested crop and an increase in the duration of the plants. It also adds value to the product and reduces transportation costs when comparing to fresh products. The currently commercialisation of dried products in the country is limited to a small local market due to inadequate and inefficient processes. The implementation of drying processes in the current Colombian agro-industry faces two challenges: The development and use of efficient economic driers that use available and cheap energy resources and the production of high quality dried products.

In the present work experimental results of the thermal behaviour of a dual solar - biomass tunnel dryer type "Hohenheim" are presented. The incorporation of a biomass burner allows continuous operation of the drier without depending of the presence of solar radiation. The total area of the solar collector is 16 m^2 and the drying area is 20 m^2. The capacity of the drier is 2 to 5 kg m^2 depending on the variety of plant. The drier is located near Bogotá, the capital city of the country. Combustion of coffee shells is used for obtaining the thermal energy for drying when using biomass. This biomass is a residual product obtainable in large quantities in the country.

In a continuous test of 50-hours temperature and relative humidity profiles along and across the drier. Graphics of longitudinal profiles and transverse sections of relativity humidity and temperature in dependence of the air flow and solar radiation are obtained. The drying chamber and collector efficiency are calculated. A linear relationship between solar radiation and air velocity is obtained. The temperatures in the collector varied between 11,69°C and 79,02°C and in the drier between 13,6°C and 69,5°C.

Keywords: Biomass, drying, energy yield, quality, solar energy

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An Assessment of the Use of Postharvest Loss Prevention Technologies for Cassava in Nigeria

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Food Security remains a major issue in the world today especially in developing countries. Availability and access to food are negatively affected by many factors, prominent of which is post-harvest loss. Minimizing post-harvest losses is thus a critical agricultural problem. Cassava, an important staple food and income earner in Nigeria and other parts of West Africa, is a perishable crop. Improved harvesting, better postharvest handling and optimized processing technologies are crucial for improving supply of cassava-based foods and income to smallholder processors. This study was carried out to examine the factors influencing the choice of post-harvest technologies used by cassava processors in the study area and assess the impact of improved technology on the processors income. Data were collected from 150 cassava processors in Kwara State, Nigeria using structured questionnaire and analyzed with multinomial logit model. Factors such as years of education, post-harvest technology capacity, processing experience, motives for processing, amongst others were found to influence the choice of post-harvest technologies used in the study area. Furthermore, the impact assessment revealed that cassava processors using improved post-harvest technologies had increased income and output compared to those using traditional technologies. The study concludes that policy should be directed towards investment in improved post-harvest technologies by both private and public sector.

Keywords: Cassava, food security, improved technologies, income, post-harvest losses

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The Influence of Integrated Crop-Livestock Systems on Life Cycle Assessment (LCA) of Soybean-Based Biodiesel in Central-Brazil

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Biodiesel in Brazil is mostly produced from soybeans. Even though it is an alternative for reducing greenhouse gas (GHG) emissions when replacing fossil fuels, biodiesel production from soybeans is put into question, especially in regards to competition with food production and the impacts from its farming process. On the other hand, a growing part of soybeans farmed in Central-Brazil is coupled with an interseasonal maize crop. Such systems mostly use no-till seeding, with its many environmental and economic benefits. Many times, these systems include grasses mixed with the maize crop, for short cattle grazing periods between maize harvest and soybeans seeding. These are the integrated crop-livestock systems. They are able to obtain three products in the same area in one single year. Such systems, though more capital and labour intensive, have been proving to be environmentally friendlier. They help to reduce emissions from the process through optimisation of resources usage, like infrastructure and machinery. Besides, they generate other products what positively accounts on LCAs. However, incorporating these integrated systems into an LCA poses many challenges, especially related to allocation of impacts among shared inputs and outputs, which may have different values according to the audience perception. Therefore, goal of this work is to propose an improved method for carrying out such analysis and suggesting allocation strategies for the different inputs and outputs of this complex system. Preliminary results show that, as a whole, integrated systems reduces the overall impact of biodiesel produced from soybeans cultivated under such systems, but when sharing enteric emissions from cattle with the crop systems, the approach adopted for input-output allocation is very important.

Keywords: Biodiesel, integrated systems, LCA

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Assessment of Post-Harvest Handling Practices and Associated Losses and Limitations in the Value-Chains of Sweetpotato (*Ipomoea batatas* L. Lam) Root: A Case Study from SNNPR, Ethiopia

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Significant post-harvest losses take place during handling and due to marketing systems of sweetpotato in Ethiopia, but little information is available in current literature with regard to occurrence in the value chain, type and causes of these losses. A field survey was conducted in the months of February and March, 2015 in the ambit of RELOAD (Reducing losses and adding value) project funded by BMBF (Federal Ministry of Education, Germany), BMZ (Federal Ministry of Finance, Germany) and DAAD (German Academic Exchange Service).

Ethiopian sweetpotato production and consumption is primarily limited to SNNPR (Southern Nations, Nationalities, and Peoples' Region) region, which is the supplier of the fresh roots to several major cities. Semi-structured interviews, load tracking, measurement and drying experiments at farm, retail and wholesale level were conducted to gather relevant information. In total 60 stakeholders were interviewed; comprising farmers, retailers, wholesalers and collectors. Additionally talks were organised with local researchers at agricultural research centre, Awassa, Ethiopia.

A detailed understanding of the flow of product from farm to market was obtained and key constraints and challenges were identified. Some of the important factors which are contributing to post-harvest losses are numerous mechanical damages during harvest and post-harvest handling; lack of curing and storage facilities; poor conditions at the retail market. The results from the survey also elaborate the activity calendar, value chain map, margins of profits for stakeholders and seasonal variations in post-harvest losses due to supply and demand imbalances. Retail and storage simulation experiments gave a good insight of various kinds of decay and losses which are taking place at market level. Fungal diseases such as Foot rot, *Fusarium* surface and root rot were major causes responsible for decay and rotting during storage at ambient conditions.

Converting fresh sweet potatoes into sun and solar dried products has the potential to create a marketable value added product for commercial use in various forms of composite flours. Dried products are easy to handle, have superior shelf life and can insure food availability throughout the year.

Keywords: Drying, post-harvest handling, shelf life, sweetpotato, value chain

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Investigation of Anaerobic Digestion Backed by Solar-Wind System for Clean Energies in Rural Areas

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Rural communities in Africa, Chamwino district in Tanzania inclusive, are facing discouraging challenges of sustainable supply of their energy needs and low soil fertility. Improving energy and soil nutrients accessibility in rural areas will essentially require strategies which will facilitate the utilisation of the locally available cheap and low value materials and resources, e.g. animal wastes (biomass), solar radiation and wind energy. It is argued that a hybrid system utilising of renewable energy resources (biomass, wind and solar) is suitable for energy generation in under-privileged rural areas where electricity grid connection has not reached. The optimally hybrid system provides a supplement of energy for cooking (biogas), electricity for lighting and bio-slurry/digestate for improving soil fertility. The focus of this study is to investigate the anaerobic digestion backed by solar-wind system for production of clean energies (biogas and renewable electricity) in rural areas, specifically in Chamwino district, Dodoma-Tanzania. The approach will involve a feasibility of the cheap and low cost materials and resources; then optimising, designing, and testing, modelling and conduct techno-economic analysis of intended hybrid energy system. The information collected from literature shows that semi-arid rural areas such as Chamwino have abundant wind and solar energy, estimated at 6 m s^{-1} and 4.7 kWh m^{-2} d^{-1}, respectively annually. These areas also face a decreasing rate of fuel wood sources, which was estimated at 0.68 % per year since 2007 exceeding that of 0.23 % per year from 2001 to 2007. The expected outcome and results of this study will be to have in place an optimised hybrid anaerobic digestion-solar-wind system for producing affordable, sustainable, and clean energies for rural areas. Model for sizing in the intended hybrid anaerobic digestion-solar-wind system based on geographical location and feedstocks as well as the techno-economic analysis results of that system will also be presented.

Keywords: Anaerobic digestion, biogas, biomass, clean energies, electricity, rural areas, solar systems, wind

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Fermentation of African Leafy Vegetables to Lower Post-Harvest Losses, Maintain Quality and Increase Product Safety

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African leafy vegetables (ALV) are important in securing the food supply and livelihood of smallholder farmers in rural and urban/peri-urban areas. Inadequate postharvest handling, facilities for storage and transport, inappropriate processing methods for product preservation, insufficient hygiene conditions in the markets and poor infrastructure aggravate these problems, causing massive losses. The fermentation of ALVs helps in preparation and extending their shelf life. Cowpea (*Vigna unguiculata*) and African nightshade (*Solanum scabrum*) leaves were fermented in three batches of 20 g, 100 g and 1 kg to test six different lactic acid bacterial starters (inoculum [10^6] cfu ml^{-1} at different brine concentrations. To determine the role of the starter cultures to inhibit the pathogens Listeria monocytogenes and *Salmonella* Enteritidis, 100 g of leaves were fermented in 1 L beakers with starter combinations of *Leuconostoc mesenteroides* ssp. *mesenteroides* and *Lactobacillus plantarum*. The largest fermentation assay was carried out in 5 liters clay pots with *Lactobacillus plantarum* and *Lactobacillus fermentum*. The pH values and microbial counts of total bacteria, lactic acid bacteria, enterobacteria, yeast and molds were determined at 0, 24, 48, 72 and 144 h. The optimal fermentation conditions were achieved with *L. plantarum, L. mesenteroides* ssp. *mesenteroides, Lactococcus lactis* and *L. fermentum*. A combination of salt and sugar (3 % each) as brine led to the quickest and deepest pH-values. The starters reduced the pH below 4 within 24 h, which makes these ideal candidates as starter cultures to inhibit the growth of spoilage and pathogenic microorganisms. In the scaled-up challenge test, the combination of the starter strains *L. plantarum* and *L. mesenteroides* ssp. *mesenteroides* successfully inhibited the growth of *L. monocytogenes* and *Salmonella Enteritidis* by reducing the pH below 4 within 48 h. In the 5 L fermentation assay, the batch with the inoculated lactic acid bacterial starter strains showed a strong decrease of pH value to 3.7 within 24 h in contrast to the control. Enterobacteria were inhibited after 24 h, and no yeast and molds could be detected. Thus, the fermentation of cowpea and nightshade leaves with selected starter cultures showed an improved status of food hygiene and safety.

Keywords: African indigenous vegetables, fermentation, lactic acid bacteria, safety

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Wood of Three Brazilian Species for Energy Purposes

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The Caatinga biome is the predominant vegetation in the Brazilian semi-arid region, covering 54.53 % of 1,548,672 km^2 area of the region. The biome has relatively low number of species. However, the region has a large number of endemic species. In addition, several plants have been described as endemic to the region, indicating that the botanical knowledge and its potential uses are still at early stages. Restrictively, the most common use of these species has been as firewood for direct burning or for charcoal production. In general terms, the charcoal is the solid product obtained by the carbonisation of wood, whose characteristics depend on the techniques used to obtain it and the purpose for which it is intended. The charcoal yield ranges between 25 and 35 %, based on dry wood. Thus, this study aimed to characterise the wood of three species of the Brazilian semi-arid targeting energy use. Three native tree species of the Brazilian semi-arid region located in the state of Pernambuco, Brazil, were selected: *Poincianella pyramidalis* (Tul.) L.P.Queiroz; *Cnidoscolus quercifolius* Pohl and *Mimosa tenuiflora* (Willd.) Poir. In the Integrated Laboratory of Chemistry, Pulp and Energy - Bioenergy and Forest-Based Bioproducts Group (ESALQ / USP) were quantified the total extractives, lignin content, holocellulose and higher heating value of wood of three species. The charcoal yield, pyroligneous acid yield and of non-condensable gases yield were also determined. By analysing the set of characteristics, *Mimosa tenuiflora* species showed better results in charcoal yield, higher lignin content, higher calorific value and lower ash content, being considered the most suitable species for uses aiming energy production.

Keywords: Biomass energy, Brazilian semi-arid, energy use

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Potential of By-Products from Primary Coffee Processing as Source of Biofuels

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Coffee is second most traded legal commodity next to petroleum. Millions of people particularly from developing countries rely their livelihood on coffee production. Primary coffee processing is conversion of fresh cherries to green bean by following the dry or wet methods. Both processing methods generate almost half the weight of the coffee cherries as by-products, mostly seen as waste and dumped, which causes environmental problems. The main process by-products from wet method are pulp (43 % w/w), mucilage (11.8 % w/w) and parchment (6.1 % w/w); while the dry method generates the husk, which is 44 % of the dry cherry. In the present study, physical and chemical properties of the coffee processing by-products were made on dry weight basis. Sample by-products were obtained from coffee processing farm in Jimma, (Ethiopia) and sundried before transported to Germany.The neutral detergent fibre (NDF) of pulp, husk, mucilage and parchment were 61.84 %, 65.77 %, 40.16 %, 96.84 % respectively. The acid detergent fibre (ADF) of pulp, husk, mucilage and parchment were 47.12 %, 149.49 %, 36.92 %, 76.85 % respectively; whereas the acid detergent lignin (ADL) was 23.85 %, 25.24 %, 13.51 % and 32.91 % respectively. The parchment has highest crude fibre content (76.92 %) of the waste fractions while the mucilage (19.38 %) exhibits the least. The fixed carbon content of the by-products was 15.80 %, 16.52 %, 9.37 % and 13.73 % for pulp, husk, mucilage and parchment respectively. Coffee parchment has highest organic total solid content of 99.55%; the other fractions show 85.10 % (mucilage), 88.31 % (pulp) and 92.85 % (husk). The parchment has higher calorific value of 19.70 $^{MJ}/_{kg}$ which is comparable to common fuel woods. The husk and pulp has heating values of 18.79 $^{MJ}/_{kg}$ and 17.37 $^{MJ}/_{kg}$, respectively. The characterisation of the by-products indicated promising potential source for renewable energy production particularly biogas and briquette/pellets.

Keywords: Biofuel, fibre, heating value, husk, mucilage, parchment, pulp

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Optimisation of Enzyme-Assisted Aqueous Extraction of High Oleic Sunflower Oil Using Response Surface Methodology

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The enzyme-assisted aqueous extraction (EAAE) is a highly efficient method for both, the recovery of oil and protein from different crops. It works on a completely solvent free basis by biochemical degradation of cell compounds, the water-based displacement of oleosomes from the cytoplasm as well as the coalescence of these oil-bodies by breaking up of the surrounding protein layer. Aside from the fact that the process is environmentally uncritical, the quality of oil will also be superior, compared to other extraction techniques. No subsequent refining is required. In the present study, high oleic sunflower seeds of variety PR65H22, harvested at a conventional farm near Würzburg, Germany, were used. Whole seeds were ground to a size < 1 mm and treated with either protease or cellulase-complexes in a prototype continuously stirred tank reactor, specifically designed for EAAE. In previous experiments, the enzyme mass, pH-value, process temperature and the amount of water were found to be the most influencing parameters on extraction efficiency and therefore varied during this study. Response surface methodology with a four factor Box-Behnken design was chosen for optimisation. In the protease experiment, second order terms (TWI and PQ) contributed significantly to the model. Proton concentration (pH-Value), temperature and enzyme concentration were found to have a significant influence on yield. The stationary point of the response surface was situated on a saddle point with an extraction efficiency of 82.3 ± 1.3 %. This was validated in a mass balance, comprising five not significantly different repetitions at an extraction efficiency of 80.8 $\pm$ 3.1 %. A canonical analysis estimated a trespass of the 95 % extraction efficiency level outside the models boundaries by increase of the enzyme concentration, which is to be proven in an ongoing optimisation attempt. The cellulase based approach only found the first order term to contribute significantly to the model with only the proton concentration having significant influence. Further experiments will comprise a two-phase extraction with cellulase- followed by protease-complex. After successful implementation, the process can be brought forward to other crops such as oil palm, rape or *Jatropha*.

Keywords: Optimisation, response surface methodology, sunflower oil

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Simulation of Air Movement in a Low-Cost Storehouse Using Computational Fluid Dynamics: Application for Bulk Sweet Potato Roots Ventilation

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The main cause of postharvest losses during storage of sweet potato roots under tropical climates is lack of suitably designed storage systems. In rural areas for instance, harvested sweet potato roots are often stored in bulk using various forms of storage technologies. Hot spots and mold damage may occur during storage especially if the roots are not ventilated. In this research, we demonstrated how commercially available engineering tools can be utilise to design a simple and low-cost African mud storehouse for storage of perishable crops such as sweet potato under tropical climates. The research contributes to an ongoing Global Food Supply (GlobE) project-Reduction of Post-Harvest Losses and Value Addition in East African Food Value Chains. The low-cost African mud storehouse was envisaged to have a rectangular air plenum built inside for bulk sweet potato storage. Aerodynamically, unfavourable designs often cause non-uniform air distribution. The arrangement of a ventilation fan, the geometric designs of the air inlet, plenum chamber and outlet decisively influence the uniformity of air distribution. To achieve this, different geometries of the storehouse were studied theoretically using computational fluid dynamics (CFD) technique. The most appropriate geometrical sketch with acceptable uniform air distribution in the storehouse was selected and constructed. The constructed storehouse has inside dimensions of about $3.10 \times 2.40 \times 2.20$ m. Experiments were conducted using potatoes to validate the selected design geometry. The potatoes were modelled as a porous media. Results of experimental measurements as well as the CFD simulations of air velocities and pressure profiles on the selected design are presented and discussed.

Keywords: Air distribution, bulk storage, computational fluid dynamics, design, mud storehouse, sweet potato roots, ventilation

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Assessment of Carbonisation of Wood Chips Using a Multipurpose Top-Lit Updraft Reactor in Rural Areas

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A multifunctional reactor for charring of biomass residues and simultaneous utilisation as stove implies great potential for its implication in developing countries. In this study, a top-lit up-draft (TLUD) reactor was re-engineered and evaluated for its performance in char production and heat provision from wood chips. Temperature sensors were installed inside the reaction chamber, chimney, and hot plate on the lid of the reactor. The air flow was measured at the primary air inlet duct, and adjusted by regulating the opening of an air flap (100, 80, and 50 %) at the bottom of the reactor. Average air mass flow rates at different openings were measured at 26, 45, and 58×10^{-3} kg s^{-1} respectively. The initial substrate load of 32 kg (80 % of barrel volume) was held constant for all runs. Transition times from biomass-conversion to char-conversion phase were decreasing with increasing air flow, namely after 144, 137, and 131 minutes. The temperature in the reaction chamber was interpolated and represented as a response surface. It was found, that heat generated in the ignition area was evenly distributed in the entire chamber after 100 minutes of operation. A similar pattern was detected for all different openings of the air flap. The mass conversion rates were fitted into exponential models, and the char yields after the biomass-conversion phase were 19.6, 23.0, and 25.8 % of the initial weight respectively. After a maximum of 15 minutes, the heat provided on the hot plate exceeded 100°C and remained above this threshold until the end of the process, indicating adequacy for cooking purposes. Smaller air openings lead to higher average temperatures of the plate, namely 210.4, 238.4, and 252.3°C. The highest temperature of exhaust gas after the secondary air inlet was recorded at 490.1, 497.7, and 494.5°C respectively. The energy could be further used for other function such as in a stirling engine. For further improvement, the reactor should be utilised with other biomass such as shells of *Jatropha curcas* L., maize cobs, and stalks.

Keywords: Biochar, bioenergy, biofuel, gasification, pyrolysis

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Experimental and Computational Analysis of Photovoltaic Powered Cold-pressing of Sunflower Seeds

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The mechanical extraction of sunflower seeds is the preferential method for oil production. The oil covers a wide range of applications from food to biofuel, and the residual press cake can be used as animal fodder or for further processing. However, mechanical extraction is difficult to be implemented in rural areas without access to electricity. Cold pressing is a state-of-the-art method to preserve the oil quality. Oil extraction experiments were conducted using a mechanical screw press (IBG Monforts Oekotec, type – CA59G). Key characteristics such as the specific energy input, total electrical energy consumed and oil extraction efficiency were analysed for modelling off-grid applications, powered by photovoltaic modules and batteries. High oleic sunflower seeds of cultivar PR65H22 were obtained from a conventional farm near Würzburg, Germany and used as the feedstock. The experiments comprised variation in rotational screw speeds (18, 28, and 40 rpm), and nozzle diameter (4, 5, 7 and 8 mm). The resulting throughput ranged from 1.2 to 2.9 kg h^{-1}. Minimum and maximum attained torques were 11.0 and 24.9 Nm. Compared to other setups, the smallest nozzle and slowest speed lead to the highest specific energy input (0.79 kWh kg^{-1}), oil recovery efficiency (89.5 %), the maximum yield of raw oil (1.1 kg h^{-1}), and the highest press head temperature (77.3 °C).

Climate data of Nairobi, Kenya, was taken into account for simulating the photovoltaic system. With respect to its performance, the screw press was assumed to be driven at higher angular velocity during sunshine hours and lower ones at night. As a result, an economical optimum was found to maximise the ratio between oil output and investment. The annual simulations also indicated that around 50 % of the whole investment of a solar press system would be related to the photovoltaic components. The system could work between 10 and 14 hours per day, depending on location. The payback periods were estimated to be around 4 to 7 years, strongly depending on local conditions like oil price, transport, installation costs, and climate.

Keywords: Cell, extruder, optimisation, simulation, solar

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Small- and Medium-Scale Biogas Plants in Sri Lanka: Case Study on Flue Gas Analysis

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Global warming, caused by increasing emissions of CO_2 and other greenhouse gases (GHG) as a result of human activities, is one of the major threats, which are now confronting the environment. CO_2 accounts for the largest share of GHG. For agricultural activities is estimated to account for about 13.5 % of the total GHG emissions and if emissions are allowed to increase without limits, the greenhouse effect can possibly destroy the environment for humans and other living creatures; even threatening the existence of humankind. Biogas production by anaerobic fermentation is a promising method of producing energy while achieving multiple environmental benefit e.g. fossil energy substitution, carbon emission reduction, pollution abatement, welfare improvement and it was evaluated as one of the most energy-efficient and environmentally friendly forms and technologies for renewable energy production.

The study was carried out in August 2014 in the different areas of Sri Lanka at the level of biogas plants (n=51) and local consultants (n=4). Methods of data collection included semi-structured personal interviews, questionnaire survey and flue gas analysis. Flue gas analysis was done through portable device TESTO 330–2, which is capable of capturing the gas concentration of CO, NO, consequently by recalculating CO_2 and NO_2.

If considered almost 20 m^3 as average size of BGP, 600–700 m^3 of biogas generation per year can be expected. In our case reflecting average time when BGP is on use: 6.03 hours per day (+/- 3.98), with minimum 1 hour per day up to 12 hours per day.

Quite high COppm was detected (COppm=10089.24), which might be caused by insufficient burning, inappropriate biogas cookers and inappropriate maintenance. NOppm is under the value of 0.046, which is showing acceptable value. Flue gas temperature seem appropriate (TS=449.16°C) as well as efficiency (53.96 %) and excess air (3.99 %). Recalculated values are corresponding with values for such biogas systems.

Easy energy access is a trigger for development, especially in form of human, social and economic development and biogas plants represents a boon for farmers and rural people to meet their energy needs. However, further factors must be also examined and evaluated.

Keywords: Biogas technology, flue gas analysis, Sri Lanka

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Diversified agriculture and nutrition - BMEL session

Oral Presentations

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Diversified Agriculture for a Balanced Nutrition in Sub-Saharan Africa – Projects Supported by the Federal Ministry of Food and Agriculture, BMEL

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Focus on Nutrition – Research funding of German-African Consortia

With the funding instrument "Research Cooperation for Global Food Security and Nutrition" BMEL strengthens the contribution of Germany's agricultural and nutritional research to the development of an efficient food system in partner-countries, by building long-term partnerships between agricultural and nutritional research institutions in Germany and in Africa.

The first call for proposals "Diversified Agriculture for a balanced nutrition in Sub-Saharan Africa" was launched in 2013. The selected research projects deal with the nutrition-sensitive food production in the target region. Research consortia contribute approaches of a diversified agriculture to combat malnutrition and favour a balanced nutrition in eastern and southern Africa.

Funding Agency of BMEL is BLE.

Session II / 7.4 at the Tropentag 2015 seeks to present the consortia and their projects funded within the frame of this call:

1. Agriculture and Dietary Diversity in Africa (ADDA), coordinator: Georg-August-University of Göttingen.
2. Crops for Healthy Diets: Linking Agriculture and Nutrition (HealthyLAND), coordinator: Justus-Liebig University Giessen (JLU). Participation: University of Hohenheim.
3. Diversifying agriculture for balanced nutrition through fruits and vegetables in multi-storey cropping systems (NutriHAF), coordinator: The Center for Development Research (ZEF).
4. Scaling-Up Nutrition: Implementing Potentials of nutrition-sensitive and diversified agriculture to increase food security (Scale-N), coordinator: Leibniz-Centre for Agricultural Landscape Research (ZALF). Participation: University of Hohenheim.

Outlook

These four research consortia involve relevant partners from research, governmental institutions, NGOs and also large numbers of farmers. With this research cooperation BMEL wants to contribute approaches and findings to regional development processes. In future, BMEL aims to enlarge this network of researchers improving nutrition and to develop interfaces to further existing engaged actors.

Keywords: Diversification, nutrition-sensitive agriculture, research cooperation, sub-Saharan Africa

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Crops for Healthy Diets: Linking Agriculture and Nutrition (Healthy-LAND)

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At the beginning of the 21st century, differences among regions and countries in nutrition security are still big. Even if food security exists, many households face difficulties in achieving a diversified diet providing all necessary macro- and micronutrients as well as health-promoting bioactive substances. Besides global malnutrition, micronutrient deficiencies are typical manifestations. At the same time, caloric overnutrition causes diseases, preventable through adequate intake of fruits and vegetables providing the bioactive plant substances. East Africa shows relatively high prevalence rates of malnutrition and faces a high need for diversified diets. Our goal is to discover to what extend and how a more diverse farming system contributes to diverse diets and nutrition security. We hypothesise that improvements in farming systems based on ecologically oriented farming has an impact on food diversity and nutrition security.

Expected outputs are a comparison of nutrition security, dietary diversity, agrobiodiversity and choice of crops among resource poor households in Ethiopia, Kenya, and Uganda. The target sites are classified as currently following monoculture survival strategies. Further outputs will be tested innovations in the farming system to increase food options by offering sustainable cropping alternatives including agroforestry mitigating soil degradation. There are several multipliers and vicious cycles to be identified along routines in farming ending in a new concept. This concept will be described by a collection of indicators and underlying factors. The concept of diversified diets we use implies: (i) healthy nutritional statuses, achieved through intake of different foods provided by diversified farming and purchased from off-farm income; (ii) use of diverse crops to prepare meals serving nutrition needs based on a diversified crop production; (iii) use of healthy crops offering full ranges of nutrients; (iv) adapted preparation techniques of food and meals for a healthy diet. The work packages (WP) 1 and 2 focus on nutrition looking at status and change of vulnerable groups, institutional set-ups in households, gender relationships, mechanism of achieving change needs, and farming diversity. Vegetables and fruit trees being part of the traditional system will be investigated in WP3, looking at organic matter turn-

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overs and impact of land use on soil degradation. With respect to finding a translation mechanism between dietary and agricultural diversity, findings are put into a communication framework (WP4).
Finally, the research aims at contributing to capacity building. The focus will be on knowledge exchange, on status of nutrient provision and maintenance of health between consumption and production units using a trans-disciplinary approach, in which crop scientist, agronomists and nutrition experts work together with farmers, households and retailers.

Keywords: Agriculture innovations, agrobiodiversity, dietary diversity, nutrition education, nutrition – agriculture linkages

Scale-N: Study Design and the Current Status in the Case Study Villages: Morogoro and Dodoma-tanzania

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Food and nutrition security must be atop of Tanzania's development agenda as malnutrition is widespread in the country. Poor nutrition reinforces with poor health and sanitation to undermine well-being of the population especially the vulnerable groups (women and children) in rural areas. The domestic agriculture sector that largely feeds the country is not adequately planned and developed in ways that foster human nutrition and health focused food systems. That is why the country's food self-sufficiency has not helped to address malnutrition and nutrition-related health problems. Country-level severe stunting and underweight disorders among under-fives are estimated at 38 % and 22 %, respectively. The distribution and levels of malnutrition and health problems differ over space and time. However, the nutritional outcomes tend to correlate with local food systems in terms of what foods the crop and animal production systems and food markets offer to the local populations. Scale-N is designed to assess the local food systems (food production, markets, and processing), health and sanitation as to identify, test and promote promising upgrading strategies for better and sustainable nutritional and health outcomes. The nutrition profile in the Scale-N case study sites indicates that stunting is at 55 % in the semi-arid Dodoma and 30 % in the sub-humid Morogoro. About 49 % of households consume salt that is not iodized, exclusive breastfeeding is done by less than half (39 %) of the mothers' population and food consumption is mainly cereal based with limited intake of protein and micro-nutrient dense foods. Women of reproductive age and children below five years are the most affected. Scale-N project is expecting to reach around 4,000 rural farming households in its case study sites. In order to identify the major nutrition and health gaps, Scale-N will start by carrying out a situation analysis of local food systems, nutrition status of the population, and water, sanitation and health. Specific analyses will include nutrition-tailored value chain analysis, food characterisation and intake patterns, screening of soils on which crops are grown for existing mineral elements (e.g. iodine, iron, zinc and selenium), and establish the nutrient status of a variety of planted and edible wild foods, and those sourced from local food markets. Moreover, nutritional outcomes indicators to be analysed include anthropometrics and blood tests for detection of micronutrient deficiencies. Through a participatory pro-

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cess, promising upgrading strategies will be identified, tested and promoted in the case study villages. Last but not least in importance, pathways for wider up-scaling of nutritional upgrading strategies will be crafted and institutionalized across the nutrition development planning scales (local, sub-national and national).

Keywords: Agriculture, malnutrition, nutrition security, protein and micro-nutrient dense foods

Scaling-Up Nutrition: Implementing Potentials of Nutrition-Sensitive and Diversified Agriculture to Increase Food Security

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Food and nutrition security is still one of the most pressing challenges to constantly growing populations in Sub-Saharan Africa. The nutritional situation in Tanzania has only slightly improved in the last decade despite high rates of economic growth. The share of the population with insufficient available calories for consumption was found to be higher than 20 % and stunting prevalence of 40 % in children <5 years are reported. To improve the nutritional status of Tanzania's local poor, the Scale-N project funded by the Federal Ministry of Food and Agriculture aims to safeguard food and nutrition security by supporting the development of diversified and sustainable agriculture. Scale-N will perform in regions with highest need: the semi-humid Morogoro and the semi-arid Dodoma region. The participatory research design of Scale-N targets the above problems by applying a holistic integrated approach while using and linking to the existing analytical research framework Trans-SEC.

The project aims at ameliorating the critical food security situation and nutritional status of the rural poor in Tanzania. Following the core principles of participatory and collaborative research, a network of scientists, stakeholders and policy makers endeavours to develop integrated solutions and upgrading strategies along local and regional food value chains after thoroughly analysing nutritional gaps and drivers for food insecurity. Scale-N is designed to empower women and build the capacity of vulnerable rural communities to shape a sustainable future.

Scale-N will establish participatory mechanisms for local stakeholder feedback and involvement as well as an inter- and transdisciplinary German-Tanzanian research & development network. Following in-depth analysis of the nutritional/ health status of the local population as well as key value chain components, nutrient-dense plant-derived foods, their growth and production requirements and processing techniques will be identified. Specific target groups will receive education on improved nutrition and sustainable agricultural practices. After successfully testing innovations, they will be communicated broadly and up-scaled in a wider spatial context.

Keywords: Food and nutrition security, nutrition education, nutrition value chains, participatory action research

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Evaluation of Adoption Potential of Modern Technologies in Potato Value Chain by Smallholder Farmers in Kenya: Nyandarua County Pilot Case Study

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In Kenya, smallholder potato farmers endeavour to increase their production through various approaches, most commonly by expanding areas under production and repeatedly planting potato on the same site, with the latter resulting in build-up of diseases. Compounded with limited access to options to improve productivity, these farmers yield less than 10 t ha^{-1}, much below realistic yields of 20 to 30 t ha^{-1}. In an attempt to address these constraints, a study in the framework of the pilot project Potato Initiative Africa lead by International Potato Center (CIP) evaluated modern interventions to improve yields and reduce harvest and postharvest losses along the production chain. The study employed a participatory research approach with a set of five smallholder farmers representing the sub counties of Nyandarua and a site at farmer training school in Nyandarua (ATC Njabini), the sites were used for demonstration of these interventions to increase productivity and incomes of the smallholder farmers. Major interventions were evaluated; Potato varieties suitable for processing, fertiliser use, seed quality, mechanisation and crop protection options. The study compared three production packages: i) Modern production technology which included fully mechanised operations, use of fertiliser blend specific for potato (NPK 16:8:22+2MgO+2S), three imported varieties and two improved spray programs ii) National Agricultural Research Station recommended operations using DAP fertiliser (DAP 18:46:0) with farmers preferred variety (Shangi) and manual operations and iii) the farmers' local production practices. The paper reports on the results of soil fertility status of the smallholder farmers' fields, mechanisation options, crop protection, cost benefit analysis, yields, farmers perceptions of the demonstrated interventions, and recommendations on the potential adoptability of these interventions.

Keywords: Adoption potential, modern agriculture technologies, potato, smallholder potato farmer

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Aflasafe Technology in Zambia: Upscaling and Dissemination through On-Farm Trials for Wide Uptake and Utilisation

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Zambian smallholder farming communities are highly reliant on maize and groundnuts, as staples and cash crops. Although yields of both crops increased in recent years, grain quality remains poor due to pre- and post-harvest contamination with aflatoxins. Aflatoxins produced by certain species of Aspergillus are toxic and cancer causing substances. Consumption of aflatoxin contaminated foods has negative health impacts and their presence prevents farmers' access to markets due to stringent regulatory standards. To combat this, an aflasafe biocontrol product was developed at the International Institute of Tropical Agriculture (IITA) in collaboration with USDA's Agricultural Research Service (ARS), Zambia Agricultural Research Institute (ZARI) and the National Institute for Scientific and Industrial Research (NISIR). On-farm efficacy trials indicate that the aflasafe product is highly effective in reducing aflatoxin loads in both crops by over 80 %. Thus the product has great potential in minimising the ill effects, enhancing food security, trade, as well as raising farmer incomes. However, it is required to scale up aflasafe utilisation. This study identified constraints hindering aflasafe scaling up and adoption by smallholder farmers in Zambia. Through consultative workshops with various stakeholders key factors threatening aflasafe upscaling, dissemination and adoption were identified. These include among others: i) lack of awareness regarding the negative health and trade impacts; ii) lack of aflasafe manufacturing capacity and market distribution channels; iii) lack of incentives for aflatoxin-free grains, iv) non-existent permit for commercialising the aflasafe product in Zambia; and v) inadequate extension staff to reach more farmers. Thus for this biocontrol product, approved production facilities and improved awareness and access to the product by removing constraints to dissemination and adoption is required.

The "Upscaling and dissemination through on-farm trials for wide uptake and utilisation" Project is supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Some years ago the GIZ supported international Agricultural research

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on Aflatoxin at IITA. In the frame of Innovation transfer support, GIZ is currently complementing the IITA and USAID efforts with a pilot project in Zambia. Upscaling is foreseen within the framework of the German Initiative ONEWORLD - No Hunger! and its Green Innovation Center in Zambia.

Keywords: Aflasafe, aflatoxin contamination, Development Cooperation, German Initiative ONEWORLD - No Hunger, GIZ, Green Innovation Center, IITA

Mutually Supportive Implementation of the International Treaty on Plant Genetic Resource for Food and Agriculture and the Nagoya Protocol on Access and Benefit-Sharing

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At the international level, access and benefit-sharing related to genetic resources (ABS) is governed by two agreements: the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), coordinated under the aegis of FAO, and the Nagoya Protocol (NP) to the Convention on Biological Diversity (CBD) coordinated under the aegis of UNEP. Both instruments establish frameworks for member states to regulate access to genetic resources and to ensure the sharing of benefits generated from R&D based on those resources, including breeding. Underscoring the importance of plant genetic resources for food security, the ITPRGFA establishes a multilateral ABS system for member states to share a defined list of the most important crops and forages for food and agriculture. The NP, on the other hand, covers all genetic resources under a member state's sovereignty and establishes criteria for bilateral ABS agreements that are to be negotiated individually between users and providers.

Both agreements refer to the ABS principles of the CBD and are meant to be implemented in mutually supportive ways. Yet, in practice countries are experiencing challenges in developing mechanisms for harmonised implementation. One of the roots of these challenges is that in most countries, environment agencies are responsible for the CBD/NP, and agricultural agencies are responsible for the ITPGRFA. And in most countries, these agencies have tended to work independently, a practice that has been reinforced in developing countries by outside donor and technical support organisations. As a consequence, there is a lack of awareness within environmental sector about the ITPGRFA and little knowledge about the CBD/NP in the agricultural sector. Many policy actors perceive 'grey areas' where it is unclear which system should apply, and are struggling to develop mutually supportive systems in place. Given the extremely close objectives and subject matter of these two international agreements, it is essential that all actors involved overcome their historical divides and work together to develop mutually supportive mechanisms for implementation.

To address these challenges, Bioversity International and the GIZ-implemented ABS Capacity Development Initiative have been cooperating since 2012 to engage stakeholders from the two fields and provide guidance on the mutually supportive implementation of the ITPGRFA and the NP. In the framework of this cooperation, an

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expert workshop (in 2013) and a tandem workshop for teams of focal points in charge of the two instruments (in 2014) were conducted to discuss the interface between the two agreements and mechanisms for improved coordination between policy actors. These workshops led to a number of spin-off publications. A third workshop, co-organised with the Secretariats of the ITPGRFA and CBD/NP and African Commission is scheduled for November 2015. Furthermore, Bioversity and CBD Capacity Development Initiative are co-executing a three year pilot project in cooperation with the ITPGRFA and NP focal points in Benin and Madagascar to develop and test concrete, mutually supportive, implementation approaches from community to national levels.

Keywords: Access and benefit-sharing, agriculture, capacity building, environment

Assessing the Costs and Benefits of Climate Smart Agriculture- A Locally Tested Tool and its Potential for Uptake by ASEAN

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Climate Smart Agricultural (CSA) practices can create benefits for smallholder farmers by achieving a sustainable increase in agricultural productivity and at the same time contribute to climate change adaptation and/or mitigation. However, how can we identify which practices are most suitable to existing agro-ecologic conditions, resilient to regional climate risks under different scenarios and that can achieve objectives identified by key stakeholders? Importantly, what are the costs and benefits of applying those prioritised practices? How can the most promising practices be taken to scale?

The study initially focuses on the development of a spatial methodology for the identification of climate risk hotspots that would benefit from the adoption of CSA practices. Based on these findings, we discuss approaches and results of an innovative tool for decision-makers, which assesses costs and benefits of CSA practices, prioritised through criteria selected by local stakeholders. The cost benefit analysis includes the quantification of trade-offs and the estimation of the level of peak adoption of CSA practices. The tool is being tested in 3 target regions in different agro-ecological and climatic landscapes in Viet Nam, Uganda and Nicaragua. Supra-regional integration unions and alliances (the ASEAN Climate Resilience Network (CRN) in Southeast Asia, the CSA Alliance in Africa and the Consejo Agropecuario Centroamericano (CAC) in Central America) are platforms to scale out prioritised CSA practices from the village level to regional level. We will explore the case example of uptake and outscale possibilities of the tool within the ASEAN and what are the requirements so that the user friendly tool can enable ASEAN policy makers to take informed and evidenced based decisions.

Keywords: Adaptation, climate change, climate smart agriculture

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Agricultural Intensification - A Pathway to Protect Forests: The PSMNR-IITA Approach in SW Cameroon

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While agriculture has been a main driver of deforestation and land degradation worldwide the South West Region of Cameroon was not as severely affected as forests in Asia or Amazonia. However, degradation is increasing and the area is already part of large scale private investments in oil palm, rubber, bananas etc. In the area of implementation, IITA works together with the "Program for Sustainable Management of Natural Resources in the South-West Region" (PSMNR-SWR) to slow down the pressure on forests and protected areas by intensifying agricultural activities in communities riparian to three national parks. The projects overall objective is to "contribute to the preservation of high-value ecosystems in the South West Region of Cameroon and thereby contribute to improved livelihoods of the surrounding communities in a sustainable manner."

Livelihood of the population living around the National Parks in the South-West Region still depends strongly on hunting, logging and collection of NTFP. Main commercial crops are cocoa and oil palms and important staple foods cassava and plantains. For these agricultural activities, land is needed, which puts the protected areas under pressure. Improved production on existing cultivated land is therefore an important way to increase cash income without adding to the pressure on forest areas. We assume that an increase in household income will reduce the need for illegal logging and hunting and therefore will contribute to the conservation of protected areas.

Currently production levels and cultivation techniques in the PSMNR target villages are not yet well developed, resulting in low productivity and increased soil degradation.

With the introduction of improved cassava and plantain varieties to increase the per hectare output, while at the same time introducing integrated crop management and sustainable production techniques with special focus on pest/disease and soil fertility management, IITA/PSMNR wants to support and promote the sustainable use of natural resources.

The project aims at improving the livelihood of households through:

- Dissemination of improved cassava and plantain varieties
- Farmer training in best agricultural practices and soil fertility measures
- Processing and commercialisation of cassava products.

Keywords: Agricultural intensification, cassava, deforestation, livelihood security, NRM, plantains

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Assessing and Refining Carbon Stocks in Soil and Biomass Across Scales in Kalimantan/Indonesia

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The amount and spatial distribution of carbon stocks in aboveground biomass (AGB) in tropical rainforest ecosystems in Kalimantan are subject of much research, but amount and variability of belowground biomass (BGB) and soil organic carbon stocks (SOC) remain uncertain for several forest ecosystems and deep soil. However, reliable data on the latter two pools are required to estimate total ecosystem carbon stocks (ECS = AGB+BGB+SOC) and their change due to anthropogenic activities across larger scales. It is therefore important to assess carbon stored in BGB and soils of varying forest ecosystems to improve our understanding of ECS and to refine their spatial distribution. In this presentation we summarise pilot efforts to assess BGB, its heterogeneity and dynamic changes due to natural and human impacts and discuss methods to refine carbon stock estimation across scales, as a basis for more reliable data to predict carbon stock changes due to global change under different land management scenarios.

Keywords: Carbon stocks, Indonesia, soil carbon, tropical soils

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Cooperation and conflict management

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Land Conflicts Are Security Risks — Can the EU Stabilize the Sahel by Trade, Investment and Development?

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The EU established recently a so-called comprehensive security approach as part of foreign security policy. This aims at extending classical military and humanitarian strategies by others like trade, development and investment approaches. Sahel-specifically in 2011 the »Strategy for Security and Development in the Sahel« was adopted, with Mali being evaluated regularly evaluated as pilot.
This paper focusses on the question of political coherence as major EU policy aim, i.e. how existing approaches towards Sahel countries work together, fit within existing UN frames like »Global Alliance for Resilience« (AGIR) and whether they finally contribute to overall political stabilisation.
Sahel countries face increasing pressure on acceding land and water resources due to climate change. As consequence especially pastoralists are at risks losing their income base due to hardly enforceable tenure rights and due to often political marginalisation. This can be counterproductive as first, especially this land use system is seen as most resilient to the extreme nature conditions of the Sahel. And second, pastoralists losing their income base may become vulnerable to several terrorist and radical activities involved in political conflicts. This finally can be a threat to European security.
Existing EU policies towards Sahel like the European Partnership Agreement EPA —ECWOAS and the bilateral foreign direct investment agreements will be analysed regarding their potential for pushing or avoiding land use conflicts. Additionally, existing development funding is evaluated regarding its impact on land use. Some best cases will be presented and finally conclusions on how to improve EU's existing policies' impacts on stable land use are drawn.

Keywords: EU trade and investment policies, pastoralism, political stability, Sahel region

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Solving Trade-Offs Between Food Security and Biomass Use: Addressing the Right to Food in Biomass Sustainability Standards

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With the emerging bioeconomies in Europe, the demand for biomass will rise. Sustainability concerns led to the development of sustainability regulations in the EU Renewable Energy directive, where ecological criteria play a mayor role. With this political sign private certification standards for biomass proliferated but with major differences regarding environmental and social criteria. While almost all standards address ecological sustainability concerns such as direct land conversion for bioenergy crops, social criteria are only demanded by certification schemes developed in a multi-stakeholder process. Those standards aim to address also local food and nutrition security, but practical approaches which determine the impact of a producer on the local food security situation lack. Approaches propose a comprehensive measurement using classical methods like house hold surveys to detect impacts on local food and nutrition security. In contrast to that, this research project uses a different approach to assess impacts on local food security through enhanced biomass production. By means of the "Voluntary Guidelines to support the progressive realisation of the right to adequate food in the context of national food security" combined with the four dimensions of food and nutrition security (access, availability, utilisation and stability) we defined a conceptual framework to identify indicators which ensure the Right to adequate Food. The framework lead to the selection of 16 main guidelines which have to be addressed by a certification scheme which shall guarantee that the Human Right to adequate Food is not violated by the carrier of that label. The indicators represent an ideal set, which, if included as a whole, encourage the implementation of the Right to Food Guidelines in sustainability standards.

Keywords: Biomass, right to food, sustainability standards

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The Factors Affecting the Trust and Risk Attitudes of Ethiopian Households

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Trust and risk attitudes are two implicit features of human behaviour that play a significant role in the decision making process. This study examines the determinant factors of trust and risk attitudes of individuals and the relationships between them. A number of studies underline that the availability of information is crucial to develop trust among the subjects whereby mitigating their risk attitudes. Trust and risk attitudes are also determined by socio-economic factors that vary across different societies. Ethiopia is a low income country, which has a multi-ethnic society that exhibits economic and social distinctions between different groups of people. Hence, the determinant factors of trust and risk behaviours of the households in our study area would include both societal and individual variables.

Data were collected from 400 randomly selected Ethiopian households residing near the southern part of the Awassa city, using survey questionnaire and a game with real money at stake. Unlike Ethiopians from the other regions of the country, the people of Awassa have encountered less severe drought and flooding. This allows the people to maintain their behaviours and daily activities, as they have been less affected by the natural phenomenon. We examine whether this plays a role in determining the risk attitude of the households, in comparison to a previous study that was conducted in other regions of Ethiopia.

Ordinary Least Squares method will be employed to analyse and explain the determinant factors of trust and risk attitudes of the respondents. Conventional draught power use, land size, off-farm activity, and previous experience of drought and flooding will be included in the regression analysis and they are expected to have a negative impact on risk preferences while availability of help during emergency, inheritance, remittance, and the revenue earned from the sale of agricultural products are expected to increase the willingness to take risks.

The findings of the study will contribute to enhancing the understanding of risk behaviour, which is important for future research and devising new policies that will promote investments and adoption of new technologies.

Keywords: Ethiopia, household survey, risk attitudes, OLS

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Role Playing Games in Land Use Research: Experiences from the Mahafaly Plateau in Madagascar

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Over the last decades, researchers and practitioners subsequently realised that natural resources can neither be analysed nor managed without considering the human factor. The participation of resource users and other stakeholders is an important feature in managing natural resources, producing scientific knowledge and developing land use innovations. In this conference contribution the participatory method Role Playing Games (RPG) is presented as one promising approach to include socio-economic factors in transdisciplinary communication and research. This simulation exercise with stakeholders seeks to foster mutual understanding and to validate science-based knowledge. To illustrate the use of RPG, the case of Mahafaly Plateau in south western Madagascar is presented. In this economically marginalised but ecologically rich region, RPG has been designed and tested to understand household decisions. A series of workshops were held by a Malagasy team over a period of four weeks in July 2014, both in the littoral and in the plateau region. A total number of 96 resource users in all four villages participated in the workshops. The methodology "Livelihood Game" was developed by scientists based on preceding research on household structures. Within the RPG, villagers assume the roles of fictive household types and simulate their annual subsistence decisions and social activities on maps. According to their endowments, the households can choose where and how they cultivate their fields and practice additional activities such as livestock keeping, producing charcoal, using natural resources or sending children to school. The game covers "good" years and drought years. To visualise their decisions, participants use maps of their familiar surroundings, pictured cards, and beans as symbols. The experiences show that villagers were well-interested and perfectly capable of taking part in the simulations. Participants of different age, gender and lignage contributed their knowledge on resources, land and activities. Thus, researchers and villagers learned to see the local reality from different households' perspectives. The approach may be useful for various purposes such as common planning, joint resource management and conflict resolution, and thus calls for further research and development.

Keywords: Land management, Madagascar, participation, role playing games, SuLaMa/Lama

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Structuralist-Constructivism Approaches for Enhanced Food Security in Wildlife-Agrarian Mosaic Landscapes: Insights from Eastern Zambia

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Wildlife management and agriculture form a complex and challenging nexus between conservation and food security in much of the African rural areas. Wildlife destroys and devours unprotected crops, livestock and other properties owned by impoverished local communities. Despite such protracted human-wildlife conflicts that result in food insecurity, the adaptive capacities of local communities and other stakeholders like wildlife managers and tour operators are rarely studied. Therefore, underlying drivers, impacts of conflicting land use types and viable solutions to address adaptive capacity challenges were investigated using structuralist-constructivism theory. Local structures like informal and formal rules, norms, challenges and institutional organs that govern community operations were investigated in the context of social-ecological systems, and how the strategies rooting from the theoretical constructs would help confront conflicts and controversies associated with contemporary food security. Systemic appraisals by use of semi-structured questionnaires were employed and administered to 131 respondents, with the help of trained field assistants. The study revealed that poverty and weak institutional governance in ever-growing human population landscapes underlie the escalation of conflicting multiple land uses. Majority of the respondents (97.71%; n =128) perceived that high food insecurity risks and degradation of natural resources ensue due to over-exploitation. Further, most of the respondents (80.92%; n =106) perceived that conflicts and controversies over food insecurity were centred on crop and animal losses to wildlife in the wildlife-agrarian landscapes. Crops in the fields closer to national parks were more predated upon than those in distant crop fields (χ^2= 219.184, d.f = 122, $p < 0.001$). However, concentration of agrarian human populations in proximity with parks and forest reserves contradicted the intensity and frequency of crop vagaries by wildlife. These conflicts and controversies were exacerbated by prevalent environmental stressors like droughts and floods. Compounding environmental and anthropogenic stressors, local adaptive capacities were constrained by low levels of social capital networking and cohesions. Consequently, the risk/reward ratios of property protection against food access and availability remained dismal for rural inhabitants. Therefore, it is posited that relational social capital, transformative and integrative land use planning should be strengthening to enhance food security, sustainable development and wildlife conservation.

Keywords: Adaptive capacity, competing claims, human-wildlife conflicts, multiple land use types, relational social capital

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Soil Related Constraints for Sustainable Intensification of Cereal-based Systems in Semi-arid Central Tanzania

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Improved management of land is critical to overcome soil related constraints to sustainable food production in degraded soils. However, limited availability of site-specific nutrient management guidelines for semiarid zones in Tanzania may undermine efforts to target technologies to biophysical and/or socio-economic conditions in which they operate. Thus technologies adopted under these circumstances may be risky to farmers. We characterised soils in Kongwa and Kiteto districts to assess the nature and fertility status and drivers of land degradation so as to inform the development of integrated land management options for sustainable intensification. Both landscape- (Land Degradation Surveillance Framework-LDSF) and field-based sampling approaches were used to collect soil data (nutrients, carbon levels, infiltration rates and types) and ecological data (land use types, tree cover and density). Remote sensing and GIS techniques were used to prepare base-maps and generate clusters of plots within a 10m $\times$ 10 m block (sentinel). At field level, standard mapping techniques were used to open, describe, and sample soils from profile pits in 5 villages in Kongwa and Kiteto districts. Results showed that soils belonged to Lixosols (Laikala, Mlali and Molet Villages), Luvisols (Manyusi, Njoro and Laikala villages) and Vertisol (Mlali) orders. Generally soils in these villages had poor to moderate fertility, especially for CEC and exchangeable bases. Soil total nitrogen and organic carbon ranged from very low to low. Aridity indices revealed that Moleti has steppe characteristics while other villages are semi-arid with a very short growing period of 2–3 months. Only 9 % of land in the Njoro sentinel is under cultivation and the rest is grazing land and forests (*Acacia* woodlands). The carrying capacity for livestock exceeded the optimum and tree cover was low 84.3 stems ha^{-1} compared to 268.9 stems ha^{-1} for shrubs. These factors are the major reasons for high land degradation noted in the district. To sustain crop production, soils will require inputs of fertilisers (N&P) and manure to replenish nutrients and build-up of organic carbon. Additionally integrating leguminous trees/shrubs or retention of trees in agricultural landscapes would enhance vegetation cover, carrying capacity of grazing lands in addition to improving soil health and land productivity.

Keywords: Carrying capacity, land management, LDSF, livestock, soil health

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Environmental Challenges and Opportunities for Enhancing Land Use Systems in the New Valley, Egypt

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The ever-increasing population of Egypt (approaching 90 million), is associated with concentration of more than 90 % of that population in only 5–6 % of the total country area. Consequently, resettlement programs, in the New Valley (NV), which is located in the Western desert of Egypt, are implemented to convert arable areas to new productive rural communities. Effective land use systems in the NV face several Environmental Challenges (ECs), including both natural disasters and improper farmers' behaviour. Among natural disasters are: desertification, loss of vegetation cover and biodiversity, sand dunes, water scarcity, raise in average temperatures and drought. Improper farmers' behaviour is demonstrated by the mismanagement of available natural resources, by new land settlers, who usually apply the old land use practices on the new local communities (such as flood irrigation and inappropriate cropping systems), without considering climate change and different types of soil in new lands.
The study objectives were to: 1) Investigate the ECs facing effective land use systems in new local communities of the NV, as perceived by different stakeholders; and 2) Explore the Environmental Opportunities (EOs) for enhancing the effectiveness of these systems, as suggested by the respondents. Field data were collected during personal interviews, with a random sample of 120 respondents (farmers, local leaders, tribes' heads and governmental officials) by using a structured questionnaire, to achieve the study objectives.
The study revealed that the most important perceived ECs are: shortage and low quality of irrigation water; and soil salinity. These ECs are aggravated by weak agricultural extension and advisory services. The suggested EOs, for facing ECs and enhancing the effectiveness of land use systems, in the NV, could be classified into 4 categories, namely : a) Infrastructural (such as supporting digging irrigation wells, improving drainage systems, providing electric power for irrigation wells; b) Human resource development (such as recruiting and training new extension workers and upgrading the skills of irrigation technicians; c) Financial (such as providing financial support for digging wells and providing loans); and d) Improving research, extension, and advisory services (such as providing technical services, awareness raising and information delivery activities).

Keywords: Egypt, environmental challenges, land use systems, new rural communities, New Valley, opportunities

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Conflict Mediation and Educational Perspective about the Development of Climate Adaptation and Land-Use Strategies: CLARIS LPB and Sinergia Projects Experiences

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Adaptive capacity to climate change can be improved by educational process. Communities have been revealed as vulnerable due to their biophysical and socio-cultural conditions, and also their lack of collective action to build adaptation strategies to climate. The collective action does not occur as a natural and spontaneous human interaction, neither it is a logical consequence of problems to be solved. Our intentions, our goals, our historical consciousness do not provide the success of our projects as much as the media we use (mediation between the "ends" and pursuing the "means"). There is a mediation, a way to be built, which is precisely what educators and policymakers should encourage in order to promote climate adaptation process. In this context, two workshops were developed to build primary land-use scenarios and to design climate adaptation strategies according to different social contexts of participants (n=37) in two different South America cities. The used methodologies were: Compound Stimulus, Forum Theatre, and Diagram of Influences. Compounds Stimulus is a drama methodology that allows investigating and scenarios through few given elements and collective action. Through workshops it was possible to develop primary scenarios and adaptation strategies between the participants. Although the construction of scenarios requires further elaboration, the workshops are an initial step in this process, and considered essential to understand the impacts of climate change. The process developed was possible to imagine, to describe and to understand climate scenarios allowing three basic human creative capacities important to learning process: to organise momentary experiences; to predict individual and collective future, and to live hypothetical stories. This result was also related with the concept of zone of proximal development that is the distance between the knowledge for which an individual already dominates and the knowledge that he is still dependent on the support of a group and mediation process.

Keywords: Climate change, popular education, rural development

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Management of Environmental Agencies on Conflict of Irregular Land Use: "Juréia Itatins" - Sao Paulo, Brazil

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The Brazilian environmental agencies policies have attributes that issue how to use and manage the land in special protected areas, including the legalisation of lands in case of occupation by traditional communities, indigenous, or vulnerable people. Also, these policies combine the preservation of natural resources and sustainable development of the local population with food production or plantations. First, the management of these protected lands could be negligently or unfair in the view of the environmental agencies because they are the product of irregular occupations and improper use. Second, these agencies could demotivate the population by implementing environmental solutions, mainly related to counteracting deforestation and improper planting.

This paper aims to analyse and criticise the role of environmental agencies on land use in special areas called "conservation units" in Brazil with respect to subsistence production and irregular occupation. Finally it discusses the assessment of the importance of land use control and the presence of environmental control by the public administration. Environmental laws have kept the agencies and technical standards, however, these laws are not always used appropriately or they are sometimes flouted creating an environmental injustice. The study area "Estação Ecológica Juréia Itatins" is situated at the coast of Sao Paulo, Brazil, has 365 families and is currently the scene of numerous social and land conflicts due to occupation of these protected areas that have been protected by constitutional legislation as environmental preservation areas. The study is exploratory and qualitative, and is based on social study data from the Brazilian Institute IBGE that collected primary and secondary data between 2005 - 2010. In conclusion, the study shows that currently the executing agencies and their public agents are non-effective to assure a sustainable, public accountable, and social application of the environmental laws.

Keywords: Conflict over land use, environmental agencies, environmental land management, irregular use of land, public accountability, sustainability

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Exploring Symbiotic Cooperation of Smallholders for Sustainability and Food Security: A Spatio-Temporal Modelling Approach

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Sustainable development of the vulnerable rural areas remains a highly complex issue nowadays. Among the main goals, it should consider ecosystem services protection while supporting the most insecure but crucial actors in food production — agricultural smallholders. Such an approach can provide a multi-benefit effect — increase of productivity along with maintaining ecosystem quality and strengthening social and human capitals. As individual farmers are often lacking resources, information and skills to make optimal land-use decisions, the hypothesis is that multiple benefits can be achieved through creating symbiotic cooperation networks of agricultural smallholders. Such networks or clusters could be a means for sharing/exchanging resources, performing collective actions and coordinating land-use, sharing knowledge and eventually adopting new agricultural policies. Nowadays there is practical evidence of usefulness of such approach (e.g. CATALIST project; Agreco organisation), however it is lacking a methodology and a tool for systematic assessment and testing different solutions in different conditions.

This study is aimed at in-depth analysis of an agricultural smallholders-based network and its environment as a complex dynamic system, where technical, economic, social and environmental components are mutually dependent. We are moving towards a conceptual framework and a quantitative simulation tool to study the dynamics of a symbiotic cluster/network in different conditions, to test the sensitivity of the system to the changes in objective functions and input variables, as well as to evaluate the impacts of the implementation of new policies and incentives. As a first step in that direction, we present a simple game model to illustrate and test how smallholders-based networks for sharing resources can work. The model can be used with stakeholders to identify and record their preferences and strategies and inform further development of more sophisticated agent-based models and tools.

Keywords: Dynamic modelling, ecosystem services, networks, optimisation

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A Political Analysis of the Conflicts among Stakeholders in the Cuc Phuong National Park, Vietnam

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The stakeholders' interests in the forests are as diverse as the products and services that forests offer. In fact some of those interests go beyond the potential of forests products and services. This research was conducted in the Cuc Phuong National Park (CPNP),Nho Quan district, Ninh Binh Province, Vietnam at a time when there is a great need to show the interests of all forest actors as driving forces in the management of forests. The understanding of interests supports the forest community to provide sound solutions to the conflicts resulting from contrary interests.

The data was collected through questionnaires and interviews with the local people living in the vicinity of the CPNP. The obtained data was analysed and interpreted in charts, the result matrix and diagrams which map the actors, the interests and the conflicts that occur in the CPNP.

The results demonstrate that a conflict exists between the Vietnamese government with the main objectives of protecting the natural resources, scientific research and ecotourism development on the one hand and the local villagers on the other hand. As the villagers' livelihood largely depends on the forest they apply huge pressure on its resources and consequently their interests (farming, grazing, NTFP-extraction, fuel wood, timber, poaching, hunting, etc.) run contrary to nature conservation.

It was concluded that if the situation in the CPNP is left unaltered, there will eventually be an overexploitation which in long-term ends in the encroachment and loss of biodiversity in the CPNP. However, a proper cooperation of forest actors might improve the current situation considerably.

Keywords: Cuc Phuong National park, forest actors, interests, local villagers, result matrix, stakeholders

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Nature and Extent of Human Wildlife Conflict in the Chichibon Corridor, Ghana

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The current study assessed the nature and extent of Human Wildlife Conflict (HWC) in the Chichibon corridor between Digya National Park (DNP) and Kogyae Strict Nature Reserve (KSNR) in eastern Ghana. Semi-structured questionnaire was used to interview 83 randomly selected farmers from 12 communities in the study area. Elephant crop raiding was reported to be the most serious HWC in the area occurring during the wet season. Elephants also scared inhabitants in the villages during the course of their migration. Most crop raiding occured from May to July, with a peak in June. Yam was the most (33 %) raided crop with the least (1 %) raided being pineapples, okro, palm and cocoyam. Highest raids occurred in farms that border the south-western fringes of DNP. Most (81 %) elephant raids occurred within 5 km of the two protected areas, there was however no significant relationship (r^2=0.282, $p > 0.05$) between number of raided farms in villages and the average distance of farms to the nearest protected area boundary line. Combination of different deterrent methods to ward off raiding elephants was used traditionally, however, noise making (beating of metallic objects) and burning of car tyres to produce smoke were most prominent. Noise making or burning of tyres alone was not very effective unless they are combined. Proper land use planning within the corridor that takes into consideration farming practices that do not attract elephants and development of better deterrent methods can potentially help reduce the incidence of crop raiding. These processes however need considerable resources particularly in creating community awareness, restoring degrading habitats and providing alternatives livelihood options.

Keywords: Crop raiding, human-wildlife conflict, livelihood, wildlife corridors

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Conflict and Controversies in Land Use System: Case of Cocoa versus Gold

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Cocoa and mining both contribute immensely to the growth of the economy of Ghana. Major cocoa growing areas have also been found to be well-endowed with minerals including gold and diamond. About 230 companies had been listed by the mineral commission and over 40 of these companies had actually received mining leases by 2004 to develop new mines and carry out actual operations. Current trends show that many of these cocoa growing areas are being used for mining purposes. A case study was conducted to determine the conflict and controversies in relation to trade-off surrounding gold mining activities on cocoa farmers and cocoa production in the Asutifi District of the Brong Ahafo Region of Ghana. A multistage sampling technique was used for data collection through interviews of fifty (50) key informants whose cocoa farms have been affected by mining activities in the district. The results show that half (50 %) of the respondents have lost between 1–5 hectares of cocoa farms to mining activities whiles about one-third have lost between 6–10 hectares of cocoa farms. Compensation paid ranges between GH¢ 1,3430 to GH¢ 4047.33 per hectare based on the maturity level of the cocoa. These estimates are based on the assumption that there is an average of about 1350 cocoa trees per hectare. The study also shows that affected farmers in the district are not satisfied with the compensation package being offered by the mining industry. Farmers indicated the scarcity of land raising livelihood and food security concerns in the community though the mining industry has instituted progammes for sustainable agricultural and livelihood development. The findings suggest the need for continues dialogue among major stakeholders in the cocoa production and mining companies.

Keywords: Cocoa, food security, Ghana, gold, livelihood

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Conflict Management Programs in Transdisciplinary and International Research Projects

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With the shift to transdisciplinarity in sustainability research, the complexity of the project design has increased. In order to minimise conflict or even a project failure, it has been acknowledged that communication among project members is key and should be facilitated by meta-communication. Integrated conflict management programs, as prominent in the business world, can help transdisciplinary research projects to work more effectively. We present the development of a conflict management programme fit to the needs of a transdisciplinary work environment. For this purpose, framework characteristics are established and existing models for conflict management are tested for their transferability to projects in sustainability research. As case study serves the food security project Trans-SEC, which is a pilot project that uses an integrated conflict management program. The project consortium consists of more than 100 researchers of 15 world-wide institutes and aims at stabilising in a value-chain approach the situation of 4000 households in Tanzania.

Such projects can be described as complex work settings which show the following characteristics: (1) transdisciplinary (2) donor-funded (3) temporary (4) intercultural (5) interorganisational and mostly (6) virtual. The sum of the established characteristics coming together simultaneously within a single project make the work environment particular. Each characteristic in turn needs to be considered when setting up a conflict management program. A blue-print model for the research context is established based on the Viadrina Component Model which gained prominence in Germany's corporate sector. Although key components of the model remain, a component of conflict prevention is added and elements are adjusted to the research environment.

Keywords: Conflict management, conflict prevention, food security, project management, transdisciplinary research

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Conflict Prevention and Moderation System (CPM-System) in Multicultural Science

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Globalisation has seen an increasingly diverse range of people working together in multicultural research projects – a process which can often result in intercultural conflicts. However, conflict prevention and conflict management systems are still not widely implemented in the scientific realm. Conflict Management and Moderation System (CPM-System) can be defined as a programme designed for conflict prevention and conflict resolution within organisations. The aim of the CPM-Platform is to prevent and, if they arise, to solve conflicts within the research consortium. CPM-System is based on the assumption that conflict management is more successful and reliable if adequate structures and procedures have been established in advance. So far Conflict Management Systems have successfully been implemented in the "business arena", they are, however, new in the research context. This study is focused on identifying the specific categories that trigger potential conflicts in a multicultural science project that are different to those in business. We used Grounded Theory to develop the study and adopted a qualitative method for the collection of the data. Results from this study were used to categorise the concepts and develop the Conflict Prevention and Moderation System (CPM System) three level categories, which consist of the conflict levels, conflict triggering factors, and the consequences of the conflict. Cultural Diversity appeared to be the most important conflict triggering factor that influences all other factors. Other specific intercultural conflict triggering factors include finances, interdependence, hierarchies, and scientific issues. The findings suggest that intercultural challenges can be controlled by the proper introduction and use of a CPM System. We conclude that the implementation of a CPM System in a scientific context strongly supports a constructive way of dealing with conflicts in multicultural scientific projects.

Keywords: Conflict management, conflict management system, conflict prevention, conflict-triggering factors, cultural diversity, intercultural conflicts

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Managing Land Use Systems with Young Farmers in Kenya: Field Experiences of Controversies and Possibilities

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This poster shall present an analysis of land use practices on small farms owned by young farmers in Kenya in relation to food security programmes in the country. Literature suggests that the future of African agriculture is in increasing its human capital, particularly in a new generation of farmers responsive to changing climate, technology, and markets. It is therefore important to understand what implications the current land use practices among 'new farmers' might have on future food security and biodiversity.

Recent programmes focusing on increasing a new generation of young farmers' participation in food security programmes have shown a huge potential for redefining Africa's food security through engaging youth in scaling up, modernizing and diversifying the farming systems. However, some of these 'youth' food security programmes, if not accompanied by sustainable approaches to land use might pose a threat to biodiversity, water, soil and as well, may be affected by the increasing impacts of climate change on agriculture.

This poster shall present findings from a case study research on young farmers' contribution to food security, and the implications on land use systems in Kenya. I show the controversies of modernising small farming systems and as well, the possible impacts of introducing sustainable farming systems with young farmers. I recommend that sustainable land use management systems including practices such as evergreen agriculture, agroforestry, and protected agriculture shall be required alongside the efforts to increase human capital and enhance technological change and markets for food security in Africa. Importantly, enhancing food security through sustainable land use systems that include young farmers contribute to achieving social equity in agrifood systems.

Keywords: Kenya, land use analysis, sustainability, youth

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Drivers and Consequences of Farmers' Resistance Against Official Resettlement Plans at the Slope of the Merapi Volcano in Indonesia

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The eruption of the Merapi volcano in 2010 was the heaviest in the last century, leading to major ecological and social devastation and in the aftermath dispute and conflict between local farmers and the government. The government prohibited the resettlement of the most severely affected areas at the foothills of the mountain, so as to diminish losses in the next eruption. In opposition to this policy, the local farmers want to stay on their land and insist to resettle. The resistance is particularly high in four hamlets located at the southern slope of the Merapi volcano, namely Balerante in Balerante village, and Kalitengah Lor, Kalitengah Kidul, and Srunen in Glagaharjo village. The villages of Kepuharjo and Umbulharjo were also strongly affected by the eruption, with the tremendous pyroclastic flow burying eight hamlets in both village territories.

To better understand the current situation, an interview-based field study was conducted in the framework of an MSc thesis in the mentioned villages. During November 2014 - January 2015, individual interviews with 24 farmers and 3 village heads, as well as three group discussions were conducted, especially targeting the resilience of human, natural, social, financial and infrastructural capital in the region.

The results show that in most village territories the ecology of the foothill landscape has recovered, together with infrastructure and people's financial situation. Therefore, farmers view a realistic chance to re-continue gaining their livelihood from farming their land; some even consider the conditions for farming better than before the eruption. In all villages, farmers have started collective as well as individual actions to cope with the current situation and adapt to it. Farmers in Kalitengah Kidul, for example, daily collect small amounts of money in their community in order to buy new land at the lower slope of the mountain.

The gained insights allow identifying the current constraints to resolving the conflict between farmers and the government, and approaches are proposed to overcome these.

Keywords: Adaptation, conflict resolution, eruption, Merapi volcano, resilience

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Effect of Communal Conflicts from Farm Land Use in Cross River State, Nigeria

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Land is considered as the most important community asset and is passed down from one generation to another. People therefore go all out to defend the territorial integrity of their communities irrespective of the consequences. This paper examined the incidence of communal clashes as a result of disputes over farm land use in communities that have suffered clashes and losses in Cross River State, Nigeria. The land ownership structure in the area was also examined as well as the causes and effects of conflicts in farm land use. Data was collected through key informants interviews, focus group discussions and participant observation from selected conflict affected communities. The paper revealed that land was acquired mainly by communities through the clearing of virgin forests. Community boundaries are usually very well known and are set using major landmarks like streams, rivers and trees. Conflicts however arise over time as a result of incomplete information passed down to the next generation, mischievous and misguided leaders/youths, selfishness and greed of some community members, and population growth that puts pressure on available land. Some of the conflicts when unresolved are passed from one generation to another and seasonally the communities have to fight over the disputed farm land. Clashes escalate after one party attacks the other and there is bloodshed or loss of life. These clashes have resulted in great psychological trauma on people, generational investment losses, loss of human lives and food insecurity. The paper recommends that community leaders should always explore the peaceful approach to conflict resolution; government law enforcement should always be at alert to contain and stop clashes before they escalate and boundary delineations should be well spelt out at every opportunity to make for good information flow.

Keywords: Communal conflicts, destruction, farming, food security, land use

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Socio-Political Relations of Urban Livestock Farmers: Potentials and Controversies

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In Ouagadougou, Burkina Faso, cattle breeding in backyards and on city fringes has become a promising income-generating activity for families with little socio-economic capital as well as for the educated urban classes, both potentially contributing to food security and sovereignty. Urban livestock production offers unique opportunities for producers to gain income. Simultaneously, structural constraints underlie urban and peri-urban animal husbandry and also induce social controversies. The particular opportunities provided for livestock raising in the urban area include access to feed produced in urban industrial zones, to information on technological practices through socio-political contacts, to expert institutions concentrated in the city and to labour markets. Ethnic and socio-cultural groups commonly associated with livestock production, as well as 'new actors' (e.g. civil servants), are active in cattle breeding. 'New actors' have considerable adaptive capabilities due to their socio-professional and financial standing. Other social groups also have knowledge of new technological practices, but are confronted with structural constraints, such as limited access to land, that prevent them from enacting these practices. Various livestock organisations have been created that are incorporated into unions in an attempt to create synergies, to channel interests and to disseminate knowledge. However, the farmers' different socio-professional backgrounds make cooperation among them difficult. This raises the question of the nature of relationships between the heterogeneous producers who may have a shared economic interest, but do not organise around a common identity. Especially for daily natural grazing, urban farmers hire rural Fulani herdsmen. Formerly tending to family herds, Fulani herdsmen now enter into market transactions where they sell their labour power. Farm owners commonly provide hired workers with food and clothing. However, extremely low wages prevent them from building their own capital and thus becoming independent herd owners themselves. These complex interactions of power and cooperation shape the long term quality of herd surveillance. Social structures thus interact to produce new forms of social stratification that shape urban food security and sovereignty.

Keywords: Cattle, labour, Ouagadougou, socio-professional groups, technology

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Sustainability of Participatory Guarantee System of Organic Certification: A Perspective from Uganda

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Organic products are credence goods, implying that determining their quality cannot be done either by observing or tasting only. Therefore, buyers of organic products require other means for assessing their quality. One of these means is certification. Certification can be third-party or participatory guarantee system. Third party certification is an export-oriented category, while participatory guarantee system is mainly applied in certification for the domestic market. Participatory guarantee system emerged as a silver bullet for integrating smallholder farmers into organic market, because it is much cheaper and bottom-up compared to the expensive and top-down approach of third party certification. However, its sustainability remains questionable. Based on secondary sources of information triangulated with phone interviews, the sustainability of the system was assessed. The findings show that the system is sustainable because of the growing demand for organic products in the domestic market, its learning process, stakeholder engagement and transparency-induced trust. However, it is compromised by opportunistic behaviours, low participation of group members and group weaknesses, over-dependence on supports from non-governmental organisations.

Keywords: Participatory guarantee system (PGS), sustainability, Uganda

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Governance and policies

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Enhancing Smallholder Farmer Access to Prime Markets through Horizontal & Vertical Linkages: The Case of Sunflower in Tanzania

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The study presents research findings on horizontal and vertical linkages in Tanzanian food value chains with a special case of sunflower. Increasing urbanisation, growing middle-classes and greater regional integration promise new market outlets with higher prices as well as larger and more stable demand. Yet, most smallholder farmers face difficulties to enter these high-value markets and produce at quality and quantity specifications required by the buyers. Creating horizontal linkages (collective action among farmers, traders and / or processors) and more formal agreements with such buyers (vertical linkages) may be a promising upgrading strategy with positive effects on further innovation adoption and livelihoods of value chain actors.

The study assesses the state of horizontal and vertical linkages in Tanzania using project farming households and trader survey data as well as LSMS data from 2012/13. In addition, insights from consultations with value-chain-actors and policy-makers with a focus on sunflower are discussed to understand factors constraining overall innovation adoption and up-scaling as well as well as livelihood improvements.

As expected, the data shows that participating in horizontal and vertical linkages is associated with higher farmer income and commercialisation. Yet, participation is very limited in the project regions for both farmers and agricultural traders. We find a number of factors that may driver participation in these arrangements.

For the case of sunflower, links between farmer groups and large-scale sunflower processor may provide substantial welfare improvements compared to conventional market channels. Still, strong price competition with imported palm oil as well as insufficient policy attention on sunflower R&D constrain wider innovation adoption, sector growth and poverty reduction. Next research steps therefore focus on detailed policy analysis of potentials for re-introducing palm oil import tariff, on developing models for integrating farmers into the market as well as on the constraints in the sunflower innovation system.

Keywords: Horizontal linkages, sunflower, Tanzania, value chain, vertical linkages

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The Policy Analysis Matrix of Profitability and Competitiveness of Rice Farming in Malaysia

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In recent years, the Malaysian rice sector has experienced structural changes to increase its competitiveness within a dynamic environment influenced by political, technical, economic and international trade challenges. Globalisation and international trade have played an important role in Malaysian national development and therefore have important implications for the rice sector, which must compete with other international producers. Using a Policy Analysis Matrix, this paper examines if Malaysia would have a comparative advantage in rice production under different scenarios of existing policies and economic reforms. This study uses data from 2011 through 2012, covering four granary areas in Malaysia. The empirical results show that rice farming is competitive and generates positive social profits. Other empirical results show that three out of the four granary areas have comparative advantages in producing rice with Domestic Resource Cost values (DRCs) less than one. Similarly, Social Cost Benefit or SCB values in these areas are less than 1, indicating that the comparative advantages in rice production are noteworthy. Given that it is socially profitable in three of the areas, clearly there are farms that produce a net surplus for the country. They generate social profits, but they might still depend on support to generate sufficient incomes for their families. In this case, policy should focus on encouraging structural change which enables these farms to grow to the point where they can generate sufficient income from social profits alone, ie. without (or with much less) subsidy. This way the government could get more self-sufficiency for less money. In the other region, however, the average farm is not producing a social profit. But here too there probably are farms that are profitable socially. For further understanding, these farms should be identified using disaggregated data and studied more closely in the future.

Keywords: Comparative advantage, Malaysia, policy analysis matrix, rice production, social cost benefit

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Two Decades of Internationally Induced Forest-Biodiversity Policies in Bangladesh – Analysing Resulting Power Dynamics among Public Bureaucracies and their Implications

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This paper aims to analyse the effects of forest-related biodiversity policies on the power of the main domestic and foreign donor bureaucracies in Bangladesh. In our analytical framework, we combine concepts from the power theory of development policy analysis, the theory of bureaucratic politics to increase organisation power, and the problem-solving policy and policy process. We analyse the power dynamics of public bureaucracies using Bangladesh forest biodiversity policy data (122 policies) from 1992—2013. Each policy was analysed employing a qualitative content analysis method and identified the strategic tasks, power elements (i.e., dominant information, incentives and coercion) resulting from these tasks, the assigned public bureaucracies responsible for implementing the task and the policy year. A strategic task (the main unit of analysis) for one bureaucracy consists of a task in each of the three problem-solving policy cycles (i.e., formulation, implementation and monitoring) resulting from distinctive policy data. Our analysis indicates it is the powerful domestic (e.g., Ministry of Environment and Forest, Bangladesh Forest Department) and foreign donor (e.g., United Nations Development Program, Asian Development Bank) bureaucracies that set the limits and directions of domestic forest biodiversity policy in a country. The results suggest that power elements vary for different bureaucracies and they gain and lose power over time due to domestic policy responses to international forest biodiversity issues. This research identifies policy mixes for forest biodiversity policy issues, but for sustainable forest management, climate change or community-based forestry policy issues, the resulting policy mixes may differ and will require further study. The study does not cover policy implementation data at field level, hence further studies on the power analysis of actors associated with implementation at field level are recommended.

Keywords: Bangladesh, bureaucratic politics, domestic and foreign donor bureaucracies, policy cycle, power elements

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Criteria for Selecting the Sites of Rural Development Programs: A Case Study from North Sinai, Egypt

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Selecting appropriate sites for Rural Development Programs (RDPs) is a key of success of these programs. Inappropriate locations for implementing RDPs could, partially, explain their failure. Some locations are selected for narrow social, economic, or political justifications that satisfy the needs of small categories of rural people. Yet, such RDPs are neither sustainable nor articulating programme ownership nor self development principals among Bedouin communities. Site selection decisions could be taken by scientists, politicians, local governmental executives or tribal leaders or all of them. However, end beneficiaries, of such programs, who are usually poor and voiceless, have no say on these decisions. The study problem was to investigate the objectivity or subjectivity of the criteria considered in selecting sites for implementing RDPs that might be reflected in their success or failure. The study objectives were to: a) List different criteria used for selecting RDPs' locations; b) Classify the identified criteria; and c) Suggest essential interventions for better RDPs' site selection. The descriptive study was conducted in Wadi El Brook, central Sinai, North Sinai Governorate, one of the very poor regions of Egypt. A semi-structured checklist was used for field data collection through personal interviews with 50 respondents from four RDPs-related stakeholders: 10 governmental executives; 10 beneficiaries; 10 Bedouin tribes heads and local leaders; and 20 researchers and scientists. The checklist included open-ended questions to keep the flow of knowledge and information. The study revealed that the main criteria for site selection of RDPs were highly subjective, based on the opinions of local political leaders, who had the say and power, whereas the needs of the majority of end beneficiaries were ignored or degraded. The used criteria had led to widespread dissatisfaction, loss of faith, loyalty and belongingness and need to be critically reviewed and replaced with more objective criteria agreed upon by the majority of community stakeholders. For enhancing more decentralised, self-reliant and resilient local communities, the study suggested establishing stakeholders' advisory units, at different administrative levels, to stimulate and maintain community dialogue and facilitate collective decision making related to site selection of RDPs and other relevant priorities.

Keywords: Egypt, North Sinai, rural development programs, site selection criteria

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The Performance of Sudanese Agriculture 1956 - 2014: Trends of Cultivated Areas, Output and Yields, and Producers' Incentives

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This paper reviews the adopted agricultural policies in Sudan since independence in 1956 up to date (2014), with the objective of analysing their impact on the performance of agriculture. The conducted analysis employed descriptive statitics and calculation of indicies to illustrate the development of cultivated areas, output and yield, as a result of the adopted policies during the 1960's through the 1970's. In addition, the Policy Analysis Matrix (PAM) technique was used to calculate nominal and effective protection coefficients to show the impact of the adopted policies during the period 1980 - 2014.

The obtained results revealed that the first three decades after independence in 1956, marked an era of complete government control on the activities of the agricultural sector. This set-up enabled expanding agricultural production and increasing agricultural exports, however, at the expense of the farming community, hence, an over valued exchange rate, production taxes and state monopolies contributed to reducing the incentives for the adoption of new technologies and increased output. This situation combined with inadequate credit and heavy regulatory environment lead to severe implicit taxation of producers in the late 1970's through the 1980s', thus, resulting in poor agricultural performance.

The implemented policies during the 1990's through 2014 aimed at mitigating the late 1970s' and the 1980s' crises through liberalisation of the economy. These policies resulted in improved agricultural performance in the early 1990s'. However, this performance deteriorated in the late 1990s' as a result to the liberalised economic environment *vis a vis* the complete withdraw of the government financing of agriculture, dismantling of export institutions, retirement and withdraw of the management and technical staff of the schemes.

Based on the above, the way for sustainable agricultural development pleas for the implementation of policies that combine the factors of success experienced during the 1960s' and early 1970s', that is, the involvement of the State in provision of production infrastructure and supervision of production, marketing and export processes, with the factors that provide adequate and sufficient output and producers' incentives.

Keywords: Agriculture, competitiveness, incentives, policy

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An Overview of Arable Land Tenure Systems and Environmental Sustainability in Oyo State of Nigeria

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The accessibility of most agricultural lands especially in the southwestern part of the country depends largely on land tenure system and the extent of competition by non-agricultural land uses. Land tenure systems influence the use to which land is put for economic and social development. Land tenure is a mix or bundle of entitlements (rights and duties) concerning the use of land resources. The study analysed the effects of arable land tenure and use on sustainability of the environment in Oyo State of Nigeria. Multistage sampling technique was adopted to select 200 respondents for the study with the aid of a structured questionnaire and analysed using descriptive and inferential statistics. It was found that land acquisition was predominantly (47.5 %) through inheritance. The result of environmental sustainability index (ESI) showed an average score of 19.67 and only farmers from 15 local government areas in the study area had values above the average. Furthermore, the result of the analysis of variance showed a significant difference (F = 26.55; $p < 0.01$) in the ESI among the 15 local government areas. A positive coefficient of education of household heads (0.50), farming experience (0.05), extension contact (0.11), crop diversification (0.34), irrigation use (2.89), land tenure security (0.82), tree planting (2.13) and quantity of fertiliser used (0.65) implied increase in environmental sustainability with increase in these variables. However, population density (-0.29) reduced environmental sustainability. It was concluded that land tenure security impacted substantially on the increase in environmental sustainability and that land use, coupled with management practices is key instrument for achieving environmental security. It was recommended that, Government should establish a more effective and efficient arable land title registration system that would enhance individual tenure security to the arable land.

Keywords: Environment, farm inputs, land tenure, land use, Nigeria

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Large Scale Agro-Businesses and Rural Development in Tanzania: Lessons Learned, Steering Requirements and Policy Responses

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Large scale agro-investments (LSAIs) in sub-Saharan Africa, in particular if including land acquisitions, are fiercely debated with regards to their impact on rural development and food security. The Government of Tanzania is actively supporting LSAIs, mainly by trying to attract them and link them into rural clusters along the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). However, the track record of these endeavours is poor up to now, and it is also unsettled yet what developmental impacts such LSAIs actually have. A study by a group of researchers from four German and Tanzanian research organisations looked into the reasons for lack of progress in establishing LSAIs, their impacts and the policy efforts hitherto made to steer them. It draws lessons learned for better national and local management of the investments to be established and to economically thrive while providing positive and avoiding negative impacts. The methodology comprised the selection of nine LSAIs, all including both land acquisition and outgrower schemes (nucleus-outgrower model), in three different sub-sectors – sugarcane, tea, rice – in different phases of realisation: planning, establishment, full production and (close to) failure. Around each investment, about 20–30 qualitative interviews and focus group discussions were conducted, in addition about 30 interviews with key informants at national level on policy issues. Results show that there is considerable potential of these investments to support local development, in particular through providing employment, outgrower farmer incomes, infrastructure and corporate social responsibility projects as part of community compensation. Depending on the concrete business model, the opportunities as well as risks are different. In general, the policies to attract and steer LAIs them are not yet sufficiently developed, coordinated and implemented. Several sets of recommendations are made with emphasis on land, agriculture-related policies, investment regulation and climate, and investor-community relations.

Keywords: Land acquisitions, large scale agro-investments, outgrower models, policy, rural development

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Farming System and Food Security in the Traditional Agricultural Sector of Sudan: An Overview Approach

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The traditional agricultural sector of Sudan occupies around 85 % of the total annual cultivated land. It also plays a significant role in supporting the livelihood for more than 70 % of the population. Accordingly, this paper seeks to describe the impact of transformation changes on cropping pattern, land use and food security. Secondary data specifically; time series data of rainfall, land cultivated and production of both food and cash crops was gathered from the ministry of agriculture and other relevant sources. Descriptive statistics using averages, histograms and percentages was applied to analyse the data. The results show the higher variation in the annual rainfall (mm) from 1997 to 2012. The fluctuation and variation in rainfall was emerged from the serious desertification and drought that hit the area during the last two decades. The averages weighted yields for both food and cash crops recorded a continuously decline over the five-ten years periods. However, the average yield of sorghum and groundnut are higher than that of millet and sesame from the period 1970/71–1979/80 to 2010/11–2012/13. Thus, moving from a high to low yield reflect the low crop production as a consequence of poor farm management, low rainfall and inappropriate policy strategies. This condition directly affected both accessibility and availability to food for the subsistence farmers. Additionally, the finding revealed that the cultivated areas under cash crops (sesame and groundnut) increased from 1970/71–1979/80 to 2010/11–2012/13 in compared to food crops (sorghum and millet). This is mainly caused by the effects of the policy transformation that seeks to expand the area under cash crops for the purpose of market orientation and exports. Thus, these policies negatively affected the availability of food. Ultimately, the paper recommends to enhance the productivity of crops through encouraging the adoption of improved technologies and to create strong and powerful links between farmers, research institutions and extension services. Additionally, the government should also support the subsistence farmers through the adoption of incentive policies that seek to achieve food security.

Keywords: Cash crops, food crops, policy transformation, productivity

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Policy Design versus Policy Application. The Paradoxes of Forest Right Act in North Kerala, India

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The access to forest resources by local groups constitutes a critical issue in the tropics. In India, the Adivasis communities, identified as the traditional forest inhabitants, have faced restrictions in accessing to forest in different historical phases. The enacting of the last forest-related law – the well known Forest Right Act 2006 (FRA) – which is intended to give back the right to inhabit and collect minor forest products (NTFP) to the traditional occupants have been considered a step forward in yielding rights to the local users. Nevertheless, it reveals inconsistencies between the written law and the practical one. Albeit the law includes positive concerns to counterbalance the historical neglect of Adivasis rights over forested lands, the implementation process shows negative results to guarantee the land security of these actors. These contradictions are highly evidenced in the northern Kerala's Western Ghats, considered a biodiversity hotspot and place of residence of most of the Adivasis communities in the state. Focused in the implementation of FRA in Wayanad, Kerala, the present research aims to provide elements to enhance the discussion about the inconsistencies between policymaking and policy application. The results show that in most of the cases the allocation of land to the Adivasis families living inside the forest is limited to the area where their houses are settled restricting the possibility for cultivation. Additionally, the rights to collect NTFP are not given formally as the act stipulates which causes permanent conflicts with forest authorities. Furthermore, new schemes to relocate the Adivasis families out of the forests or in the fringes of them are being implemented by Forest Department and Kerala State government changing and affecting the livelihood patterns of the relocated families. The study is based in a qualitative approach. More than 60 semi-structured interviews were carried out with Adivasis leaders, Adivasis settlers, government officials, NGO representatives and activists. The research is complemented with the review of grey literature concerning the implementation of the law as well as official documents from different public institutions involved.

Keywords: Adivasis, forest right act, India, NTFP, policymaking, Wayanad, Western Ghats

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Government Support in Maximizing the Utilisation of Restricted Land through Eco-Agriculture Practice in Semarang City, Central Java

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Land scarcity is one of the main problems in the agricultural sector in Semarang City. The construction of houses has reached out into areas that were used for agriculture. The majority of farmers in Semarang City were small scale farmers with low bargaining position, so they were defeated by rich investors. Currently, the average land owned by a farmer is only 0.27 hectares. Even though, agriculture is not a main sector in Semarang City, it significantly contributes to providing jobs and alleviate poverty. Farmer groups play an important role in the agricultural sector in Semarang City. Currently, there are 323 farmer groups at several levels; 205 groups at the beginner level, 102 groups are at intermediate level, and 16 groups are at advance level. The farmer groups exist in almost all sub-districts. The commodities handled by farmer groups are various, such as beef cattle, dairy cows, vegetables, fish and combinations. In February 2015, data was collected through field observation, direct interview of stakeholders, government officials, and focus group discussions with farmer groups. Eco-agriculture is already practised by many farmer groups, and the use of local genetic resources is emphasised by the government, to protect local genetic resources from extinction. Furthermore, processing edible and non-edible by-products of agriculture into valuable items such as fertiliser, natural pesticides, and food, are ways to decrease environmental effects from agricultural activities. Group members are having additional income and access to healthy agriculture products. The government of Semarang City, office of agriculture, pushes the farmers to increase their productivity through eco-agriculture practice and supports them with financial aid, technology transfer, agricultural education, intensive guidance, motivation, and market facilitation.

Keywords: Eco-agriculture practice, farmer group, government support, restricted land

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Evaluation of the Agricultural Program in the Czech Official Development Assistance Since 2008

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Agriculture is still the most important economic sector for 70 % of rural people living in the Global South. Farmers continue to face low productivity, unstable agricultural policy, population growth and climate changes. Nowadays, the agricultural development cannot be understood only in terms of production. Foreign cooperation in agriculture must also take into account the social, environmental, cultural and other aspects.

The study analyses the trajectory of the Czech development assistance focused on agricultural sector since 2008, the year when the professional Czech Development Agency was created. The research uses descriptive methods to evaluate the agricultural projects of the Czech ODA according to selected criteria (type of project, time period, type of funding and donor, project country, target group, type of implementing organisation, etc.). Furthermore, the qualitative evaluation criteria reflecting current discourse on aid effectiveness in the agriculture and rural development are also used. The underlining framework is based on OECD/DAC evaluation criteria (relevance, efficiency, effectiveness, impact and sustainability). Primary data includes interviews with the actors of the Czech development assistance. Secondary data is obtained from the project's documentations.

The accession of the Czech Republic to the EU has influenced aid effectiveness and institutional structure of the Czech development assistance. The coordination of agricultural projects is no longer in the hand of the Ministry of Agriculture; this responsibility was taken over by the Czech Development Agency in 2010. The Czech assistance to agriculture profits from the experience with the transition process, from a centrally planned economy to a market one. Nowadays, the Czech Republic considers agriculture as a sector priority in the Czech ODA. Since 2008, the Czech development actors have implemented more than 50 agricultural projects in wide range of topics from the supply of technology to the non-formal education services, quality management, etc. in the countries of Eastern Europe (Moldova, Bosnia and Herzegovina and Georgia), Africa (Ethiopia, Angola and Zambia) and Asia (Mongolia, Yemen). Most of the agricultural projects are implemented by NGDOs; the rest of them is carried out by private companies, universities and governmental institutions.

Keywords: Development, donors, effectiveness, farmers, NGDOs, programme evaluation

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Historical Assessment of Land Use Policies Depending on Food Security: A Multi-Criteria Decision Making Experiment

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The current study investigates historical achievements of land use policies in order to ensure food security in the context of selected European countries. The selected countries are Germany, France, Netherlands and Turkey and include the years 1980, 1990, 2000 and 2013. Various agro-economic and environmental indicators are tested in current research to measure agricultural sustainability as well. These indicators are per capita cereal production, per capita meat production, per capita milk production, yield of cereals, gross agricultural production value, fertiliser and pesticide use efficiency, and total agricultural emission. The study attempts to rank the countries according to sustainability criteria. In the studies of ranking, Multi Criteria Decision Making (MCDM) methods are best suited for effectively dealing with a number of multifaceted evaluation criteria. The use of a MCDM method usually involves asking experts to express their opinions in terms of criterion selection and weighing according to their knowledge, experiences, and special concerns. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method was used to rank the countries according to abovementioned criteria in terms of successful land use policies in a historical way. According to TOPSIS results, in 1980 the country which was closest to the ideal solution was Turkey with 0.75 points, and the Netherlands was the country which farthest from this ideal solution with 0.24 points. Germany and France had 0.56 and 0.74 points, respectively. As for 2013, France, with 0.59 points, was a country that was closest to ideal solution. Turkey, the Netherlands and Germany had 0.476, 0.469 and 0.466 points, respectively. Statistically, European lands seem to be poor in terms of excessive use of pesticides and inorganic fertilisers. Also the contributions to global climate change, due to agricultural production, have been increased. Thus, EU's agricultural production might be shifted to the 10+2+1 countries that newly joined the Union. Agricultural products processing industry is more developed in the EU-15 countries if compared to resuming countries in the EU. The success of the Netherlands and Germany on this topic is clear. A "pollution tax" in agriculture might be applied to European countries that have poor agri-environmental management systems.

Keywords: Land use policy, multi criteria decision making, sustainability, TOPSIS

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Results-Based Approaches - An Effective Instrument to Increase Food Security?

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Increased and more effective public and private investments in the agricultural sector are needed to address the challenge of ending hunger and achieving food security until 2050. This paper analyses the potential of results-based approaches, an innovative financing instrument that links payments to pre-defined results, to contribute to this challenge.

Results-based approaches play an important role in the development-policy debate and promise several potential advantages over traditional aid modalities, such as a greater focus on results, better accountability systems and improved incentives. Results-based approaches can thereby contribute to improve governance in the partner country and to increase aid effectiveness. They are also discussed as an important tool to accelerate innovation and to leverage additional resources from private investors for agricultural and food security interventions.

While widely applied in health and education, to date only few experiences with results-based approaches in agriculture exist and the suitability of the sector for the instrument is debated. We aim to contribute to this debate by reviewing six pilot interventions representing different types of results-based approaches: results-based aid programmes (contract between governments) and results-based finance programmes (contract between a donor/host-country government and a service provider).

The six cases are compared based on three criteria that have been shown in the literature to be important pre-conditions for results-based approaches. These are (1) measurability and verifiability of results against which payments are made, (2) control of the incentivised actor over achieving agreed results, (3) capacity and financial means of the agent to carry out necessary activities and investments. Moreover, we analyse incentive effects introduced by the programmes and whether the focus on specific measurable results leads to adverse effects.

Our analysis shows that results-based approaches have the potential to foster innovation in agriculture and can play an important role to increase food security in developing countries. However, we also find that the agricultural sector poses additional challenges for implementing results-based approaches. For example, paying for results is more difficult in agriculture than in many other sectors. Desired outcomes such as increased yields or incomes are highly variable and subject to external whether and market conditions. We also find that pre-financing of activities is a particular challenge when smallholders are targeted who often do not have access to credit.

Keywords: Agriculture, aid effectiveness, food security, results-based approaches

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Participative Elaboration of a Wildlife Management Model in the Northeastern Periphery of Korup National Park, South-West Cameroon

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Since 2009, data have been gathered to develop an artificial landscape representing the hunting ground in the North-East periphery of Korup National Park. An Agent-Based Model (ABM), aiming at promoting discussions among stakeholders to collectively explore possible options to enhance sustainable wildlife management in the area, has been constructed. Two series of three-workshops were organised in April 2012 and 2013 with the inhabitants of seven study villages whereby a questionnaire was administered to 43 and 36 hunters (IH) respectively before and after each presentation to evaluate their attitudes towards the hunting of blue duiker *Cephalophus monticola*. Three months after each presentation, a semi-structured interview was addressed to 98 and 130 IH respectively to evaluate their perceptions of the model, changes in their attitudes during wildlife harvesting and the potential management options. The CORMAS platform was used to implement an ABM representing the hunting of *Cephalophus monticola* by snare trapping. Before the 1st presentation of the model, IH revealed that the hunting of blue duiker is not sustainable and should not be for commercial purposes; hunting practices should be regulated; and agriculture and livestock breeding should be encouraged in the area. Before the 2nd presentation of the model, IH confirmed to have reduced hunting efforts for the benefit of agriculture as a result of the 1st presentation in 2012. During the 2nd presentation, as management options, IH proposed the creation of a community hunting zone, the implementation of local rules on hunting supervised by a local institution, the prohibition of professional/external hunters, the development of alternatives to hunting and the continuation of sensitisations. After the 2nd presentation, IH affirmed that they will contribute to sensitisation campaigns, be part of the management body, and participate in any local development initiative. IH appreciated the model in its role as a Companion Modelling, and are willing to contribute to the implementation of the best management scenario. It is also necessary to assess the perception of villagers one year after the 2nd presentation of the model in order to apprehend a real change in their attitudes toward wildlife hunting.

Keywords: Agent-based model, *Cephalophus monticola*, community-based wildlife management, companion modelling, CORMAS, Korup National Park, southwestern Cameroon

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Food Sovereignty in South Africa: Policy Implications and the Right to the City in Urban Agriculture

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In South Africa, the official interest in agriculture in urban centres and suburbs is quite recent, although it has been practised for a long time. Urban agriculture is associated with many benefits including increasing food security of households, diversifying diets, livelihood support, and provision of informal sources of income. These are just some of the reasons why academics, governments, and aid organisations have touted urban agriculture as the panacea for urban food insecurity in the Global South. However, an adequate incorporation into policies including the interests and needs of communities remains challenging.

This research project identifies critical perspectives on urban agriculture, emphasising the agency of food gardeners in South Africa and how they individually perceive the benefits. This reflection is guided by the theoretical approach of the right to the city and the concept of food sovereignty. The combination of this theory and concept offers important aspects for the improvement of urban agriculture from a socio-political and ecological perspective and promotes the much needed dialogue between policymakers and communities. In this context, this research questions how an optimal environment for community gardening in terms of governmental support and integration on a local level should be designed. The project focuses on the role of community initiatives, the way they contribute to policy-making and inclusive development in the city.

As the empirical case of this study, the innovative community initiative "Kos en Fynbos" which emerged in George, South Africa, is analysed. The voluntary movement started with the concern to improve nutrition in the community through the implementation of permaculture practices and no-till gardening. So far, communities from different parts of the city have joined these activities and vital competitions strengthen the interest in participation. Nevertheless, support of the local government is imperative to sustain these efforts. Increasing governmental responsibility in the urban realm and disinvestments in disadvantaged neighbourhoods are part of the challenges.

Keywords: Community initiatives, food insecurity, right to the city, South Africa, urban agriculture

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Local Governance of Agriculture and Nutrition Programmes for Achieving Sustainable Diets in Vaalharts, South Africa

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South Africa's food and nutrition policies are favourable towards sustainable diets. Yet, the country, despite being food secure at national level, battles with high levels of household food insecurity, childhood malnutrition, obesity and diet-related diseases.

This study explored the local governance of agriculture and nutrition programmes in seven rural resource-poor communities in the Vaalharts region, and whether they are supportive towards sustainable diets.

As part of the larger project 'Sustainability of diets in rural South Africa', this study followed a qualitative approach to investigate 12 existing programmes. Observations and face-to-face interviews were carried out with decision makers from governments (n=6) and civil society (n=3) as well as beneficiaries (n=27). Three programmes were then identified for in-depth investigation, namely: soup kitchens run by NGOs in partnership with the Department of Social Development; agricultural support programme for small-scale farmers run by the Department of Agriculture; and the nutrition education component of the integrated nutrition programme of the Department of Health.

Various governmental programmes have been implemented in Vaalharts to address poverty, food insecurity and nutritional challenges in the communities. Departments, however, often struggle with identifying eligible and committed beneficiaries and staff capacities are too low to follow-up on cases after programme implementation. Further, inter-sectorial communication and collaboration are often insufficient to address the complex challenges within these communities. NGOs and CSOs seem to be more embedded within the communities and combine programmes that address poverty, hunger, skills development, and legal support in an integrated way. However, these programmes often face financial and capacity-building difficulties, particularly in the beginning phase. Existing programmes focus on socio-economic support and food and nutrition security to address the immediate needs of these communities. The support of local economies, nutrition-sensitive food production, cultural knowledge and environmental protection that are crucial for more sustainable diets seem to be of less priority.

The study highlights the important role of local governance for achieving food and nutrition security in these communities. Capacity building of local decision makers, inter-sectorial collaboration, and recommendations on sustainable diets should be given priority in future programmes to achieve more healthy and sustainable diets in Vaalharts.

Keywords: Food and nutrition security, local governance, South Africa, sustainable diets

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Human Development and Food (In)Security in Brazil: Prioritisation of Regions for Policies Targeting Rice and Bean Production

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Rice and beans represent staple crops in Brazil. They are grown mainly for domestic consumption. Small farmers, in Brazil commonly considered as 'family farmers', do a significant part of the production of both staples. In Brazil, rural poverty often relates to regions where small farming is the main form of agricultural production. Thus, the objective of this study was to identify the main poverty areas in Brazil and check if they are important in growing rice and beans in order to be considered as priority areas for agricultural research and extension services. As poverty, we consider a monthly per capita income of less than US$ 100 and very low (0-0.499) and low (0.5–0.599) Human Development Index (HDI) according to the Human Development Report 2014. Poverty data are based on national household survey data. Rice and bean production data is based on national statistics from several official sources. Cluster analysis and spatial correlation is done to identify priority target regions for implementation of technology transfer and extension services focusing on improving food security. In the majority of municipalities with the lowest HDI, rice and bean production is weak and of low technological level, mainly done by family labour. In the states of Maranhão and Piauí, who are part of the "MATOPIBA" region (last agricultural frontier region of Brazil, as part of the states of Maranhão, Tocantins, Piauí and Bahia), the lowest HDI's are found. Education dimension represent the weakest part of HDI in those states. The municipalities with the lowest HDI's are located in those states. They represent poverty zones where families have less income than the daily limit of US$ 1.25 recommended by the United Nations. Low HDI in those municipalities require targeted policies including training and extension services in order to improve rice and bean production and, thus, improving food security of poor population.

Keywords: Education, health, per capita income, production costs, profitability

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Food Sovereignty in Colombia: Seed Certification as Property Rights to Agro-Biodiversity, Enforcement, Controversies and the Seed Freedom Movement

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Food sovereignty is a critical concern across the globe as the concentration of power in the hands of a few agro-industrial corporations structures the agricultural economy. The process of definition, enforcement and subsequent resistance to intellectual property rights for seed certification in Colombia presents an iconic case among global controversies. Neo-liberal politics to attract capital and guarantee markets for corporations dominate negotiations over trade and generate legislation. From 2006, Law 1032, art. 306 protects breeders' rights over plant varieties, forbidding farmers to replant certified seeds. From 2010, Resolution 970 of the Colombian Agricultural Institution (ICA) regulates the production, commercialisation and use of all improved seeds, both conventional and transgenic, with the justification of ensuring seed quality and crop health. Application of this resolution, resulting in the destruction of over 4 million tons of seeds, created so much confusion, controversy and resistance that by August 2013, nationwide agrarian strike, campesino mobilisation and road blocks brought Colombia to a halt. Governmental negotiations suspended Resolution 970 and counteractions surged from the newly formed national collectives, revived seed trading networks, rural strongholds of cultural knowledge and urban home-garden and educational projects. This research empirically documents dynamics of the exercise of political authority governing access to seeds as property, associated protocols for use of inputs, agrochemicals and cultivation practices on the one hand and social processes of resistance through the movement for 'seed freedom' on the other. Tension for the commercialisation and legitimisation of seeds as property has inspired a 'shift to the left' and strengthened resolve to guard and share agro-biodiversity and eco-agricultural knowledge, traditions and practices. Fundamental power hierarchies framing food sovereignty manifest within the concept of seeds, evoking a potent symbolism of struggles for freedom from control over life itself.

Keywords: Agrarian problem, agrobiodiversity, international trade, power, social movements

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Land Reform Politics and Food Security Challenges in South Africa

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South Africa is the most industrialised state in Africa. This comes with a price in the epoch of globalisation where sovereignty is at bay when considering policy options by government. As a member of the World Trade Organisation (WTO), the state is contending with the dictate of various international regimes of ultra-capitalism origin. The implication of this is that policy options at the domestic level should be in line with the dictates of globalism; hence globalisation of public policy. Activities of various multinational corporations (MNCs) in the country in the form of food production and its negative impacts on South Africans and government would have made the state president, Jacob Zuma, in his State of the Nation Address, to call for lease agreement with foreigners on the issue of land rather than for the previously willing buy, willing seller approach to land ownership in the country. The impacts of this on food production and food security, Vision 2030 through National Development Plan of neoliberalism and, by extension, on the Living Genetically Modified Organisms (LMOs) is yet to be seen. Before this time, the activities of large scale farmers through production of foods, almost enough for the Southern African states, makes South Africa to be a credible hegemon at the sub-regional level. Attempts to cater for the previously disadvantaged blacks in the state is not without its lapses considering the way they want to be a party to food production. The 1996 Constitution, as amended, created an enabling environment for verandah farmers of lately with negative impacts on the state development and food security. As a member of WTO with all its politics of global patenting without border forced local farmers to embark on genetically modified seeds and animals with negative impacts on traditional food production. This, by extension continues to trample on human rights and the same is encouraging health challenges with more pressure on the state budget. This paper is going to adopt social constructivism in conjunction with triangulation data collection as departing point of its discussion. In doing this, the tentative conclusion is to encourage organic food production for a sustainable environment and general human development as a sine qua non to food security.

Keywords: Food security, South Africa

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Institutions and cooperatives

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Policy Impact Analysis, Sustainable Practices and the Drivers of Food Demand. Selected Works Related to Sub-Saharan Africa

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A reliable picture of policy impacts remains elusive in sub-Saharan Africa (SSA). This represents a key challenge for effective food security intervention strategies, mainly due to limited reliable statistical data and sound analysis. As part of an exercise to develop quantitative tools for the analysis of policy impact in SSA and leveraging on its expertise of farm level analysis in Europe, the Joint Research Centre (JRC) of the European Commission is conducting a micro/regional-level analysis. Main task is to use the FSSIM-Dev (Farm System Simulator for Developing Countries) model as a decision support tool to carry out *ex-ante* assessments of the impact of relevant policies on the livelihood of farming households. The FSSIM-Dev model was first used to assess the effects of rice seed policy on the livelihoods of representative farm households in Sierra Leone. Results showed that the seed policy would improve farm productivity and household income, but falls short in fighting poverty since most of the surveyed farm households would continue to live with less than 1USD per person and day. Current exercises are developed for Ivory Coast and Niger with foreseen developments in Ethiopia, Rwanda and Tanzania.

Complementary assessments are conducted on the drivers of food demand and the potential of sustainable agricultural practices in SSA. A comprehensive analysis of the response of food demand to rising incomes shows that income elasticities are highly heterogeneous. As expected, demand is more responsive to changes in income for beverages, or meat, compared to basic diet's food (e.g. cereals). The considerable regional differences in food-income elasticities suggest differing regional impacts of food policy in Africa. In turn, the review of sustainable agricultural practices within a SSA institutional context also looks at how local environmental governance could enable a transition to a more sustainable agriculture. Given the high diversity of African crops, proven record of land-sharing practices but fragile soils of the region, early results suggest a clear potential for agroecological practices along-side the more publicised input-intensive alternatives. Foreseen analysis will look at the interplay of landscape-level choices such as common resource management and agriculture practices for a more sustainable food security strategy.

Keywords: Food demand analysis, food security strategy

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Incorporating Local Institutions in Irrigation Experiments – Evidence from Rural Communities in Pakistan

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Many irrigation systems are special cases of common-pool resources (CPRs) where some users have preferential access to the resource which in theory aggravates collective action challenges, such as the under-provision of necessary infrastructure as a result of unequal appropriation of water resources.

We present experimental evidence based on irrigation games played in communities which are dependent on one of the largest contiguous irrigation network – the Indus basin irrigation system in Punjab, Pakistan. Furthermore we simulate, amongst others, two institutional mechanisms which are neglected in experimental studies despite their importance in many CPR governance systems: a) traditional authorities and b) legal pluralism.

In our experiments, Punjabi farmers (n=160) managed to provide the CPR at a level close to the social optimum, even without communication or enforcement opportunities. The equal investment in water infrastructure seems to be a strong social norm, even though those in disadvantageous positions (tail-users) earn less than those who have preferential access (head-users). At the same time, head-users restrain themselves from maximum resource extraction, which could be interpreted either as a norm or a stationary bandit strategy. In contrast to one of the most consistent findings of experimental studies, the participants in our experiment increased their earnings over the experimental rounds by using the available resources in a more efficient manner. One explanation for this behaviour could be the availability of social information in our game.

Starting from a high level of cooperation during baseline rounds, the treatments did not change the group investment significantly. The introduction of external sanctions created additional coordination problems which lead to a decrease in the level of group welfare. More specifically head-users reduced their water extraction in the face of possible external sanctions to a level that the remaining water could not be used productively anymore by tail-users.

Keywords: Asymmetric access, common-pool resources, field experiments, irrigation management, Pakistan

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Triangulation Analyses of Large-Scale Land Based Investments and Employment Dynamics in Nigerian Communities

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There has been an increase in the flow of Large-scale Land Based Investments (LLBIs) into Nigeria within the last decade with the aim of transforming the agricultural sector to improve the productive capacity. This is with the idea that LLBIs will be relevant in helping the country – especially the rural areas – improving food security and rural development in host communities. However, there is some disconnect between LLBIs and gainful employment opportunities in the host communities. This study aims to empirically investigate the extent to which the development of indigenous institutions can enhance the realisation of gainful employment as one of the promises of LLBIs to the host communities. The aim is premixed on the fact that the consequences of increasing unemployment, especially for the youths, can undermine social cohesion. Data from the Living Standards Measurement Study-Integrated Study on Agriculture (LSMS_ISA) are utilised. A regression model is formulated and estimated based on the tenets of impact evaluation using the propensity score matching (PSM) approach and complemented using the Difference-in-Difference (DiD) approach. In addition, the study validates the results from quantitative analysis using qualitative techniques, notably: Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). Evidences from the analyses show significant effects of LLBIs on the employment levels in the host communities in Nigeria when appropriate means of carrying the local institutions in the form complementarity and not substitutability are implemented. The study therefore recommends proper improvement of the instruments that can maximise the existence of the LLBIs particular in the host communities in Nigeria.

Keywords: Agricultural sector, employment, large-scale land-based investments

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Leadership and Nepotism in a Trust Game with Third Party Punishment in Rural Namibia

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Social norms and leadership structures are two of the success factors for the self-governance of natural resources. However, it has been frequently stressed that local elites may be corrupt, nepotistic and thereby not acting in the interest of their community. Nepotism (i.e. favouritism granted to relatives/friends regardless of merit) or arbitrary enforcement of norms can significantly undermine the development of trust among users of natural resources. Thus, nepotistic leaders might impede collective action for the conservation of resources.

The aim of this project is to establish experimental evidence on the nepotistic use of punishment of democratically elected and traditional leaders in rural Namibia. We use a combination of experiments in 32 communities in Northern Namibia, in the Ohangwena region. First, traditional authorities inherit their power and remain in power for their lifetime. A main task is to regulate access to grazing land. Secondly, there exist democratically elected water point committees in every village which were implemented by the government in the early 2000's who manage access to water. This legal pluralism enables us to compare traditionally appointed (TL) and democratic elected (DEL) leaders in every village.

The experimental set-up consists of a one-shot binary trust game between two villagers and a third party punishment option that a leader can exercise. In particular, the leader decides (using the strategy method) whether or not he wants to spend money to punish the second player based on his behaviour. The experimental design includes two novel components. First, the third-party is either the traditional leader or the democratic authority in the village. Second, the two villagers playing the trust game, players A and B, and the leader are aware of the other player's relationship to the leader (i.e. whether they are family members of the leader). Villagers are also informed that a certain leader (name, position) will observe their relationship status and their actions and can reduce their earnings.

Preliminary results show that traditional leaders are less nepotistic. We discuss these results based on additional surveys and qualitative data gathered in the field.

Keywords: Decentralisation, democracy, leadership, Namibia, nepotism, traditional authority, trust

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Institutional Landscape for REDD+ Investment in Tanzania: Does it Include Private Business?

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The paper reviews the institutional landscape for Reducing Emissions from Deforestation and Forest Degradation (REDD+) investments in Tanzania. It goes on to assess whether there exist framework conditions for inclusion of private business as partners in REDD+ activities, especially with the experience gained from some of the earlier REDD+ pilot projects in the country. The paper is based on the premise that, inclusion of private business in the implementation of REDD+ activities will widen and sustain forest conservation efforts and reduce REDD+ investment dependence from the government and the associated development partners. The assessment shows the existence of well established institutional landscape for REDD+ implementation from the central to the local government levels. Various legal and policy frameworks exist in support of the implementation of REDD+ activities in the country. The institutional structure for REDD+ implementation and reporting in Tanzania includes the National Climate Change Steering Committee (NCCSC), National Climate Change Technical Committee (NCCTC), National Carbon Monitoring Centre (NCMC), and a number of regional and local government authorities. It is, however, noticed that under the existing institutional landscape, inclusion of private business in REDD+ implementation is limited. The available system outlines the inclusion of NGOs while excluding an important stakeholder, the private sector, who is a key component for sustainability of REDD+ in the country. Lack of proper framework for private sector inclusion in REDD+ implementation will increase reliance on government and its development partners and hinder its sustainability. The paper recommends setting up of framework conditions that will encourage private business to invest in REDD+ activities as a way to sustain these conservation initiatives.

Keywords: Conservation initiative, framework conditions, sustainability

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Land Policies for Upland Cambodia: Historical Perspective and Impacts on Land Use

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Rural Cambodia is often described as a demographically saturated "inner country", on the alluvial plains of the Mekong and the Tonle Sap Lake, surrounded by upland "empty Cambodia" where the population density is ten times lower. This dual land situation is likely to generate important migrations in the process of development, with an important impact on the deforestation and land use in general. This situation is also a product of the institutional reforms promoted since early 2000 (Land Law, Forestry Law, following directions and regulations). Based on field surveys from 2011-2013 done in Mondulkiri, one of the provinces of so-called empty Cambodia, this article analyses the major changes in the land use as a result of the successive public land policies in upland Cambodia. Considering the diverse strategies of local stakeholders previously identified in the province, the communication also elaborates on four scenarios of further transformations foreseen in the next ten years. The findings show that the policy favoring large scale concession may result in several positive effects, but only when rubber prices are high. On the contrary, policy more favorable to the rights of indigenous communities and of individual immigrants lead to higher employment creation and better balanced food security. Based on the findings the paper offers a critical discussion of Cambodian land concession policy arguing that the multifuntionality of rural areas should be taken into account by Cambodian policy-makers and planners as a viable strategy to achieve rural development targets.

Keywords: Cambodia, employment opportunities, indigenous people, land concession, land strategy and policy

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Common Resource Management and Sustainable Food Security: Evidence from National Surveys in Malawi, Nigeria and Uganda

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Sustainably responding to the food security challenge in Africa implies to go beyond agriculture and account for the wider landscape. Access to common resources plays an important role as rural source of income and as a safety net against poor agricultural output or seasonal food gaps, hence contributing to food security. The direct livelihood role of common resources management (CRM) has benefited from in-depth case studies and subsequent reviews of these but seldom from large data sets analysis such as the Household Living Standard Survey – Integrated Surveys on Agriculture (LSMS-ISA). Drawing on the latest LSMS-ISA developed in Malawi, Nigeria and Uganda (sample sizes of 3200 and 5000 households), this exploratory paper tests connections of CRM arrangements and perceived performance (e.g. satisfaction of resource users) with the recorded indicators for food security conditions of rural households (e.g. days without food for the household). In parallel to the surveys to households, information on the existence and status of CRM for water, grazing land, arable land and forest/bush was gathered in surveys to leaders of communities. For the analysis, the data was merged to associate households to the characteristics of their communities and CRM in particular. The identified CRM arrangements' performance is tested against their known characteristics, including their wider institutional connections such as local forums and assemblies dealing with natural resources and more broadly with justice. First analyses suggest that food security is associated with CRM, although not for all resources. For example, in Nigeria, the connection between CRM and food security is statistically significant for common forest, water and pasture, although with a notable lack of significant connection with regards to communal arable land. The paper closes with the further analysis options on the possible indirect effects of CRM on sustainable food security such as whether performing CRM at community level is also associated to the adoption/conservation of given agriculture practices at farm level.

Keywords: Common resources management, food security, LSMS-ISA, Malawi, Nigeria, Uganda

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Economic Analysis of Land Tenure Systems on Arable Crop Production for Households' Food Security in Ekiti State, Nigeria

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Globally, famine and starvation are becoming severe most especially in the developing world, leading to food insecurity. The study examines the economic effect of land tenure systems on arable crops production in Ekiti State, Nigeria. Attempts were made to examine the type of land ownership rights, problems of land acquisition, the pattern of land use and the resource use efficiency of land as a factor of production in arable crop farming. Data were collected using a multistage sampling technique from 120 arable crop farmers. Data were analysed using descriptive statistics and production function analysis. The study reveals that majority (80.8 %) of the farmers are small holders having less than 4 ha of land. It was indicated that 76.7 percent of the farmers operate on subsistence basis. Result shows that the prevailing tenure type was inheritance ownership right with 60 percent of the respondent acquiring their land through inheritance. This type of land tenure system has resulted to farm land fragmentation which would not encourage mechanisation and commercial agriculture. The production function analysis shows that all the variables used in arable crop production have positive and direct effect on productivity except fertiliser application and chemical use which have inverse relationship. The result also shows that land acquisition through category 1 (inheritance, communal, purchase or gift) would increase arable crop production because this set of land ownership allows the farmer to make their own production decision. The study therefore reveals that the attainment of a sustainable and secured food production hinges on acquisition and accessibility to arable land in accordance with the principle of land use.

Keywords: Analysis, arable crops, food security, land tenure, production

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Landscape Level Integrated Land Use Developmental Initiatives to Secure Food Security among Mountain Communities: An Evidence-Based Analysis of the Attappady Wasteland Comprehensive Eco Restoration Project, Kerala, India

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The realisation of complex social phenomenon such as food security calls for integrated approaches involving enhancement of agricultural productivity, access to productive resource base, availability of social safety nets, operations of robust institutional arrangements under the overall umbrella of strong political commitment. However, such strategies are often challenged by imperfections, deficiencies and compatibility-related issues vis à vis the stakeholders expectations and actor incongruities. It is also observed that aggravation of food crisis often is accompanied by the incidences of natural disasters, degradation of the natural resource base, weak institutions and poor governance arrangements. The precarious scenario is further accentuated and threatened by incidences of drought, deforestation, loss of biodiversity, land degradation as well as the new and emerging threat of climate change. The vulnerable sections of the society such as indigenous and mountain people are often pushed to high levels of food insecurity and livelihood issues by such vicious circles.

In the current paper we analyse, demonstrate and describe as to how such issues could be effectively addressed by integrated landscape level resource developmental initiatives under good governance arrangements supported with political commitments taking evidences in context of much disadvantaged social groups such as indigenous people and other mountain communities. We have adopted a case study method to understand how creation of a favourable political environment for participation of actors and stakeholders under good governance arrangements help realise the expectations on securing food and livelihood security and inclusive development. In the current case study we have considered evidence based decision making recorded by the indigenous people in the Attappady block of Kerala State in India under a unique eco restoration project which addressed several cross sectoral developmental issues at landscape level, with a high level of inclusion leading to improved food security and livelihood security. We expect that the developmental model discussed herein as well as evidences from the current case study can potentially complement the efforts towards promotion of productive, sustainable, cultural and environmental practices aimed at realising the targets under the Millennium Development Goals as still 805 million people across the globe are living with hunger and malnutrition .

Keywords: Food security, integrated land use systems, Kerala, mountain communities

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Cooperatives in the Wine Sector in Argentina: Can They Improve Prices Paid to Farmers?

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Many agricultural sectors are characterised by increasing market imbalances. Processing and retailing industries may acquire dominant market positions, while farmers are likely to receive lower and/or non-transparent prices for their products. Collective action through different kinds of organisations such as cooperatives is a potential tool for improving farmers' economic performance.
Even after controlling for product heterogeneity, differences in prices paid for agricultural goods and services have been explained by factors like imperfect information, transactions costs associated to the exchange of goods or services, spatially uneven competition, as well as by differences in the objective function and ownership structure among agricultural firms. While the first three reasons belong to the theory of price dispersion, the other arguments make part of the competitive yardstick theory of the cooperative firm. The main claim of the competitive yardstick theory is that in a situation of monopsonistic pricing cooperatives are one way to improve market efficiency. The idea is that cooperatives' services at cost discipline the service offers of non-cooperative service providers (investment oriented firms) thereby contributing to relatively higher producer prices.
This article analyses if cooperatives can pay better prices to farmers than investment-oriented firms do in the non-varietal wine market in Mendoza, Argentina. An econometric model was developed to analyse cooperatives' effect on prices paid to farmers. Our sample consists of 4,076 wine selling transactions observed in six departments of two regions in Mendoza during 2007–2012. The effect of cooperatives on prices was analysed on two levels. Firstly, the model analysed the existence of a price differential paid to farmers according to the type of buyer, cooperative or investment-oriented firms. Secondly, the model assessed the effect of cooperative strength (measured by surface area, members, grape and wine handled) on prices at departmental and regional level. We find that cooperatives pay lower prices to producers than investment-oriented firms do. However, in the region with the lower grape production, cooperatives have a higher market share and they positively influence prices compared to the other region. We discuss these results taking into account the specific context of each region.

Keywords: Cooperatives, market efficiency, rural development

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Political Economy of Energy Subsidy - Groundwater Depletion Nexus in Iran: The Role of Irrigation Water

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The depletion of groundwater resources mainly due to the irrigation water pumping in Iran is an obvious problem which threats rural life and sustainable development. The latest estimates show that 70 % of the groundwater resources are overexploited in the last 15 years. The expansion of groundwater use for irrigation, reaching 450,000 permitted wells and 103,000 non-permitted wells in 2015, is one of the reasons for the quantitative and qualitative deterioration of groundwater resources, but not the only one. The huge subsidies which are given to energy consumption (electricity or gasoline) for pumping irrigation water from aquifers since many years should be considered as the major problem in this area. The cheap energy makes the deep water pumping possible and huge investments in deepening and relocating wells feasible. The latest estimates show that 95 % of provision costs of electricity are subsidy for water pumping and farmers are paying 5 % of these costs. In this study we present the historical trend of energy prices in agriculture and non-agricultural sectors. The number of wells and general groundwater depletion are also presented for the same period. The comparison of the development of agricultural products prices and energy prices shows the distance of this pricing system from full cost recovery for water extraction from groundwater resources. The non-successful attempt of price policy reform by the Iranian government in December 2010 for mild elimination of the tremendous subsidies which were devoted to irrigation water pumping is analysed in this study. The government was more successful with partial elimination of subsidies to domestic and industrial usages than to agriculture. By considering the developments before and after the implementation of the price policy reform in December 2010, our study focuses on the political economy of groundwater irrigation. The results show that without deep understanding of the key institutions and stakeholders for groundwater pumping, this problem can't be urgently solved and the extreme depletion of groundwater resources will continue. By neglecting the political economy, functioning policy for eliminating subsidies in this sector will not be applicable by the future attempts.

Keywords: Energy subsidies, groundwater deterioration, irrigation water, political economy, price reform, pumping

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Farmers' Engagement in Local Cooperatives, the Maker or Breaker of Sustainable Agricultural Development

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Sustainable agricultural development is a key for poverty reduction in less developed countries. Though Egypt has been acquiring rural developmental funds from international and local donors for more than 50 years, the "per-capita income" is only slightly increasing and, accordingly, rural quality of life is not significantly improved in many Governorates. Local Cooperatives (LCs), in each Governorate, should primarily bridge gaps between farmers, donors and large corporations. The sequential role of the LC starts by getting funds from large Non-Governmental Organisations (NGO's) and inject them in learning activities for farmers, who, in turn, could transform learning into tangible results and finally generate profit through providing products and services to beneficiaries. This qualitative study investigates the case of some LCs that could not function and, accordingly, were losing their credibility with both donors and farmers, and compromise their developmental role. The study revealed some reasons why LC's fail to engage farmers in one of the mega developmental projects funded by large NGO's that have projects located at the Nile Delta of Egypt. This project included big multinational organisation, producing dairy products. These projects worked on empowering farmers who raise cows to milk and to provide quality supplies of dairy raw materials to dairy manufacturing organisations. The study analysed the challenges that were threatening the effectiveness and sustainability of such projects, among which are the following: a) The LCs' failure to identify their objectives based on developmental mindset (due to over-emphasis on acquiring additional funds to keep operating, jeopardising their essential role of empowering farmers); b) The failure to put farmers in direct connection with beneficiaries and technical support agencies fearing to be excluded from such networks; and, c) The failure to work properly on raising farmers' awareness on value chain-related areas, which is essential for achieving sustainability in the supply and demand processes. The study suggested to activate farmers' engagement, in the LCs, to be rural development-oriented rather than for repeating or increasing donors' funds.

Keywords: Egypt, farmers' engagement, local cooperatives, Nile Delta, sustainable agricultural development

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Estimating Reallocation Cost of Water Resources through Agricultural Production Function

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Human-ecosystem interactions have largely been ignored by people, especially in developing countries. Due to most ecosystem services characteristics as public goods and difficulties in quantifying their value to the society, the cost of consuming ecosystem goods and services are not assigned properly. The effect of human activities on ecosystem has no price and is seldom considered in decision making by governments. Increasing research and knowledge on global environmental change tends to more focus on the relationship between human activities and ecosystem sustainable use. A large number of interdisciplinary studies about global ecosystem changes have improved our information about the importance of humanity's dependence on ecosystem for their survival. Sustainable development refers to the economic and social development together with the protection of environmental quality. Sustainable development is strictly tied to wise use of environment and natural resources.

Making a balance between economic developmen,t and water resource degradation and depletion secures economic development without imposing excessive costs or lost on environment. Since agriculture has the major share of the raw water use in developing countries, with the aim of providing a support for policy makers in the agriculture development plans, we apply economic methods to identify the non-marketed gaps and monetise the real economic value of water.

The main goal of the study is an interdisciplinary linkage between water resources in wetland conservation and goods provided by water to assist policy makers for a sustainable water resource management. The research investigates the current and alternative water allocation strategies and their effect on farmers' welfare. This attempt, as a help for policy makers, determines a more desirable way for water management plans from the environmental perspective. The production function is applied as a methodology for assessing the economic value of water as an input in production process, while it can then be used in a reallocation analysis.

Keywords: Sustainable development, water management, welfare measurment

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The Relationship between Tenure Security and Investment among Derived Land Rights Holders in Selected Communities in Wa East District of Ghana

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Land related activities and other natural resource use are central in promoting rural livelihoods in Africa. In Ghana, land transfers from kin, and derived rights arrangements in the form of renting, share contracts and weeding contracts remain major means by which the landless access land for farming. The security of tenure associated with these arrangements is very essential for investment on the land in order to obtain maximum retains. Discussions of tenure security focus mostly on land ownership or otherwise, titling of land and to some extent private property rights arrangements. Using qualitative and quantitative data collected from Biisikang, Tuassa, and Chaggu farming communities in Wa East District in the Upper West region of Ghana, between October 2009 and April 2010, this paper unearths the types of derived rights arrangements operating in the district, established the level of tenure security associated with these arrangements, brings to the fore the types of investment undertaken by various derived land rights holders, and determines the extent to which tenure security influences investment on land under derived land rights arrangements. The paper clearly indicates that open-ended loans and 'land begging' arrangements are the two main derived land rights arrangements operating in these communities. It also shows that open-ended loan arrangements offer relative more secure tenure than 'land begging'. Investment was found to be relatively high among those under open ended-loans, though mainly applying fallow the land while investment under land begging was relatively low and mainly with fertiliser application. This supports the theoretical security-investment relationship found in literature. Using the logistic regression model, tenure security appeared to be influencing fallowing under open ended loans.

Keywords: Derived rights arrangement, farming, investment, land tenure security

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Determining Minimum Compensation of Smallholder Farmers for Lost Agricultural Land in Land Grabs

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The recent global expansion of large-scale land acquisitions by domestic and international investors, popularly known as land grabs, has placed increased strain on smallholder farming households as the loss of their agricultural land is associated with severe reductions in food production and thus food security. The land grabbing issue has produced a plethora of debates ranging from ethical conduct of land grabbing agents, specifically concerning displacement, to evidence for and against positive externalities such as technological spill-overs and construction of infrastructure. Interestingly an underexplored topic is the valuation of agricultural land and the compensatory payments made to land users, distinct from land owners, for the loss of their source of food security. This paper establishes a theoretical framework for the valuation of agricultural land from the perspective of land users, based on a household production function. For the analysis data were collected in a survey of 203 households in the Land Grab affected area in the Northern Province of Sierra Leone during 2013. It shows that, for the case of a specific land grab in Sierra Leone, the compensatory payments received by land users are far below the value of the land lost and as such the lease income is unable to allow these households to maintain their previously, already tenuous, levels of food security. A clear distinction is made between land owners and even more vulnerable land users who depend on the agricultural land for their food security and livelihoods. The methodology implemented by this *ex-post* study can identically be applied to an *ex-ante* scenario allowing land grabbing agents to define a minimum compensatory payment to land users based not on asymmetrical bargaining power but on actual land value to this vulnerable section of the local population.

Keywords: Agricultural economics, land grabbing, productivity method, Sierra Leone, smallholder farmers, welfare

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Multiple Policy Instruments for Sustainable Water Use in Crop Production in China

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Massive expansion of irrigation agriculture and consecutive overuse of water resources leads to aggravating ecological and economic problems in the extremely arid Aksu-Tarim Region (ATR) in northwestern China. Therefore the evaluation of policy instruments aiming at a more sustainable water management in crop production is of high relevance for research and regional decision makers. Building on a primary crop production data set of more than 250 farm households, a regional farm model was developed applying a positive mathematical programming approach. The tested water policies (taxation, pricing and quota) differ significantly in their effectiveness and efficiency, with water pricing constituting the most promising policy option. However, the scenario simulations revealed a strongly negative effect of water policy implementation on crop production and agricultural incomes. Therefore, the water policies are applied in an integrated approach together with agricultural policies, namely subsidisation of advanced irrigation technology for cotton production as well as a subsidisation of cereal production. With this integrated approach water saving could be realised with much less negative impact on crop production. Aiming at water saving rates of 10 % and 20 % decreased cotton production by 7 % and 15 %, increased cereal production by 17 % and 4 %, and caused an overall agricultural income deficit by 6 % and 13 %, respectively. The study complements existing literature by the assessment of multiple policy instruments and presents a useful model framework to address further research questions of crop production and agricultural water management in water scarce regions of China.

Keywords: China, crop production, irrigation, mathematical programming, policy instruments, regional model, water saving

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Institutional Conflict and Access to Resources in Ghanaian Urban and Peri-urban Agriculture

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Food insecurity is a global problem particularly prevalent in sub-Saharan Africa. Here, urban agriculture has rarely been formalized and institutional conflict often threatens the possibilities for it to contribute to food security. Yet this case study finds that in Tamale, northern Ghana, conflict between institutions has inadvertently led to innovative resource provisioning in urban agriculture. Vegetable cultivation is a means of survival for many residents of Tamale. It requires access to infrastructure such as markets, transport and extension support. Fourteen months of ethnographic study was carried out to understand the resource politics of vegetable farming in Tamale. Traditional institutions whose allodial right over land has encouraged a lucrative land market play a decisive role in determining the form of farmers' access to land. Agricultural land is sold out for industrial and residential purposes. The resultant shortage of city farmland has led to innovations like farming in and around buildings, on plots of less than 0.25 hectares. Farmers also opportunistically collaborate with the state and private institutions against traditional authorities to get permanent access to designated farming zones in the city. Furthermore, this uneasy institutional relationship has given rise to a cordial association between farmers, academics and other researchers, whereby inputs such as improved seeds are provided for farmers to test on their fields. This process has also encouraged crop diversification in farmers' fields and increasing productivity. As farmers' management practices have become more productive and less risky, their adaptation to climate variability has improved. In a further bid to increase production in a land-scarce situation, farmers and NGO's such as 'New Energy' give *'kola'* (a token) for land and in turn bring technological innovations like drip irrigation to peri-urban fringes. This paper explains how conflict between some institutions directly and indirectly involved in urban and peri-urban food production has led to collaboration and synergy between others, increasing innovative farmers' access to the critical resources of land and technology. Such links, if formalized, will improve food security. In demonstrating these relationships, this paper provides an insightful, optimistic picture of the elements that actors must consider in policy decisions around urban agriculture.

Keywords: Food security, institutions, peri-urban, technology, vegetables

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Food Security Crisis in Bwabwata National Park: Khwe San Perceptions

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The Khwe San people of the West Caprivi are amongst the richest traditional ecological knowledge holders yet also amongst the most food insecure groups in Namibia. Once living as nomadic hunter-gatherers in vast areas in the landscape, today they had to adapt to sedentary lifestyles on only a small piece of land in the Bwabwata National Park.

Although the Khwe are among the few tribes who were allowed to remain on National Park land in Namibia, they have to comply with imposed park regulations with limited access to natural resources or benefits gained from tourism sector. In addition, their practice of traditional knowledge is slowly vanishing. Today due to very few livelihood options, and difficulties to modern life-style adaptions most of the Khwe San people live in extreme poverty and a big portion of the population is seriously malnourished due to lack of access to healthy, nourishing or traditional food.

A number of institutional development effort have been undertaken in the last decades by government (predominantly community garden projects) but most of them have died off due to lack of project management training, poor planning and also serious internal conflicts inside the community.

This first phase of my PhD study aims to assess past and present programs and initiatives addressing food security from the Khwe perspectives. Semi-structured interviews and focus group discussions has been carried out in April 2015 to explore a) livelihood changes that have taken place, b) the current state-of-the art vis-à-vis food security, and c) future visions and opportunities. Complementary interviews were carried out with other stakeholders (e.g. park managers and NGO employees). The findings of this research will not only help give voice to the Khwe and their perspectives and visions but may foster different, holistic approaches for finding solutions for food-security crisis in Khwe San communities.

Keywords: Food security, Namibia

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Farming with Alternative Pollinators (FAP) Increases Production, Farmers' Incomes and Protects Pollinators and Biodiversity

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Globally pollinator diversity decreases due to habitat fragmentation, habitat loss and agricultural practices. Several climate change effects fuel the decline. The loss of pollinator diversity can significantly endanger food security, biodiversity and ecosystems. Pollinators have four key-functions which make them indispensable for mankind: 87 out of 115 most important food crops, mostly high value crops, require pollinators; 60–90 % of plants need pollinators; most ecosystem services rely on pollination services to a certain extent; and cross-pollination promotes higher genetic diversity supporting climate change resilience by potentially better adapted varieties. Wild pollinators provide about 85 % of all pollination services and honeybees cannot compensate the losses. As most wild pollinators depend on the quality of an area of 300–2000 m around their nests pollinator protection requires a mass basis of intrinsically motivated local people on nearly the entire terrestrial area. Thus pollinator protection is almost impossible to obtain with subsidies, donations, Payments for Ecosystem Services or good-will groups. We suggest Farming with Alternative Pollinators (FAP; 2012), a low-cost agro-ecologic approach focusing on highest income gain by optimal crop-based habitat enhancement on fields and in corridors. FAP is based on (1) the TEEB-approach requesting to show the economic value of ecosystem services and (2) broad evidence, that wild pollinators can significantly enhance the harvest of many crops (quality and quantity); diversity of pollinators is more important than abundance and distance to the nesting area often is the main limiting factor. FAP fields use 25 % of the area for habitat enhancement and 75 % for the main crop; control sites use 100 % for the main crop. FAP assesses the insect diversity on fields and compares the net income from FAP- and control fields. The high additional income gain makes FAP self-sustaining: farmers get an economic interest in protecting pollinators. FAP allows increase of horticulture production without enlarging the area, which is important as 9.6 billion people are forecasted for 2050. We present the FAP-methodology and promising first field results (cucumber, sour cherry) as an alternative to seeding wild-flower strips promoted by entomologists. The approach addressing farmers' interests best will have the highest potential for global adoption and pollinator protection.

Keywords: Agriculture, food security, low-cost, pollinator protection, scalable, TEEB

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Wild Pollinator Diversity in Landscapes Surrounding Cranberry Bogs in Quebec (Canada) and their Usefulness to Harbour Species Providing Crop Pollination

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Although honeybee hives are routinely introduced in cranberry bogs to ensure high pollination rates, the importance of wild bees as pollinators of both these commercial crops and the surrounding native plants has been increasingly recognised. It has been established that wild bees have a strong complementary role in cranberry crop pollination. Sustainable agriculture must thus favour the preservation and protection of these wild pollinator species. Landscape context and availability of nesting and foraging resources are among the main factors strongly influencing these bee communities. In order to protect and enhance the habitats for the bee species important for cranberry crop pollination and the resulting crop yield, our study compared bee communities present in cranberry fields to those from three types of natural habitats (i.e. fallow, bog and forest) surrounding cranberry fields in Quebec (Canada). The objectives were to identify the bee species visiting cranberry flowers and recognise environmental factors that are the main drivers of these bee assemblages. Specimens were collected in 2013 and 2014 using pan-traps and net sweeping in 15 natural habitats adjacent to cranberry fields as well as in the flowering crop. Overall, 135 bee species were captured, 106 from natural habitats and 88 from cranberry fields. Our results show that bee community assemblages are strongly shaped by natural habitats, and unequally distributed among habitat types. Sunlight intensity and soil compaction were found to be the main drivers of bee community assemblages. Results also suggest that each natural habitat studied played a specific role in maintaining bee biodiversity within this agro-ecosystem.

Keywords: Cranberry crop, diversity, habitat, landscape, pollination, wild bees

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Work in Darkness: How Hawk Moth Produce Mangabas (*Hancornia speciosa*, Apocynaceae) in Brazilian Cerrado

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Mangaba (*Hancornia speciosa*, Apocynaceae), native to Cerrado in Brazil, is a tropical fruit crop, consumed mainly as juice. Supply, however, does not satisfy the market because mangabas are still harvested mainly in natural populations. Thus, the species has a great potential as future fruit crop. Recently, first experimental mangaba orchards arose in agricultural research stations in northeastern Brazil.

We analysed floral biology and breeding systems, determined effective pollinators and evaluated the pollination success of mangaba in natural environments and experimental orchards. Furthermore, we evaluated environmental demands of effective pollination.

Hancornia speciosa is a self-incompatible tree with nocturnal flowers. Insects with long mouthparts of more than 30 species, especially nocturnal hawk moths (Sphingidae), visited the flowers. The flowers exhibit a precise pollination apparatus, which optimises pollen transfer between flower and pollinator. During a flower visit, almost half of exogenous pollen grains adhering to the proboscis are deposited on the stigma surface.

While the pollination mechanism avoids self-pollination, mass-flowering promotes geitonogamy. A pollination experiment with nylon threads simulating consecutive flower visits within a crown revealed that there is no fruit set after the third consecutive flower visit. Nevertheless, all groups of flower visitors with long mouthparts were effective pollinators and, mangaba plants, in general, benefit by a high pollinator abundance and diversity.

Fruit set in the studied populations were strongly pollinator limited, and the mangaba berries showed a high variation in size and weight. Seed number was directly correlated to fruit weight. An optimised pollinator mediated flow of cross pollen, thus, is responsible for large fruits.

Our data suggest that fruit set could be increased two to three times with better pollination service. The study indicates that pollinator management implies management of

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the surrounding vegetation of the mangaba orchards guaranteeing a diversified environment. Strong pollinator populations require sphingophilous plants in the surroundings of the plantation that provide nectar when mangaba does not flower. Moreover, their oligotrophic caterpillars need specific species of host plants to survive. Orchards with clonal mangaba plants will result in low fruit set.

Keywords: Brazil, *Euglossini mangaba*, pollination, pollinator management, Sphingidae, tropical fruits

Pollination of Acerola (*Malpighia emarginata*, Malpighiaceae) and Promising Management of Oil-Collecting Bee Pollinators in Brazil

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Acerola (*Malpighia emarginata*, Malpighiaceae), also called Barbados cherry, is a vitamin C rich neotropical fruit crop, widely cultivated in Brazil and consumed in numerous countries. The flowers require specialised native pollinators to set fruit. We evaluated the pollination success in acerola orchards, determined effective pollinators, their environmental demands and pollinator friendly cultivation conditions to maintain strong pollinator populations. Furthermore, we defined pollinator species with potential to be reared for commercial use. The study was conducted in experimental orchards and commercial plantations.

The flowers of acerola produce floral oils, collected by females of oil collecting bees, which harvest these oils with specific brushes on their legs. The oils are used for brood cell impregnation and, mixed with pollen, to feed larvae. Females of numerous species of *Centris* and *Epicharis* (Apidae, Centridini) were determined as effective pollinators of acerola flowers. Surveys of bees and pollen analysis of scopa loads revealed that females of Centridini frequently vibrate flowers with poricidal anthers to collect pollen, especially of *Solanum* (Solanaceae), mixed with pollen of acerola and other Malpighiaceae. Moreover, the *Centris* and *Epicharis* bees depend on additional nectar flowers for adults' energy supply.

While most of the effective pollinator species nested in the soil, females of two species, *Centris analis* and *C. tarsata*, were successfully attracted to use trapnests introduced in the orchards. The cavities were frequently re-used by the daughters in both species. Both *Centris* species, thus, are strong candidates for manageable pollinators in acerola orchards. Pollen analyses of brood cells revealed that females collect almost exclusively pollen from acerola flowers, when reared inside the plantations. To feed one larva, the total pollen amount of about 80 flowers of acerola is necessary, an quantity gathered in about 2900 flower visits.

Our study revealed pollinator limitation at the study sites. Fruit set could be substantially increased, if pollinator populations were stronger. The effective pollinators require a diversified environment in the surroundings of the plantations. Isolated orchards inside an environmental matrix, impoverished in floral resources like that of sugar cane plantations, reduce their productivity and can sustain only small populations of specialised pollinators.

Keywords: Acerola, Brazil, ecosystem services, pollination, pollinator management, tropical fruits

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Identifying Honeys for Geographical Indication Recognition: Motivation for Land Use Improvement and Honey Bee Conservation

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Pollinator decline is a global issue due to the impact on food production. This study addresses local pollinator decline and land use management in local communities by valorisation of honey through Geographical Indication (GI). Ghana has potential to create monetary value from origin honey. GIs give a premium to producers of Oku white honey in Cameroon hence provide an incentive for conserving the most important factors: honey bees (*Apis mellifera*) and the environment (Proper land management), which is also key to food security. The challenge is, GIs as a potential tool to conserve pollinators and improve land use is currently not being promoted in Ghana. The State has to introduce local quality labels, laws, policies, a regulatory framework, agricultural extension services, market analysis (national, regional, international), capacity building and improved value chain infrastructure in the honey sector.
Two objectives were followed; (a) Identify honey producing regions with potential for GI recognition; (b) Assess the potential of conserving local pollinators and improving land use management using GI honeys. Relevant literature and documents were reviewed. Expects views were also sorted on potential GI honeys. Interviews were made with 16 individual honey packagers on honeys with good reputation and with 31 individual local honey producers regarding value addition to their honeys, the potential of improving local land use management and local pollinator conservation in the communities. 30 honey consumers were surveyed on readiness to pay an extra cedi for a GI honey in Ghana after explaining the concept to them.
Data showed that, the Volta Region have honeys with good reputation based on quality perception; clean, smooth, viscous, sweet, its liquid nature, no heating, unadulterated and shelf life. Periodic training on best practices and knowledge sharing amongst local beekeepers played a key role to maintain honey quality. Beekeepers agreed that a good market, which is currently a challenge, could be an incentive and motivate them to conserve local pollinators as well as improve proper land use management in their communities. Most beekeepers interviewed are also crop farmers. All 30 consumers showed readiness to pay an extra cedi for a GI honey in Ghana. Therefore, creating monetary value as a resolution will encourage local farmers/beekeepers to conserve honey bees through appropriate land use and agricultural practices. Furthermore, value addition to local honey and appropriate marketing may also generate needed rural employment options.

Keywords: Beekeepers, Ghana, geographical indications, honey, land use management, pollinator decline

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Effect of Landscape Composition on Native Bee Communities (Apoidea) of an Oak-Pine Forest and Agricultural Land Mosaic of Sacatepéquez and Chimaltenango, Guatemala

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In this study we raised a comparison among three landscape categories (continuous forest, fragmented forest and agricultural or farming areas) in Sacatepéquez and Chimaltenango, Guatemala; defined on the basis of their degree of fragmentation and types of land use, during the dry and rainy seasons of 2012. We sought to determine patterns of bee diversity variation among the three landscape categories, and identify changes in community composition. The results point towards two general situations: (1) Difference in bee diversity was observed in different types of vegetation, this being highest at sites corresponding to the fragmented forest category. This category has a greater heterogeneity in landscape configuration, composed of fragmented forest and agricultural areas. In addition, the continuous forest category had higher abundance of individuals, both in the dry and rainy seasons. This last can be explained by the presence of social bees, which are usually associated with forest areas. (2) Regarding the composition of bee communities, some degree of clustering of the sampling sites was observed, but it seems to respond to geographical closeness among them rather than to differences in land use.

Aside from assessing native bee diversity and composition, we recorded the frequency of floral visits made by bees to different botanical families. The most frequently visited botanical families were Asteraceae, Solanaceae, Brassicaceae and Fabaceae. Based on the results, we highly recommend the protection of forest remnants, both fragmented and continuous, in order to preserve pollination services given by native bees to natural and agricultural systems in the study area.

Keywords: Agricultural land, bees, landscape ecology, pollinating insects

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An Assessment of the Effect of Human-Caused Disturbance on Pollination Services in a Highlands Landscape of Guatemala, Using *Brassica rapa* L. as Model

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Habitat fragmentation is known to cause isolation of natural populations and promote the propagation of invasive species, with drastic effects on biodiversity. Animal-mediated pollination is necessary for sexual reproduction of many wild and cultivated plants. Several studies have reported the negative effects of fragmentation on natural pollinator communities, and consequently on the fruit set of many plant species; also an increase of productivity in crops that are surrounded by forests that provides them with natural pollinators. Given the high estimations of the value of pollination services, the assessment of the effect of fragmentation in agriculture lands is imperative. In this study, we hypothesised that pollination is significantly reduced in highly disturbed areas Guatemalan highlands. We used an experimental treatment-treatment approach ("human-modified" and "forest protection" treatments), using *Brassica rapa* L. as the model species. We installed 22 experimental plots in agricultural areas that were classified within 6 sites, three for each treatment: three sites with forest protection areas and three sites that are predominantly used for agriculture and urbanized areas. Insect floral visits were recorded and fruit set was quantified for each plot. There was no significant difference among floral visits among treatments, but "predominantly natural" plots had 17 % more visits from native bees, and double the fly visits compared to the "human-modified" treatment. Also, a significant effect of flower density on bee floral visits was found. Fruit set was significantly higher in the "predominantly natural" treatment. The results suggest an important role of natural pollinators in the availability of pollination services in Guatemalan highlands.

Keywords: *Brassica rapa*, Guatemala, habitat disturbance, highlands, pollination services

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Production of Honey with a Potential for Geographical Indications Labeling as a Bee Conservation Tool

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The Kenya Vision 2030 and the Agricultural Sector Development Strategy identifies agriculture as a key sector to enhance economic growth, ensure food and nutritional security while contributing to environmental sustainability. Protecting a product with Geographical Indications (GIs) boosts farmers' incomes through improved price premiums and market access and it is also important in biodiversity protection. In Kenya, bees' diversity, abundance and activity density have been reported to be low, locally affecting pollination of important food crops. A study was thus carried out in Kitui, Baringo and West Pokot Counties in Kenya to assess how bees' conservation and pollination services can be enhanced through production of quality honey with GIs potential. This study will inform and support the GIs Bill in Kenya which is awaiting enactment and also it will inform the debate on the development of a pollination policy in Kenya. Data was collected through six Focus Group Discussions (FGDs) and key informant interviews with 15 honey producers and additional key stakeholders in the honey sector. Descriptive statistics, such as frequencies and graphs were used to present the results. Results indicated that most of the honey producers practice organic agriculture and they conserve particular plants with nectar that is known to produce high quality honeys that qualify as potential GIs. These plants also provide pollen for the brood and they also act as habitats for bees and other pollinators. Production of potential GI honey can thus be a tool to enhance conservation of bees. There is need to; inform and capacity build honey producers about the benefits and consequences of GIs; improve institutional capacity to ensure protection of honeys with a potential for GI labelling; create a regulatory framework for GIs products and improve market infrastructure for honey marketing.

Keywords: Bees, conservation, geographical indication, honey, Kenya, pollination

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What's Best for Bees? Determining Landscape Suitability of Bumblebees Using RFID Technology

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Pollination by insects is a crucial ecosystem service that helps to provide over 70 % of economically important crops worldwide. As the world population and food demands continue to increase, there is a premium for these services. Despite this, pollinating insects, especially bees, are declining due to increased agricultural intensification. However, these declines can be mitigated by developing conservation strategies aimed at protecting landscapes that support healthy and abundant bee communities. In order to develop conservation strategies, it is imperative that we determine which types of landscapes are most suitable to bees. In a 2014 pilot study, we used radio frequency identification (RFID), we tracked common eastern bumblebee (*Bombus impatiens*) foraging and monitored colony performance in relation to floral resources and a range of landscape types across southern Wisconsin in attempts to determine an empirical relationship between the landscape and colony health and performance. We found no evidence of differences in foraging patterns between locations, but did see a positive response in colony reproductive success in agricultural landscapes, and a negative response in urban landscapes. These data suggest that using behavioural traits such as foraging pattern and performance metrics could be used as a measure of landscape suitability to wild bees. Identifying the most suitable landscapes in terms of the aforementioned metrics could help to guide conservation strategies for these essential ecosystem service providers. Work in 2015 will involve testing these methods in a larger subset of landscapes, as well as in a mass-flowering crop (American cranberry: *Vaccinium macrocarpon*) to determine how bumblebees respond to resource pulses in agroecosystems.

Keywords: Agroecosystem, bumblebee, cranberry, ecosystem service, foraging, landscape, pollination, RFID

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Marine production systems and aquaculture

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Certification as a Tool to Ensure Environmental Sustainability in Fishery: The Case of Grupo Pando Sardine Fishery in Mexico

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World fisheries have increased, and with it, natural resources from which they profit, have been decreasing; being this activity an important source of employment, income and food supply, a fishery management plan which considers both biological and socioeconomic aspects is needed to ensure a sustainable behaviour through the development of this activity. Food security, fish quality, social empowerment, and development and environment's conservation might be high impacted by a fishery management system.

To ensure sustainability, natural resources and socioeconomic activities are being protected and regulated at a national level, with mandatory regulations, and at an international level with voluntary requirements. The adoption of a mandatory and voluntary regulation framework may improve the sustainable performance from an organisation. Grupo Pando as a fishery industry in Mexico aims to acquire sustainability from the natural resources needed for their production processes, and for the organisation itself. Grupo Pando sustainability system might be a basis for other mexican sardine fishery enterprises. To ensure the sustainable performance from Grupo Pando sardine fishery a sustainability certification system was designed based on the national, international and institutional regulatory framework. There are twelve principles, 56 criteria and 231 indicators with different legal enforcement degree adapted based on Mexican Official Norms, international sustainability standards and institutional policies.

Current sustainability performance of Grupo Pando sardine fishery plants shows an acceptable fulfilment degree according to the compliance of the sustainability certification system; nevertheless there are opportunity areas at the environmental and economic dimensions that need to be incorporated by the organisation for a better performance.

Keywords: Policies, standards, sustainability, sustainability certification system

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A Closer Look at Boring Issues: Root-Inhabiting Invertebrates, and their Role in Mangrove Ecology

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Inhabiting the intertidal zone along tropical and subtropical coasts, mangroves trees are prone to attack by both terrestrial and marine parasites. Wood-boring marine invertebrates, such as amphipods, isopods or gastropods, for instance, settle on aerial roots of mangrove trees during tidal submersion and drill holes into the wood. Heavily infested pieces of wood with drastically decreased stability through severe tunneling-activity can frequently found in the intertidal area of, and next to, mangrove forests. However, these trunks appear to be mostly settled on after having been detached from the tree. It is essentially unknown what triggers settlement by marine wood-borers on living woody tissue of mangrove trees, as well as what are the consequences of infestation of living trees and their roots by marine wood-borers on either the individual tree or the mangrove system. We studied (1) effects of root-inhabiting isopods on root growth and survival in the field; (2) effects of phenolic wood exudates on colonisation of mangrove wood by shipworms in the lab; (3) small-scale environmental conditions around holes of shipworm in mangrove wood. Preliminary analyses suggest that wood-boring isopods do not increase the die-off risk of individual aerial roots, but affect root growth reduce their chance of reaching the sediment. A complex mixture of phenolic compound is released from mangrove roots into the water, potentially affecting the nearby environment and the attractiveness of the root as habitat for marine wood-borers. When densely colonizing mangrove roots, wood-borers can affect oxygen consumption by, and water movements next to, mangroves. These studies serve as a basis for large-scale studies on element fluxes from mangrove roots into coastal waters.

Keywords: Element fluxes, intertidal zone, mangrove roots, parasites, tropical and subtropical coasts, wood-boring marine invertebrates

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Mangroves & Earth Plate Subduction: A Case Study from Nicobar Islands, India

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Mangroves are unique ecological communities that thrive in the intertidal habitats of tropical and subtropical coasts where their salt tolerance and unique morphological features leads to a competitive advantage over other vegetation communities. Owing to the occurrence of mangroves in the buffer zone between sea and land, natural disturbances such as hurricanes, cyclones, tsunami and sea-level change can cause significant damage to its habitats. The sea level change in the Andaman and Nicobar Islands, India due to the earth plate subduction during the Sumatra- Andaman earthquake 2004 is a striking example for how natural disturbances can cause everlasting impacts on mangrove forests. This earth plate subduction resulted in a third largest earthquake (9.3 Mw) in the known history of mankind and giant tsunami waves in the Indian Ocean. The Andaman and Nicobar Islands that were situated on the subduction trench had undergone tremendous landscape level changes due to the landmass uplift and subsidence relative to sea level. In general the Nicobar Islands in the South had sunk in the sea for about 1.1 – 3 m and the Andaman Islands in the North had uplifted from the sea for about 0.1 – 1.4 m. This has caused a significant damage to the coastal ecosystem in general and mangrove forests in particular.

We have studied the impacts of tsunami and landmass subsidence on mangrove vegetation and their natural recovery patterns from the Nicobar Islands. Our findings have suggested that nearly 95 % of mangrove forests undergone an irreversible damage and five species of mangroves have gone locally extinct from the Nicobar Islands. Also we found a landward migration of mangrove species to the habitats that were coastal evergreen forests before and became inter tidal habitats after the subsidence.

Keywords: Buffer zones, earth plate subduction, India, intertidal habitats, mangroves, sea level changes

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"Inversification" of Estuaries and the Loss of their Role as Nursery Areas in West Africa

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Drying out or "Inversification" of estuaries and the loss of their role as nursery area is a consequence of decreasing precipitation in West Africa, this will be showed through an example from Senegal, the Sine-Saloum Delta.
There is a widely-held paradigm that tropical estuaries are critical for sustaining production in coastal fisheries through their role as essential nursery areas for important exploited species. Since early life stages are a particularly vulnerable phase, it is hypothesised that in order to maximise survival, marine fish larvae are transported and juveniles migrate into estuaries to make use of the high food abundance, refuge against predators, and shelter from physical disturbances. There is also evidence that some freshwater species use estuaries as breeding and nursery places. The Sine Saloum Delta in Senegal is a mangrove estuarine system impacted by climate change and bad management practices. The combined effects of reduced freshwater inputs, intense evaporation and a low gradient in the lower estuary, have resulted in a high overall salinity and an inversion of the salinity gradient. This results in a so-called inverse estuary with salinity usually greater than that of seawater in the upper part of the system. As part of the trilateral (Germany-France-West African Coastal States) cooperation project AWA, the potential of the Sine Saloum system as a recruitment and nursery area for locally exploited coastal fishes is being investigated by looking at the relationships between the environmental conditions, fish larvae and reproduction potential of important species.

Keywords: Breeding and nursery areas, decreasing precipitation, estuaries, fisheries, Senegal, Sine-Saloum Delta, West Africa

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Carbon Exchange: Do Mangrove Forests Facilitate Carbon Outwelling to Seagrass Beds and Coral Reefs?

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Recent research highlighted the importance of connective nutrient fluxes between systems within the tropical coastal seascape i.e. mangrove forests, seagrass beds and coral reefs. Connective nutrient fluxes have been shown to facilitate the establishment and health of these ecosystems. However, the complex interactions of carbon exchange between connected mangrove forests, seagrass meadows and coral reef ecosystems are poorly understood. The amount of dissolved carbon exported by the mangrove forest and made available for passive tidal exchange between downstream seagrass meadows and coral reefs may be important in understanding changes in coastal productivity. Currently, there is limited quantitative data on the effect of DIC availability from mangroves on recipient ecosystems. In addition scientists and managers lack information of the actual hydrodynamic movement of dissolved and particulate nutrients between these systems. Here, we quantify the amount of DIC outwelled from mangrove leaf litter and the mangrove forest and made potentially available for phytoplankton, seagrass beds and coral reefs. This data is then used to develop a model, validated with data from our site (Chwka Bay, Zanzibar), which captures the most relevant processes of carbon exchange in the present time. An essential additional aspect in the model is that the areal extent of mangrove forests and seagrass beds can be changed to allow us to see how changes in size of the ecosystems will alter nutrient fluxes across the seascape. We can also monitor movement of nutrients fluxes within the coastal zone from an external nutrient source such as a fish farm. Both of these aspects would allow us to relate how future scenarios of the bay could affect the extent of mangrove forests and seagrass beds and thus derive from this affects on the ecosystem services.

Keywords: Coastal productivity, connective nutrient fluxes, coral reefs, dissolved carbon, mangrove forests, model, seagrass beds, Zanzibar

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Reef-Scale Assessments of Ecosystem Health Using Bio-Indicators

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Tropical reefs provide a number of important ecosystem services and a resource base for generating fisheries income and act as the food source for island coastal communities. Reef ecosystems in Zanzibar for instance, are currently threatened by local anthropogenic disturbances including: untreated, urban wastewater pollution; increased boating activities; overharvesting of marine resources and the effects of future predicted climate-driven ocean warming. These factors and especially high nutrients and climate-driven warming are deleterious to benthic, marine calcifiers such as corals and large benthic foraminifers (LBFs). Both corals and LBFs possess algal-symbionts, however stressors such as oceanic warming increase mortality, resulting in the expulsion of symbionts and subsequent bleaching. Increased atmospheric CO_2 leads to acidification and a decrease in abundance and richness of species. Large benthic foraminifera (LBFs) are found in high abundance and taxonomic diversity in reefs world-wide. In the past decade they have been increasingly used as a tool for monitoring water quality and in quantifying reef health. Unlike corals, their high sensitivity and fast reproduction results in a fast response to environmental changes. Therefore, LBFs provide a rapid, cost-effective way to assess reef-scale changes crucial for future ecological forecasts due to human disturbance, eutrophication, warming temperatures and ocean acidification. In Zanzibar's reefs, LBFs are prolific calcium carbonate ($CaCO_3$) producers contributing to the carbonate budget and stability of reefs. The comparison between communities from impacted and non-impacted reefs shows warning signs of degradation due to local impacts. Long term monitoring is crucial in securing the economic welfare of Zanzibar's reefs.

Keywords: Eutrophication, fisheries income, large benthic foraminifers, ocean acidification, overharvesting, tropical reef ecosystems, urban wastewater pollution, Zanzibar

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Improved Management and Technological Innovation in African Tilapia Farms and Hatcheries: Integrated Fish-Horticulture Farming System

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Improved management and technological innovation in African tilapia farms and hatcheries (ITACA) is a project implemented by the National Institute of Oceanography and Fisheries (NIOF, Egypt, coordinator), the Institut de Recerca i Tecnologia Agroalimentaries (IRTA, Spain, partner), and the Institut Sénégalaise de Recherche Agricole – Centre de Recherches Oceanographiques de Dakar-Thiaroye (ISRA-CRODT, Senegal, partner). The action was grant under the African Union Research Grants programme 2012, which is financed by the Financing Agreement between the European Commission and the ACP Group of States (Agreement No REG/FED/2009 /021/-575) under the ACP Research for Sustainable Development Program RPR/011/ 09, of the 10th EDF Intra-ACP Envelop. The ITACA project, which has an overall duration of 36 months, aims to enhance the sustainability of African tilapia farms and hatcheries through improved management and technological innovation. The present study aims to evaluate the integration of vegetable farming in the fishpond during winter and after fish harvest season as sustainable Integration system applicable in rural area (Kafr El-Shiekh, Governorate, Egypt). The total fish production per acre in polyculture system is 4.0 tons (Nile Tilapia 3545 kg and mullets 505 kg). The daily feeding rate is 5 % (fish biomass/5 days a week), reduced to 3 % when fish reached 50g to the end of fattening period. During winter and after fish harvest season some fishponds dikes cultivation by wheat and vegetables including (lettuce - tomatoes - zucchini - okra - beans - pepper) for human consumption. As well as in some pond cultivation either by alfalfa or fresh herbs, not only in order to increase the cohesion of the dikes but also protect it from erosion and corrosion, and to feed some farm animals such as sheep, cattle, and buffalo. The main idea of this system is convert the fish excretion rich in nitrogen (nitrate and nitrite), phosphorus, and potassium, which are necessary nutrients, needed for plant growth into valuable products such as edible organic vegetables. Often rural families are sold excess crops in the same area markets.

Keywords: Integrated system, rural area, sustainability, vegetables

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Increase in the Plant Protein Ratio in the Diet of Nile Tilapia, *Oreochromis niloticus*, Using Saccharomyces Cerevisiae-Fermented Sunflower Meal as a Replacement

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This study aimed to improve the nutritional value and utilisation of sunflower meal (SFM) used as feed ingredient for tilapia by an approach of solid-state fermentation with Saccharomyces cerevisiae. The protein content and lipid content were increased, while, phytic acid and tripsin inhibitor were decreased during solid state fermentation process. A feeding trial was conducted to investigate the effect of yeast fermented sunflower meal (YFSFM) on the growth, feed utilisation parameters of Nile tilapia *Oreochromis niloticus*. Dietary fish meal was replaced with yeast fermented sunflower meal (YFSFM) in four isonitrogenous (295 g kg^{-1} crude protein and isocaloric 19.5 MJ kg^{-1} gross energy) diets. Fish meal was replaced with YFSFM in the experimental diets in four levels 0, 25, 50 or 75 % to formulate four experimental diets (control diet), YFSFM-25, YFSFM-50 and YFSFM-75, respectively. Each diet was fed to triplicate groups of fish with an initial weight 10.30 $\pm$0.12 g. The experiment was conducted for for 84 days. The highest final body weight (FBW), weight gain (WG), specific growth rate (SGR) and the best condition factor (K) were obtained with control diet and YFSFM-25. The lowest growth response was obtained with YFSFM-75. Generally, a positive protein substitution effect was observed at 25 % substitution levels YFSFM-25. The highest feed intake (FI) g/fish and the best feed conversion ratio (FCR) and protein efficiency ratio (PER) were recorded for fish fed control diet and YFSFM-25, with values statistically different from the other treatments. Fish fed different levels of YFSFM did not have a significant impact on dry matter, lipid, crude protein and ash contents of the fish.

Keywords: Growth, *Oreochromis niloticus*, solid state fermentation, sunflower meal

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Partial and Total Substitution of Dietary Fishmeal by Conventional Soybean or Genetically Modified (GM) Soybean Meal Supplemented with Formic Acid for Nile Tilapia, *Oreochromis niloticus* Fingerlings

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A feeding trial was conducted to reduce the cost of diet by using two sources of soybean meal (conventional or genetically modified) instead of the expensive commercial fishmeal (FM). In the present study, commercial FM was substituted by partial (50 %) or total (100 %) soybean. Diets were supplemented with formic acid (FA) at level of 0 or 10 ml kg^{-1} to investigate the growth performance and feed utilisation of *Oreochromis niloticus*. The experiment was conducted with 360 Nile tilapia fingerlings (with initial weight of 22.15 $\pm$ 2.70 g). Nine isonitrogenous 25 % crude protein and isocaloric 19.28 MJ kg^{-1} gross energy experimental diets were formulated. Over the 10-weeks feeding period, formic acid supplementation elevated the growth performance and feed utilisation for fish fed either 50 % conventional (C-SBM50) or 50 % genetically modified soybean meal (GM-SBM50). Serum ALT, AST, glucose and triglyceride values were lower in fish fed the control diet and conventional soybean in comparison with those fed genetically modified soybean meal. No obvious changes were found in micronucleus or in nuclear abnormalities for all diets compared with the control diet. FA supplementation improves the growth performance, feed utilisation and biological abdominal parameters in fish fed either C-SBM50 or GM-SBM50. In spite of that, genetically modified soybean elevated the levels of ALT, AST, glucose and triglyceride. These results draw our attention to the important use of organic acids in fish diets to improve the growth performance and feed utilisation. As regarding the genetically modified soybean, it needs more investigation to evaluate their effect in feeding trials on fish.

Keywords: Conventional soybean meal, fishmeal, formic acid, genetically modified soybean meal, *Oreochromis niloticus*

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Scientific Knowledge Transfer on the Mangrove Used Attraction in Segara Anakan Lagoon, Central Java, Indonesia

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The Segara Anakan lagoon is located in Central Java, Indonesia. Its ecosystem is made up of a variety of habitats: mangrove, saltwater marshes, inter-tidal mud flats, and open water. Mangrove becomes estuary for the spawning ground, nursery ground, and feeding ground of the fish, shrimp and other water biota. Since the first mapping of the Lagoon in the early 1900s, its surface area has continuously declined. Many researches was conducted and policy was implemented to save the lagoon and mangrove forest, thus conflicts of interests involving economics, conservation, and welfare lead to the shrinking of the lagoon continuing up to now. Reasons are: (1) illegal logging and agricultural activities in the upstream; (2) commercial farming, fishing activities, and aquaculture on the mangrove and lagoon areas; and (3) conflict with neighbouring district for the river diversion plan to bring the upstream sediment to the open sea. The research question of the paper is why scientific knowledge transfer was not successful in this case. For answering this question, the RIU-model of scientific knowledge transfer is applied to analyse the interests and interactions between actors of the science-policy-interface within the three spheres Research (R), Integration (I), and Utilisation (U). The RIU model illuminates the importance of integration activities as the key to successful scientific knowledge transfer from science into political practice. The objectives of our research are: (1) to identify scientific knowledge that was utilised by actors in practice; and (2) to identify and to analyse integration activities between research and utilisation. The results show that due to the weakness of the integration process, emerging science-based policies failed to achieve their goals to conserve the mangrove and lagoons areas. Based on the analysis by the RIU model we identify problems of scientific knowledge transfer in this case and can formulate recommendations that could be used to improve the implementation of science-based policies.

Keywords: Knowledge transfer, lagoon, mangrove, RIU model, Segara Anakan

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Food Security in Cambodia: Fishing in the Mekong in the Light of Declining Fish Stocks

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With its fertile soil, low population density and abundance of fish in the Mekong river, the province of Stung Treng in Cambodia's north offers its people rich resources for food production during much of the year. This is reflected in measures of dietary diversity such as the Food Consumption- and Household Dietary Diversity scores indicating widespread Food Security. Looking at the details reveals that fishing in the Mekong as source of protein is of utmost importance for large parts of the population. At the same time, incidences of food insecurity during parts of the year coupled with signs of overfishing and expected further reduction of fish stocks due to the construction of hydroelectric power stations along the Mekong speak a different language: In the absence of alternative sources of income and the presence of degradation of environmental resources, especially fish, the future of Food Security in Stung Treng is not secured. The aim of this paper is to assess the current situation of food security in Stung Treng, to identify the groups which are most dependent on fishing and to project the possible impact of declining fish stocks on these households. We use data on 600 rural households in 30 villages collected in the province of Stung Treng, Cambodia, in 2014, analysing household characteristics in relation to the importance of fish in their daily diet and fishing as part of their income generating activities. Different scenarios of declining fish stocks are used to project the future of food security for the households in the province, deriving implications for the need to adjust income generating activities.

Keywords: Cambodia, fishing, food security

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Submarine Groundwater Discharge as Invisible Connection Between Land and Sea: First Results from Indonesia

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The term submarine groundwater discharge (SGD) describes all water that enters the sea through the seafloor. Although the largest proportion of SGD is recirculated seawater, freshwater SGD can constitute a major pathway that connects the terrestrial and the marine realm. Tropical regions are characterized by high anthropogenic pressure and heavy rainfalls. On tropical islands, SGD can be a relevant source of nutrients and pollutants to sometimes very sensitive coastal ecosystems. However, only little is known about the amount of SGD, its constituents, and their impact on marine ecosystems around tropical islands.

We analyse SGD from Indonesia and its impacts on the surrounding coastal ecosystems. Here, we present first results regarding locations and nutrient content of SGD from different Indonesian Islands. We used conductivity and visual identification to locate SGD sites around Java and other islands. In Java, SGD locations are abundant; we found obvious and large sites, e.g. at the beaches south of Yogyakarta, which are even used for freshwater supply of the local people, by asking locals. Smaller, unknown sites were identified visually during a reconnaissance field campaign, whose results we present. At some locations elevated nutrient levels were identified within the groundwater which might force eutrophication within the coastal regions of Java. In the future, we will use the identified locations for a more detailed study to understand the controls and impact of the SGD on the Indonesian Archipelago.

Keywords: Indonesia, nutrient, submarine groundwater discharge

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Production of Freshwater Mussels with Nile Tilapia in an Integrated Multi-Trophic Aquaculture (IMTA) System

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Improved management and technological innovation in African tilapia farms and hatcheries (ITACA) is a project implemented by the National Institute of Oceanography and Fisheries (NIOF, Egypt, coordinator), the Institut Sénégalaise de Recherche Agricole – Centre de Recherches Oceanographiques de Dakar-Thiaroye (ISRA-CRODT, Senegal, partner) and the Institut de Recerca i Tecnologia Agroalimentaries (IRTA, Spain, partner). The action was grant under the African Union Research Grants programme 2012, which is financed by the Financing Agreement between the European Commission and the ACP Group of States (Agreement No REG/FED/2009/021/-575) under the ACP Research for Sustainable Development Program RPR/011/09, of the 10th EDF Intra-ACP Envelop. The ITACA project, which has an overall duration of 36 months, aims to enhance the sustainability of African tilapia farms and hatcheries through improved management and technological innovation. The present study aims to investigate the potential utilisation of Nile tilapia feed waste by freshwater mussels, Aspatharia chaiziana cultured in an integrated multi-trophic aquaculture (IMTA) system, if co-cultured freshwater mussels enhanced their IMTA system and evaluate the physical properties of several cooked processing forms of freshwater mussels. The results showed that the combination of Nile tilapia with thin-lipped grey mullet and prawn as detritivorous fish, increases dietary nitrogen (N) and phosphorous (P) utilisation efficiency to 17.49 and 24.44 %, respectively. By added freshwater mussels in the system as herbivore consumption, increased dietary efficiency of N and P by 12.67 and 19.89 %, respectively. Finally, dietary N and P efficiency increased by addition hydroponic systems (HS) by 35.76 and 44.31 %, respectively. Metals bioaccumulation in the flesh mussels did not exceed the permissible limits set for heavy metals. Concerning the effect of applied cooking methods (boiled, fried, steaming and France sauce), on mussels values of Trimethylamine-nitrogen (TMA-N), total volatile basic nitrogen (TVB-N) and thiobarbituric acid (TBA) were decreased. The odor and tenderness of the boiled and steaming mussel samples received a lower score than other cooked methods. This result indicates that IMTA system is not only a successful method for biomass production as food crops, but also a useful system to recycle aquaculture wastewater and it is applicable to desert, rural and urban area.

Keywords: Burning, maize, relay cropping, residues, rice bean

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