

# Tropentag 2010

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

## **World food system - A contribution from Europe**

### Book of abstracts

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# Preface

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. Since 1999, it is convened alternately by a number of German universities engaged in agriculture and forestry in tropical countries in co-operation with the Council for Tropical and Subtropical Agricultural Research for Development (ATSAF e.V.) and the GTZ Advisory Service on Agricultural Research for Development. This year, for the first time in its history, the TROPENTAG will be held outside of Germany – at the ETH Zurich in Switzerland. Since quite some years, members of the North-South Centre of the ETH Zurich have been regular participants of the TROPENTAG, leading to this adventurous experience of moving the three-day conference to a new national and cultural environment.

The TROPENTAG provides an international platform for scientific and personal exchange for students, junior and senior scientists, development experts and funding organisations together with their various international partner institutions. The increasing international interest in the TROPENTAG of a large and still growing audience – some 1200 participants from 82 countries have registered so far – demonstrates its importance on the agenda of both, the development-oriented scientific community and the implementing development organisations.

The TROPENTAG 2010, organised by the North-South Centre of the ETH Zurich, will shed light on the conference theme “World food system – A contribution from Europe”.

The world food system encompasses all the natural resources required for, and affected by the production, distribution and consumption of food. This also includes resource management and food processing. The world food system provides the foundation for the nutrition of humankind and includes all related ecological, economic, health and social aspects.

The global population faces many challenging problems, among them population growth, food, water and energy scarcity, climate and land use change, as well as threats to human health. All these problems are interrelated and most are also connected to the world food system. Food production under changing climatic conditions

will become even more difficult as human population grows, natural resources such as soils and water become increasingly depleted, and global markets set diverging priorities such as agriculture versus bioenergy. By providing relevant information and advice, scientific knowledge supports policy-makers and society in implementing strategies that address and solve these problems.

The TROPENTAG 2010 will address these enormous challenges in a development-oriented and interdisciplinary manner. To broaden the accessibility of the results of this venue, the abstracts of all contributions are published both as hardcopy and at [www.tropentag.de](http://www.tropentag.de). In addition, student reporters will contribute to a multi-author blog with text and visual content in order to increase the outreach of the conference.

We would like to express our sincere gratefulness to Eric Tielkes, DITSL Witzenhäusen, who handled the registration, the book of abstracts and many more issues. Our very special thanks go to the team of the North-South Centre who organised the conference in Zurich: Mathias Egloff, Emma Lindberg, Dorota Niedzwiecka, Ursula Gugger Suter and Lukas Egetemayer. Our thanks include all the reviewers and additional contributors who have made this conference possible.

We wish all participants a most interesting and rewarding conference.

For the programme committee and the organising committee  
of the TROPENTAG 2010

Michael Kreuzer and Barbara Becker

Zurich, August 2010

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# Food security and food quality

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# Food production

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## Modelling Impact of Climate Change on Agricultural Food Production in sub-Saharan Africa and Measures of Mitigation

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Several recently published studies have shown that climate change will very likely have a significant impact on the global agricultural production. While an increase in agricultural yields is expected in temperate zones, crop yields are supposed to decrease even further from already low levels in (sub-)tropic and (semi-)arid regions of sub-Saharan Africa. Our study makes use of a regionalised large-scale crop growth model based on the GIS-Environmental Productivity Integrated Climate (GEPIC) model. The regionalisation can provide more precise estimations of future yield change than global models with very general parameter setups. For this, global soil data will be adapted to more realistic conditions and local agricultural practice will be taken into account as far as possible. A global circulation model (GCM) ensemble consisting of 4–5 GCMs will be applied to assess the likeliness of decreases and increases in yields.

Preliminary results from the model without regionalisation have shown that yields of the staple foods maize, wheat, and rice will be affected to different extents. For maize an increase in yields can be expected along the east African coast, southern Africa, and the Gulf of Guinea. This can be attributed to the heat tolerance of the crop, increasing CO<sub>2</sub> concentrations in the atmosphere, and local increases in precipitation. In the Sahel zone and Central Africa, losses are very likely, though. Wheat and rice will mostly be negatively affected, while the most severe losses can be expected for wheat in the Sahel countries.

Besides the sole assessment of climate change impact on agricultural production, different strategies for climate change mitigation will also be tested using the same model. Thereby, investment intensive technologies like irrigation and industrial fertilisers will be compared with low-cost techniques like rain water harvesting and ecologic sanitation. Also crop suitability under current and future environmental conditions will be an objective of the study.

**Keywords:** Climate change mitigation, crop growth modelling, food security, GEPIC

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## Securing Food Supply by Adapting Millet Growing to Climate Variability: Decision Making Rules of Fulani Agro-pastoralists in Mopti Region, Mali

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Climate data show that the Sahel region and its neighbouring regions are exposed to reduction of precipitation and an increase of climate variability that might result from climate change. In the Mopti region, former pastoralists of the Fulani ethnic group have settled after the severe droughts in the 80<sup>th</sup> of last century. Besides livestock keeping, they increasingly depend on crop production. In both production lines, they have to cope with a high climate variability that is characteristic for this region and have developed strategies to manage their production system in this environment. The study examines production strategies of Fulani agro-pastoralists and their ways of adaptation to climate variability. Four villages in two different ecological zones (Séno and Niger delta) were chosen in order to study the production strategies of the Fulani agro-pastoralists. Data collection had a focus on qualitative methods. The research team lived for two weeks in each of the villages and conducted seasonal calendars (n=8), pairwise ranking (n=2) and open in-depth interviews (n=12). All data collection sessions were recorded with a voice recorder. The interviews were transcribed. The data were first analysed using content analysis. The information provided on management was analysed using a cybernetic analysis tool.

Decision making rules could be identified, including routine action rules, problem solving rules and selection rules. This is shown using the example of sowing millet. The producers make their decisions which variety to sow when and where according to rainfall patterns, soil characteristics, crop rotation schemes, cereal stock, labour and plough availability, and other environmental and individual factors. Problems frequently encountered are interruption of rainfall, high spatial fluctuations in precipitation, and fluctuations in the duration of rainfall which causes high variability in the length of the vegetation period. The results show high flexibility and complexity in management decisions taken by the agro-pastoralist producers. It can be shown that the agro-pastoralists perform their production strategies in order to balance between the objectives of achieving high yields, secure yields and sustain soil fertility.

**Keywords:** Adaptation, agro-pastoralists, climate variability, food security, Fulani, Mali, millet, Mopti, Peulh, risk management

## Measuring Water Footprints in Dairy Farms Worldwide: Implications for Food Security

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The increasing trend of worldwide water availability risk issues in dairying are becoming burgeoning important. In 2050, water availability is expected to decrease by 19–35 % due to climatic change and by 67 % due to the expanding population. The water crisis around the world is a potential threat toward achieving a Millennium Development Goal to cut the hunger people to a half in 2015. In order to ensure food security, it is necessary to ensure the optimum use of water in dairying. Measuring water footprint might be the option for efficient water use in dairying. So far, there is very little effort made in the calculation of water footprint for dairy production. The aim of this study is to develop a method for calculating water footprint in dairying worldwide.

The TIPI-CAL (Technology Impact Policy Impact Calculations model) of the International Farm Comparison Network (IFCN) was used to collect data and calculate variables of water footprint. The method was tested on 12 typical dairy farms from six developed countries: Switzerland, Germany, Spain, Canada, USA and New Zealand and six developing countries: Bangladesh, Pakistan, China, Jordan, Czech Republic and Argentina.

The results show that the milk yield per day varies between 2.6 kg in Bangladesh to 34 kg in USA. The cows have the highest water requirement during lactation period. Cows in Bangladesh use 66 % of their total requirement during lactation period compared to 97 % in Jordan. The water use during dry period for Bangladesh was the highest (33 %) due to very long dry period. The water input per kg milk production varies from 430 liters in USA to 2400 liters in Pakistan. The water used for drinking and washing was 3.5 liters and 56.0 liters for Germany and Pakistan.

The study shows that feed production is the major driver for water use on dairy farms. The greatest challenges were in obtaining coefficients on water input for feed production and water usage in dairy farms. The accurate measurement of water use in dairying can be a step towards achieving more efficient water use which will augment food production and thus ensure food security.

**Keywords:** Dairying, food security, water footprints

## **The Sustainability of Bushmeat Hunting in Central Gabon and the Implications for Local Food Security**

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Bushmeat hunting, the hunting of wildlife for human consumption, is an activity integral to many rural forest communities throughout the humid tropics, often providing a high proportion of household income and protein requirements. However, bushmeat hunting is also considered a major threat to the persistence of biodiversity in tropical forests: in Central Africa alone annual wildlife harvest is estimated to be 1 to 3.4 million tonnes. This raises concern about the survival of hunted species, ecosystem functioning and thus, the future food security of rural communities, especially in the face of expanding human populations and decreasing habitat availability.

Hence, assessing the sustainability of current hunting levels is key to species conservation and people's livelihoods. Unsustainable wildlife harvesting has widely been reported in the literature. However, given the paucity of available biological data and the difficulty in collecting such data, previous sustainability assessments have been based either on (i) models incorporating highly simplistic sustainability indices or (ii) snapshots in time of levels of wildlife offtake. An assessment of sustainability instead requires empirical research on whether and how hunted population levels and/or offtake change over time.

This study therefore investigates bushmeat hunting through interviews and hunter follows in two villages in central Gabon in 2004 and 2010, in particular reporting on the spatial distribution and characteristics of bushmeat catches over time and their contribution to household food intake and income. This talk will outline (i) whether key ecological and socio-economic changes related to hunting took place in the two Gabonese villages during the study period and (ii) the implications for bushmeat hunting sustainability and local food security.

**Keywords:** Bushmeat, Central Africa, food security, Gabon, hunting, livelihoods

## The Influence of Serially Correlated Shocks on the Conservation of Fish Stocks under Open Access Harvesting

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Renewable resources like fish stocks randomly fluctuate due to the influence of unpredictable environmental variability. Random environmental events can have consequences on the livelihood of fishing communities. Considering that with climate change severe weather events are expected to become more frequent, studying how disturbances affect the dynamics of a natural resource like fish stocks is particularly important. Standard models of renewable resource allocation under uncertainty typically assume that environmental disturbances are identically and independently distributed. When weather patterns impact environmental conditions, shocks may be serially correlated. This serial correlation has implications for the long run conservation of harvested renewable resources. This paper investigates the dynamics of a harvested, open-access renewable resource whose productivity is influenced by serially correlated random environmental disturbances. The main question addressed in the paper is: how does the expected value of stock escapement depend on the parameters that determine the distribution of environmental shocks? In answering this question I also characterise how the maximum and minimum escapement policy functions depend on these parameters. An application of the conceptual framework to the American lobster fishery of Long Island Sound is used to address these issues qualitatively and quantitatively. In the application, the model is parameterised using an econometric model of population dynamics for the Long Island Sound lobster fishery. In this application shocks are negative correlated and transient so a high current productivity shock decreases the probability of high future shocks. The results suggest that conservation is promoted by increases in both the autocorrelation of the random shocks, as well as the variance of the uncorrelated error term. The conclusions provide useful information regarding how serial correlation in environmental disturbances impacts the conservation of open-access renewable resources.

**Keywords:** Autocorrelated shocks, bioeconomic model, open access

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## Adaptation of Livestock Farming to Spatiotemporal Variability in Semi-arid Rangelands: An Ecological-economic Modelling Approach

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Arid and semi-arid rangelands are characterised by highly uncertain and variable climatic conditions. This poses the major challenge to extensive livestock farming that is the predominant form of utilisation in these areas and provides food and livelihood for millions of people. Hence, the need for well adapted grazing strategies is especially high to enable an effective risk management. However, there exist several contradictory management approaches that differ in their level of complexity and flexibility, *e.g.* in their consideration of spatial variability.

In this paper we analyse how to adapt semi-arid grazing systems to spatial and temporal variability in ecosystem conditions. In particular, we evaluate the viability of different management options, and their response to fluctuating climatic conditions. We study the importance of space in management decisions and figure out how it should be incorporated into the management approach.

To this end, we use a generic simulation model that consists of a physiologically well-founded vegetation model combined with a rule-based model for the livestock management. The vegetation is represented by a perennial grass species, described by storage biomass (the 'vigour' of the plant) and aboveground biomass, which provides forage for the livestock. Vegetation growth rates increase with precipitation, which underlies stochastic fluctuations due to temporal heterogeneity of the rainfall. Furthermore, the state of the vegetation is negatively affected by livestock grazing. Therefore, the way a farmer manages his livestock has a direct feedback to the ecosystem providing his livelihood. The characteristics of a management strategy include the rules of herd rotation, and the stocking rate.

This study shows that adaptive stocking rates are less sensitive to overstocking compared to a constant stocking strategy. Furthermore, the spatial element of the grazing strategy becomes important at optimal stocking numbers, where the highest income is generated. Altogether, an adaptive stocking rate combined with a rotation that adapts the spatial fodder availability and seasonality is the best tested strategy to maximise the mean income while maintaining a viable rangeland condition. We conclude that adaptivity is a powerful instrument for management improvement and risk mitigation, if all important system properties are considered in the management approach.

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**Keywords:** Livestock production, modelling, semi-arid rangelands

## Use of Geographical Information Systems and Crop Simulator Models for Agriculture

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Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. According to previous studies, there will be an increase in the mean temperature in many regions in the world, and this will further affect other factors like rainfall and evapotranspiration, impacting agricultural productivity. The La Plata basin is located in South America and plays a very important role in local food security and world's food system supply. This region experienced an increase of 20 % to 30 % in annual precipitation during the last decades, creating favourable conditions to a huge expansion of agriculture, and several studies present a tendency of increase in precipitation during the next decades. However, while agriculture may benefit from a warmer climate and more precipitation, the increased potential of extreme events will pose challenges for farmers. Another very important issue is that the expected continuous increase in annual precipitation may not be compensated by increase in evapotranspiration.

In order to analyse the possible impacts of new climatic conditions, current cropping systems of major economic relevance for La Plata basin – corn, soybeans and wheat – will be studied and simulated with models using synthetic future climate scenarios. These models, combined in software packages like DSSAT and SUR, will couple information related to chemical and physical characteristics of soils, local past climate data such as radiation, precipitation and temperature, and phenological and genetic information of crops and management of systems. After simulation, calibration and validation of the performance of crops in current conditions, other simulations will be run with climate change forcing scenarios. As a result, the probabilities of crop performance in future scenarios will be interpolated on regional maps. This was already done for the North part of Buenos Aires Province using actual climate conditions, and will further be extrapolated to other regions of the La Plata basin and with future climate scenarios. Key features of this work are the possibility of simulating the effect of different environmental conditions, as well as to assess and compare the performance of different crops species, varieties and agricultural management strategies in La Plata basin.

**Keywords:** Agriculture, climate change, climate variability, crop modelling

## Quantify the Impact of Climate Change on Mesoamerican Coffee Farmers Livelihoods and Develop Community-based Adaptation Strategies

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According to the fourth Intergovernmental Panel on Climate Change (IPCC) report is Mesoamerica one of the regions that will suffer severe impacts from a progressively changing climate. Coffee production is the mainstay of thousands of families and the major contributor to the agricultural GDP of these countries. As a result of climate change, traditional coffee growing regions will decrease drastically. A significant number of farmers will not be able to produce coffee in the future anymore; others will be producing coffee in marginal areas and be confronted with decreased coffee quality and increased pest and disease pressure.

Using the A2a emission scenario (business as usual) and twenty downscaled Global Circulation Models (GCM) in combination with Maxent, a general-purpose method for making predictions or inferences from incomplete information, and the crop-niche suitability model Ecocrop, we map the change in suitability of coffee in Mesoamerica and the change in suitability of the most important diversification crops for coffee farmers. Combining the spatial modelling with participatory impact assessment approaches we appraise the vulnerability of coffee farmers livelihoods and quantify the impact of the changing climate on socio-economic indicators. Finally we develop community based adaptation strategies according to the level of vulnerability and the capacity of communities to adapt to climate change.

The analysis shows that the vulnerability to climate change varies a great deal depending on the geographical location, natural resource management practices, education, level of community development and diversity of household income. We propose concrete adaptation strategies for different vulnerability profiles and draw general applicable conclusion to inform policy makers at regional and national level.

**Keywords:** Adaptation strategies, climate change, coffee, vulnerability

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## Using Soil-Vegetation-Atmosphere Models and Downscaled Global Climate Scenarios to Assess the Impact of Climate Change in Morogoro Region, Tanzania

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ReACCT (Resilient Agro-landscapes to Climate Change in Tanzania) aims at assessing the regional impacts of climate change on agriculture and environment in the Morogoro region of Tanzania and at designing adaptation strategies and practices for small-scale agriculture and land use.

The sub-project crop-soil modelling concentrates on model based estimations of climate change impacts on current land use systems and practices. At three research sites, distributed over the project region and with distinct climates, field trials are conducted to assess the yield potential of widely-used maize and sorghum varieties. The data obtained from the study are used to calibrate multiple soil-vegetation-atmosphere models ranging from rather simple to process-oriented models, which are able to simulate the bio-geophysical interactions between climate, soil and vegetation. These models are sensitive to changes concerning soil hydrology, nutrient cycling, and crop response to assess combined climate change and management effects on crop production, water resources and soil fertility. Combined with downscaled global climate scenarios, these models evaluate the best management practices for future climatic conditions. In another approach tested at sites at the Sokoine University in Morogoro the effects of including trees into the farming systems are investigated. Here the maize and sorghum varieties taken into account are cultivated at one site under standard conditions, whereas at the second site the plants are shaded by native *Acacia* trees. The effects of the shading on growth and development are measured *in situ* as well as the water use of trees and crops to quantify water competition between the plants. The interrelationship of these processes is modelled using the Water, Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS) model, which has been developed at the World Agroforestry Centre.

**Keywords:** Adaptation, agroforestry, climate change, crop modelling, global climate scenarios, Tanzania

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## **Vulnerability of Rural Small-scale Producers in the Brazilian Amazon: Priorities and Research Needs for Climate Change Adaptation Planning**

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The Brazilian Amazon, 60 % of the national territory, accounts for only 8% of Brazil's GDP. Still, the region's main rural economy sectors: agriculture, fisheries and extractivism contribute about EUR 12 billion annually to the national economy. According to recently published Agricultural Census data, 72 % of the almost 800 thousand rural producers in the Brazilian Amazon can be considered small-scale. Research suggests that extreme weather events, such as seasonal droughts or excessive rainfall and related effects on forest fire and river flood susceptibility, are likely to occur more frequently in the Amazon as a result of climate change.

Most studies emphasize the potentially significant impacts of climate change on local livelihoods, based on macro-level assessments of exposition to climate risks. Very few studies have, however, scrutinized the other two components of vulnerability, namely sensitivity and adaptive capacity, which often depend on specific local contexts. Based on results from an ongoing research project, this paper thus attempts to provide preliminary answers to the following interrelated questions: Which factors matter most in determining small-scale producer's vulnerability in the Amazon? If action is needed, what are the priorities and major knowledge gaps for the design of effective adaptation measures? We use stochastic cost-benefit analyses and regression techniques based on field data from a case study in the Baixo Amazonas region to determine the relative importance of climate and non-climate risks in smallholder production systems. New Agricultural Census data in combination with meteorological and spatial information on human activities in the region is used to evaluate the relevance of case study findings at the regional scale. We find that smallholder vulnerability is influenced by (1) spatial and temporal variability in exposure to climate risk, (2) locally highly specific variations in sensitivity to such risks, *e.g.* the diversification of local economies and resource quality, and (3) variations in adaptive capacity due to access to supporting public services, awareness, and cultural background of the members of rural communities. Finally, we discuss the implications of our findings for national and local climate policy and development cooperation.

**Keywords:** Climate risk, production systems, smallholder

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## Climate Change, Genetics of Adaptation and Livestock Production in Low-input Systems

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The harsh effect of a changing climate is expected to have maximum impact on vulnerable pastoral communities engaged in extensive livestock production systems in drylands. Questions arise concerning options and strategies for reducing vulnerability and building resilience among these communities. The design of intervention measures for climate change (CC) adaptation for these communities, to be effective, has to be hinged on comprehensive knowledge of the overall structure and dynamics of these production systems, including key information about traditional breeding strategies, indigenous knowledge systems relating to animal adaptation and management in climate-sensitive drylands. This presentation discusses some crucial preliminary steps as part of a conceptual framework for getting the perspective of herders on animal characteristics related to adaptation to harsh environments. The approach embraces a participatory action process involving herd owners as project partners. Data capture involves the use of structured questionnaires complemented with focus-group discussion and key-informant interviews, with a focus on herders' perspective on animal characteristics related to adaptedness to harsh climates. Pertinent information from pastoralists include listing and ranking of key traits (*e.g.* qualitative, morphological, fitness and functional characters) in relation to animal adaptation and survival in highly unpredictable environments, climate oscillation and its effect on herd dynamics, vulnerability and adaptability ranking of different livestock under extreme climatic conditions, livestock adaptive characteristics, as well as indigenous practices related to stock selection and management in arid lands. Other records include proxy-indicator variables for animal adaptive traits, dam progeny histories, complemented with comprehensive production environment descriptors. Detailed statistical analysis of herders' responses, as well as qualitative and quantitative data relating to animal morphology, adaptive and performance-related characteristics, involving exploratory principal component, factor, discriminant and correspondence analyses are discussed. Inferences generated will provide crucial baseline information needed for the design of sustainable breeding strategies for extensive livestock production systems in drylands, in the face of a changing climate.

**Keywords:** Adaptive traits, climate change, drylands, low-input systems

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## **Farmers' Perceptions and Adaptation to Climate Change: A Case Study in Sekyedumase District of Ashanti Region, Ghana**

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Climate change is expected to have serious environmental, economic, and social impacts on Ghana, particularly on rural farmers whose livelihoods depend largely on rainfall. The extent of these impacts depends largely on awareness and the level of adaptation in response to climate change and variability. This study examines whether farmers in Sekyedumase district of Ashanti region of Ghana perceive climate change and analyses farmers' adaptation responses to climate change and variability. A hundred and eighty farming household were interviewed in February and October 2009. Results showed that about 92 percent of the respondents perceived increases in temperature while 87 percent perceived decrease in precipitation over the years. The major adaptation strategies identified included crop diversification, planting of short season varieties, change in crops species, shift of planting date, reduction in farm size, among others. Results of logit regression analysis indicated that the level of education, gender, age, soil fertility, education, farm size, farming experience, land tenure, access to extension services and credit, all influence farmers perception and adaptation. The main barriers included lack of information on adaptation strategies, poverty, lack of technology and lack of information about weather. It is concluded that the communities have a high awareness of climate issues, but only 44.4 percent of farmers have adjusted their farming practices to reduce the impacts of increasing temperature and 40.6 percent to decreasing precipitation, giving poverty as the main barrier to adaptation. Implications for policymaking will be to make credit facilities more flexible, to invest in education of extension officers and more education on climate change and the possible adaptation strategies.

**Keywords:** Adaptation, climate change, perception, precipitation, temperature



## Potential of Smallholder Farmers in Mau Forest, Kenya to Adopt Land Use Based Clean Development for Climate Change Mitigation

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Land use change linked to climate change could be the cause of drought and food shortages in Kenya in the last decade. Smallholder farmers around Mau forest-Kenya's biggest water tower; compensate for the declining land productivity by opening new agricultural sites in the forest reserve. Reforestation efforts so far have not adequately integrated onfarm practices with the forest management leaving the riparian farmers with no incentives to avoid deforestation. The community Based Integrated Forest Resource Management (COMIFORM) project coordinated by the UNEP Nairobi, Kenya through which this study was undertaken targets carbon offset scheme to integrate farmers livelihood needs, forest restoration and climate change mitigation and adaptation. To provide a scientific basis for such initiative we attempted to establish the potential of the smallholder farmers in Maasai Mau catchment (MMC); part of the wider Mau complex to participate in the voluntary land use carbon offset (LU-Co) scheme. We identified present land use types and allocations in thirty (30) representative plots of size 2-6 ha located in 3 socio-ecologically representative administrative locations of the MMC. We then measured aboveground carbon stored in each using the multipurpose survey technique recommended by IPCC greenhouse gas inventory and Winrock-bio-carbon guidelines. Based on the guidelines, diameter at breast height (D) was measured for all the tree species of various age-sets in a plot. The tropical (East Africa) based regression equation;  $Y(\text{Biomass}) = 42.69 - 12.800(D) + 1.242(D^2)$  was applied to calculate the biomass as a baseline. Herbaceous samples mainly from the croplands in each farm were oven dried at 70°C and weighed at the National Agricultural Research Laboratories in Nairobi, Kenya. Using the carbon baseline, a conjoint valuation was undertaken with the same farmers plus 20 others (50 cases in total) who were asked to choose and rank hypothetical land use and policy options that make up a carbon offset scheme to model carbon offset scenario. Results show that smallholder farmers in MMC allocate an average of 52 % of farmland to food crops and 19.5 % for cash crop (wheat) and the rest left for grazing with scattered indigenous trees left from initial forest cover. Based on ranking correlation, farmlevel aboveground carbon varied more with land use type ( $p^{**} = 0.05$ ) than area allocated. Carbon amounts ranged from highest (40.5 tC ha<sup>-1</sup>) in onfarm forest to lowest (10.2 tC ha<sup>-1</sup>) in annual croplands. Results of conjoint analysis shows that size of land to be committed for a carbon offset project, waiting period for the benefits

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and certainty of livelihood were the strongest determinant of farmers acceptance for LU-Co options (each at  $p^{***} = 0.01$ ). Based on prospective carbon scenarios derived from the baseline and farmers choices in the conjoint analysis, a high potential for carbon offsetting by individual farmers in MMC can be reported. The potential can be enhanced by technical support of the farmers on land use designs that incorporate onfarm forestry as part of cash crop for carbon sales promoted through creating awareness on LU-Co and the co-benefits.

**Keywords:** Acceptance, carbon offsetting, farm-level, livelihood, mitigation

## An Exploratory Climate Time Series Analysis in Mercedes, Argentina

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The Corrientes Province grasslands constitute a major alternative for Pampas' meat production. Besides, Mercedes Department represents the major livestock production region of this Province. Several works have shown that climate can influence the net primary production. Therefore, on a climate change scenario, to know the climate trends is a key when looking for adaptive responses by grassland/livestock production systems.

In this work, climate linear trends of observational data at Mercedes Experimental Station were analyzed. Our study considered a 29-year period (1981–2009) divided in periods of 10 years, in relation to the long term normal (1961–1990). Due to lack data, potential evapotranspiration (ETP) was calculated only for the 1994–2009 series, according to Thornthwaite, Turc and Hargreaves methods. The resulting trends indicated fluctuations in mean temperature considering the long term. However, if short time series of 10 years are considered, the first time period saw an increase of 0.3°C, followed by a decrease of 0.4°C during the next 10 year period and finally an increase of 0.5°C mean temperature in the last decade. Monthly mean temperature showed a similar trend. The observed climate data revealed slight decreases in the annual precipitation when the long term time series was considered (especially in spring and summer), but a decrease higher than 100 mm during the last 10 years period, which was also characterised by a decrease in the number of rainfall days “El Niño” events were frequent during the first and the second time series, while in the last one, only two light events occurred. ETP analysis showed a small increase independent of the considered calculation method ( $r^2=0.36$ ;  $r^2=0.05$  and  $r^2=0.11$ ), especially in spring and summer 2001–2009 period. This work presents a more realistic appraisal of climate variations in Mercedes, Corrientes–Argentina, as a first step for future research considerations on adaptation strategies.

**Keywords:** Adaptive responses, climate change, evapotranspiration, grassland ecosystems, Province of Corrientes

## The Potential of Medium-resolution Satellite Imagery to Estimate Regional Yields of Cotton, Wheat and Rice in Irrigated Cropping Systems in Uzbekistan

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Regional crop growth monitoring and yield estimation continuously gain in importance, especially with regard to climate change and food security issues. Remote sensing data combined with light-use efficiency (LUE) models based on the fraction of photosynthetic active radiation (FPAR), have a great potential to monitor regional plant growth. The objective of this study was to develop and evaluate a satellite-driven LUE model using 250 m MODIS (Moderate Resolution Imaging Spectroradiometer) data to predict regional yields of cotton, wheat and rice in the Khorezm province, Uzbekistan.

For this purpose, freely available 16-day FPAR data from MODIS was processed for the years 2000–2009. Meteorological data and photosynthetic active radiation (PAR) were taken from a weather station and modelling results, respectively. A satellite-derived land use classification was used to distinguish between crops. Actual crop light-use efficiency was calculated via daily weather data and crop-specific maximum LUE. FPAR, PAR and actual LUE were used to calculate daily biomass accumulation. Crop yields were then estimated by multiplying total biomass with species-specific harvest indices. The estimated yields were evaluated against field and secondary data. Our results suggest the MODIS-driven model can accurately estimate regional crop biomass production and yield. The observed yield trends in official statistics were generally captured by the model. Moreover, calculation of multi-year average yields allows detecting seasonal over- or underperformance of crops in terms of biomass production and yield. Problems exist with the calculation of actual regional yield amounts because of the discrete nature of the land use classification. The possibility of identifying underperforming areas demonstrates the potential for planning purposes and early warning systems.

**Keywords:** FPAR, irrigated croplands, light-use efficiency, MODIS, remote sensing, Uzbekistan

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## Food Security Versus Water Security: A Policy Related Study about Iran

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The Iranian government puts strong emphasis on the strategy of food security and in that context aims to reach self sufficiency in wheat production. This strategy is due to the daily growing population and the increase in demand-to-production capacity relation, as well as the political desire to be independent from other countries food supply.

The constitution of the Islamic Republic of Iran, macro policies and general development programs strongly emphasise, directly and implicitly, food security. To reach wheat self-sufficiency level the government concentrates on wheat production increase strategies. Therefore, the Iranian government in particular intervenes into wheat production and wheat marketing by a policy of guaranteed minimum prices, exchange rate interventions, product insurances against natural hazards, tariff protection, input subsidies, output subsidies and cheap credit.

Over the last years, the Government has especially powered the policy of guaranteed purchase price. Higher wheat prices should motivate farmers to increase wheat production level. Wheat production increase pressure on the ground-water resources especially in arid and semi-arid areas. This pressure is eroding the long term sustainability of water resources and water security.

This paper studies the sustainability of wheat self-sufficiency and water related policies at macro level. It focuses on the constitution, macro policies and general development programs and plans of Iran. It presents the Iranian government plans and laws regarding food security and food self-sufficiency policies on one hand, and the water related policies on the other hand, using a literature review as well as secondary data, collected from governmental organisations of Iran. Evaluation of the collected data is based on Revealed Preferences Approach. Share of the governmental budget allocated for each policy is used, as an indicator, to weight the importance and priority of the related policy.

**Keywords:** Food self-sufficiency, sustainability, water resources, wheat

## **Adaptation of the CROPGRO Growth Model to Chinese Cabbage (*Brassica campestris* spp. *pekinensis* (Louv.) Rupr.)**

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Chinese cabbage (*Brassica campestris* spp. *pekinensis* (Louv.) Rupr.) is a major vegetable crop of East Asia, which has special nutritional value as source of vitamin C in many rural regions during winter months. However, its production is often characterised by unbalanced use of fertiliser and irrigation, which negatively contributes to ongoing resource degradation. Process based simulation models can help to enhance agricultural production by facilitating the assessment of management strategies for different environments, soils and production systems. The CROPGRO model, which was initially developed for soybean (*Glycine max* (L.) Merr.) is a generic model that is also employed to simulate growth and development of various vegetable crops like tomato, bell pepper and cabbage. For the adaptation of CROPGRO to Chinese cabbage basic growth parameters and temperature response data were obtained in a series of greenhouse and climate chamber experiments. Based on the results the phenological parameters in the species file were adjusted, as well as the parameters determining vegetative partitioning in leaf, stem and root compartments. Additionally, canopy development and leaf growth parameters were modified. Identified as the key trigger to determine final yield was the timing of the onset of head formation, which is the economic tissue in Chinese cabbage. As the phenological development differs between cultivars the demand of thermal and photothermal days to reach a certain phenological stage had to be calibrated for each cultivar in the .CUL file. The model was calibrated and later validated for three cultivars, using two years experimental data from two sites, one in Germany and one in China. The new model, that is going to be incorporated as part of the DSSAT, version 4.5 suite of crop simulation models, has potential to test and evaluate production of Chinese cabbage under various management strategies in different environments.

**Keywords:** Chinese cabbage, CROPGRO, model

## Influence of Mineral and Organic Fertilisers as Source of Nitrogen on the Yield and Mineral Content in Roots of Carrots (*Daucus carota* L.) from Myanmar and Germany

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Use of organic and mineral fertiliser can influence the yield and mineral composition of the harvested crop. In Myanmar, local carrot cultivars are normally grown with organic fertilisers as they are readily available and cheaper than mineral fertilisers. However, higher amounts of mineral nutrients supplied by mineral fertilisers are necessary when the farmer wants to introduce hybrids cultivars. The effect of using mineral fertilisers alone and the combination of organic and mineral fertilisers might vary the nutritional composition of the crop. The present study aim to investigate the yield and mineral composition of local and hybrid carrots supplied by mineral fertiliser alone and combined application of organic and mineral fertilisers.

The pot experiment was performed in winter season 2007 in the green house. A split-plot experimental design was applied with three replications. Both mineral and organic fertilisers were used as a source of nitrogen fertilisers with  $N = 120 \text{ kg ha}^{-1}$ ,  $P_2O_5 = 140 \text{ kg ha}^{-1}$  and  $K_2O = 220 \text{ kg ha}^{-1}$ . In the main plot, three kinds of fertilisers were set: mineral fertiliser (MF), MF + farmyard manure (MF+FYM), and MF + Compost (MF+CM). A common carrot cultivar (cv.) from Myanmar (Srup) and a hybrid cv. from Germany (Flyaway) were used as sub plot factor.

Yield and mineral composition of the carrot cvs. were unaffected by all fertiliser types. However, higher yield potential was observed from combined application of mineral and organic fertilisers. Root N content increased after MF application compared to combined fertiliser application. However, N content in cv. Flyaway applied by MF was the highest. Comparing the cultivars, independent on the fertiliser treatments, the local cv. Srup contained fewer minerals than the hybrid cv. Flyawy. The present data suggest that combined usage of mineral and organic fertilisers could be more efficient than chemical fertiliser alone. Interestingly, hybrid carrot was relatively superior to local carrot in mineral nutrients uptake and for higher yield potential.

**Keywords:** Chemical fertiliser, combined application, hybrid cultivars, local carrot cultivars, organic fertilisers

## **Influence of Nitrogen and Water Availability on Biomass Yield, Water Relations and Leaf Gas Exchange of *Chenopodium quinoa* (Willd.)**

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Global climatic changes already affect crop yield, water relations and nutrient availability. Drought lowers the H<sub>2</sub>O availability in the soil and decreases also the uptake of nutrients such as nitrogen and carbon (in form of CO<sub>2</sub>). Latter one is mainly a consequence of an increased stomatal resistance to reduce the water loss.

Some crops, such as Quinoa (*Chenopodium quinoa* Willd.) are able to withstand drought stress up to an impressing level. Quinoa is a cash crop of the Andean regions of South America. It is cultivated for its balanced nutrient content and moreover for its high acclimation to temperature, drought and atrophy.

The aim of this study was to determine the physiological mechanisms enabling this plant to solve the contradicting demand for photosynthesis activity (CO<sub>2</sub>-uptake) and plant water relations (minimising water loss) at low soil water availability and the impact of N-availability and elevated atmospheric CO<sub>2</sub> concentration (C<sub>a</sub>).

An increase of N availability led to an increased water absorption by lowering the leaf water potential from  $-2.32 \pm 0.16$  MPa to  $-2.93 \pm 0.03$  MPa. However, low H<sub>2</sub>O supply (down to  $12.6 \pm 6.2$  % WC in the soil) led not only to a significant decrease of biomass yield and total-N-content, but to an increase in RuBisCO-, proline- and chlorophyll concentration as well as to an increase of the nitrate reductase activity ( $p < 0.001$ ).

The reduced photosynthesis activity was partially compensated by the above mentioned increase of the RuBisCO content (large sub unit) leading to a high water use efficiency of photosynthesis which could even be enhanced by an elevated C<sub>a</sub> (up to 2000 ppm). Either the increase of N content or of C<sub>a</sub> led to an increased drought tolerance of Quinoa, an increased assimilation rate of photosynthesis and consequently to an increase in biomass yield and carbohydrate content. The drought tolerance and the benefit in biomass yield at elevated C<sub>a</sub> proof the potential of *C. quinoa* to become a suitable crop in times of global climatic changes.

**Keywords:** *Chenopodium quinoa*, drought tolerance, elevated CO<sub>2</sub>, hydrological balance, leaf gas exchange, nitrogen availability



## On the Road to Sustainability? Economic, Environmental and Social Performance of Kenyan Smallholdings from 2006 to 2009

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Sustainable smallholder farming arguably is a cornerstone of sustainable development in large parts of the world, including much of Sub-Saharan Africa. There has been much dispute over whether smallholdings are an asset or an obstacle to economic development and resource protection. Smallholders have been acclaimed for securing food supply and maintaining diverse cultural landscapes, and blamed for inefficient resource use and farm management. We present evidence from farm sustainability surveys conducted in the Laikipia district of Kenya. A sample of 29 smallholder farms was analysed in 2006 and again in 2009 using the RISE (Response-Inducing Sustainability Evaluation) method. Analysed aspects comprised nutrient, water, soil, energy, pest, biodiversity and waste management, as well as farm economics, working conditions and social security.

Major deficits were identified at soil management, water supply, and manure management causing environmental pollution and nutrient depletion on the arable land. Poor revenues compared to the invested assets, for the labour and for the raw performance led to poor inadequate social securities and salaries far below the subsistence level. Lack of knowledge on safe use of chemicals impeded a considerable risk for farmer's health.

From 2006 to 2009 most of the farmers participated in trainings predominantly in domains of conservation agriculture, plant protection and livestock keeping. In five villages demonstration farms were established recently, in order to present possible solutions and to train interested farmers.

The re-evaluation results were stamped by severe droughts in 2008 and 2009 causing recurrent crop failures, loss of livestock and high pressure on natural resources (cutting trees). Most farmers were confronted with competition for biomass between livestock (fodder) and crop production (mulch), making effective soil conservation difficult. Farmers accessing water during critical periods were able to produce crops for subsistence and local market. Smallholder farmers mainly compete with large horticultural farms for water resources.

Our results supported both assertions made in the beginning: smallholders exploited not protected natural resources; on the other hand they were important elements in securing food supply. In contrast to them the large horticultural farms exploit natural resources as well; but their products are consumed in Western-Europe.

**Keywords:** Holistic, Kenya, monitoring, smallholder farming, sustainability

## Does Technology Adoption Reduce Risks for Smallholder Farmers in Cameroon?

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Increasing food production is a major aspect of sustaining livelihoods for a majority of rural African households especially for subsistence, smallholder farmers. In Central and West Africa in particular where population growth has been faster than economic growth, the adoption of new and improved agricultural technologies offers the potential to reduce consumption and income risks for smallholder farmers. Although this position is generally accepted within the literature on agricultural technology adoption, empirical evidence is diverse.

This paper presents the results of a comparative analysis for a random sample of 152 smallholder farmers (60 adopters and 92 non adopters of integrated fish farming technologies) from Cameroon villages. The technology was promoted by a non-governmental organisation, known as the Presbyterian Rural Training Center (PRTC). Primary data collection took place between September 1<sup>st</sup> 2003, and February 15<sup>th</sup> 2004.

Based on an analysis of selected socioeconomic characteristics (such as income and consumption), the results reveal that technology adopters were better-off and less risk averse, compared to the matching sample. This however could not be attributed to the adopted technology, as returns from the new technology made insignificant contributions to household well being. The results indicate a deficiency in targeting the most risk-exposed smallholder farmers. Nevertheless, the enhancement of sustainable natural resource management is clearly significant amongst adopters and could be attributed to the innovation. The paper concludes with the need to identify and involve most risk-exposed households in technology adoption, and to adapt innovative technologies to the specific needs of such households for optimising risk reduction

**Keywords:** Fish farming, risk reduction, smallholder farmers Cameroon, technology adoption

## Crop Diversification and the Technical Efficiency of Smallholder Farms in Nigeria

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The literature not only identifies crop diversification as a stage at which many developing agriculture currently operates, but also suggests that the impact of the diversification phenomenon on the livelihood of agricultural producers and their efficiency appeared mixed. In Nigeria for instance, there is evidence that the majority of farmers embrace a cropping pattern that is characterised by growing a wide variety of crop mixes under multiple cropping systems adapted to various agro-ecological zones across the country. Based on this background, it is important to investigate the development of crop diversification in Nigeria over time and its impact on the efficiency of smallholder farmers in the country. However this study examines the relationship between crop diversification and the technical efficiency of smallholder croppers in Southwestern Nigeria. We employed Herfindahl and Ogive indices to compute the crop diversification indices across the farms while a heteroskedasticity corrected stochastic frontier production model is used to compute the efficiency of the farms. The study used unbalanced panel data covering 3 farming seasons (2006/07 to 2008/09) with a total of 846 observations. The surveyed farm households were observed to have portfolios consisting of a maximum of 5 activities (or enterprises). These activities include: cassava, yam, maize, potatoes, and cocoyam. The result of both the computed Herfindahl and Ogive indices showed that cropping pattern increased significantly with the intensification of crop diversification in the region. Additionally, the results demonstrate evidence of decreasing returns-to-scale and technical progress in food crop production in region. Education, extension, and crop diversification are identified as efficiency increasing policy variables. Furthermore, an average technical efficiency level of about 81 %, which implies that an inefficiency level of about 24 %, is observed from the study. The correlation between the computed technical efficiency and Herfindahl and Ogive indices of crop diversification support the earlier observation that diversification enhances the efficiency of the farmers. This observation however, highlights the potential possibility of crop diversification as a strategy to increase food production/food security in the country as erstwhile in Asia in the 90s.

**Keywords:** Diversification, Nigeria, smallholder, technical efficiency

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# Food quality and technology

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## Application of HACCP Principles to Local Drying Processes of *Capsicum* Species in Bolivia and Perú

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Dried *Capsicum* products have high value in Bolivia and Perú, a centre of origin for *Capsicum*, and represent an opportunity for development in the region. Unfortunately, problems faced in postharvest handling of dried *Capsicum* have not been studied in these countries. Simple drying procedures, mainly open sun drying in the field, are still used due to low cost and easy management. The process is dependent on environmental conditions and final products vary widely in quality as a result, since extended drying times are required to reach the secure limit of moisture content and microbial contamination and development of mycotoxins are common. The production needs a standard and systematic control throughout the whole process in order to avoid losses, guarantee optimum quality and higher value on local and international markets. The aims of the proposed research were to identify and document species, production and uses, describe processing procedures for drying, evaluate drying conditions and practices and apply Hazard Analysis and Critical Control Point (HACCP) principles to identify the critical control points involved in drying processes. The study focused on cultivated species of capsicum in the areas around Chuquisaca, Bolivia and Lima, Perú under the guidance of local partners.

Farmer interviews were conducted to obtain information about current postharvest handling practices. In addition, drying procedures were evaluated at several sites. Parameters were documented, including drying conditions and behaviour of the product by placing climate sensors in the drying bulks and sampling and analysing the product at significant processing points. Based on this data, HACCP principles were applied, namely: product description, identification of intended uses, construction and confirmation of flow diagrams, list potential hazards, hazard analysis and consideration of control measures, establishment of critical control points based on Codex Alimentarius and establishment of critical limits. Recommendations are given as a baseline for the complete implementation HACCP standards corresponding to the monitoring of the production chain to ensure food safety. Corrective actions can now be implemented via verification procedures and documentation and record keeping will allow realisation of HACCP quality assurance for the production of dried *Capsicum* in Bolivia and Perú.

**Keywords:** *Capsicum*, codex alimentarius, drying, food safety, HACCP, South America

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## **Complimentary Feeding Practices and Nutrient Intake of Children Aged 6–18 Month in Ebonyi State, South East Nigeria**

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Ebonyi State is one of the states in Nigeria. It is largely an agrarian State with less than 50 % literacy level. The nutritional status of the indigenes especially the women are attracted by their low income levels, cultural beliefs and food habits. Complementary feeding is the process of introducing other foods in addition to breast milk. Timely introduction of appropriate complimentary foods have been found to promote good health, nutritional status and growth of infants and young children during a period of rapid growth. Low quality complimentary foods combined with inappropriate feeding practices put under- twos in developing countries like Nigeria at high risk of malnutrition and its associated out-comes. A descriptive and exploratory study was hereby carried out to investigate the complimentary feeding practices used on infants of between the ages of 6–18 months in Ebonyi State Nigeria. Three hundred mothers (300) with infants attending immunisation centre in hospitals and health centres were used in the study. Validated questionnaires were used to collect data. Dietary home observations of some selected infants were carried out. It was observed from the study that 97.4 % of the mothers breast fed their children while 2.7 % never breast-fed their children. 25 % mothers started solid foods before 4 months, 49.7 % between the ages of 4–6 months, 19.3 % at the age of 7–9, 2 % 10–12 months and 1 % after 12 months. Most mothers breastfed their children at will or when the baby signaled. Only 34.3 % practised exclusive breast feeding. Fermented corn (pap) was the most popular complimentary food used. It was also discovered that although mothers had a wide knowledge of optimal infant feeding, actual practices were constrained by cost of food, maternal HIV status and availability. The average nutrient intake of infants were  $626.1 \pm 196.6$  Kcal,  $19.9 \pm 7.6$  g,  $8.2 \pm 5.9$  mg,  $25.9 \pm 13.4$  mg,  $442.5 \pm 164.5$  mg for energy, protein, iron, ascorbic acid and calcium respectively. The energy values were lower than the recommended daily allowances while protein and iron intakes were generally adequate. Grassroot nutritional campaign that will educate the women on strategies to improve the traditional complementary practices is therefore recommended.

**Keywords:** Breast feeding ,Nutrient intake, Children, complimentary feeding practices, Ebonyi-state

## Risk Assessment in the Pork Meat Chain in two Districts of Viet Nam

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Pork occupies an important place in the diet of the Vietnamese population. Most people buy and sell meat in informal markets (called wet markets) where there is little safety and quality regulation. As part of a larger project on competitiveness of smallholder pig production in Viet Nam, we carried out a comparative risk assessment to identify and characterise hazards present in representative pork meat chains. The study addressed all levels ("from stable to table") of food supply chains in the districts of Ha Noi (urban environment) and Ha Tay (transition from urban to rural environment) in northern Viet Nam. We used Participatory Risk Analysis, allowing rapid and participatory assessment of hazards in resource-constrained environments. Different tools were used in this pathway approach to identify practices and hazards at production, slaughter, transport, sale and consumption, including:

- Observational check lists and questionnaires ;
- Participatory rural appraisal;
- Rapid diagnostic tests for several pathogens in pork meat, including several bacteria, different parasites and antibiotic residues.

The collected data were evaluated to assess hazards as well as risk amplifying or mitigating practices.

The farms scored moderately well on measures of biosecurity, good hygienic practice and reduction of zoonoses transmission. Farmers reported the occurrence of disease outbreaks in their pigs, but also an adequate coverage with veterinary services and drugs. Slaughterhouses scored low on hygienic practices, suggesting this may be a critical step because of a high likelihood of carcass contamination with faecal bacteria. Applying diagnostic tests on slaughtered pigs and pork meat at selling points, we found six hazards present in pork at concerning levels. We also report on the prevalence of consumer practices around purchase, keeping and preparation of food which are likely to influence risk. Finally, we integrate the findings from the different levels of the chain to assess the risk to consumers and conclude that although there is strong evidence for high levels of hazards in pork, there is less evidence of high levels of risk to consumers of pork meat.

**Keywords:** Food borne disease, pig production, pork meat, risk assessment

## Lean Meat for 21<sup>st</sup> Century: A Case Study of Emu *Dromaius novaehollandiae* [Le Souef 1907]

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The demand for meat and meat products is growing in Nigeria, especially in urban centres. This tendency rises also the demand for non-conventional meat sources. As the population of many wildlife species in Nigeria declined due to unsustainable harvest of bush meat, animals like snails, antelopes and rodents have been domesticated. Although this improved livestock production in Nigeria, the demand for and the supply of meat is still not equilibrated. Especially the demand for lean meat is increasing in the major urban centres.

Emu *Dromaius novaehollandiae* the second largest bird in the world started its domestication in the United States in the early 1980's and the present trend in the production of emu in the U.S can be compared with cattle industry. For this study, emu meat was obtained from the Ajanla farms, Ibadan, Oyo State, Nigeria. There, 16 emus at age of 20 months were held in a semi-intensive system for a period of 24 months. 2 kg of the chest and drum stick of emu meat were used. The meat was trimmed of bones, nerves, blood vessels, connective tissues and external fat and kept at 4°C for 24 hours. The study assessed the proximate composition of emu meat compared to ostrich meat and conventional beef meat.

Fat content obtained was highest ( $p < 0.05$ ) in beef with a value of 6.34 % as against values of 1.00 %, and 2.10 % for emus and ostrich meat, respectively. Protein content was highest in emu meat and ostrich meat with 24.00 % and 22.90 %, respectively, and 18.95 % for beef. The result also showed that emu meat had the lowest cholesterol level of 54.7 mg per 100 g compared to 63 mg per 100 g, and 86 mg per 100 g for ostrich and beef meat respectively. The results showed that emu's meat is low in fat, cholesterol and is high in protein content.

**Keywords:** Birds, domestication, emu, lean meat, wildlife

## Effects of Processing *Mucuna* Bean (*Mucuna pruriens* L.) on Protein Quality and Anti-nutrients Content

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*Mucuna* bean is grown in many parts of Kenya as a green manure/cover crop. The bean contains a high protein content but remains a minor food crop due to the presence of anti-nutrient compounds mainly 3,4-dihydroxy-L-phenylalanine (L-Dopa). The potential for utilisation of *mucuna* bean as an alternative source of protein was evaluated by assessing the effect of various processing methods on its protein quality and anti-nutrient compounds. *Mucuna* bean was processed to remove L-Dopa and other anti-nutrient compounds by different methods such as soaking, autoclaving, roasting, germination, and alkaline fermentation. Protein quality was determined by amino acid composition, *in vitro* and *in vivo* rat balance methodologies. All processing techniques, except roasting, reduced levels of L-dopa by >95 % and other anti-nutrient compounds such as total phenols, trypsin inhibitor and phytates. Processing improved *in vitro* protein digestibility (IVPD) but significantly ( $P < 0.05$ ) reduced protein content. Soaking in acidic medium (pH 3.2) at 60°C for 48 hrs significantly improved IVPD (80.5 %) and biological value (80.8) of *mucuna* bean protein. The content of essential amino acids met the recommended FAO/WHO reference requirements for 2–5 yr old except for tryptophan. However, true digestibility for processed bean diet was poor (58 %) and protein digestibility-corrected amino acid score (PDCAAS) low (0.4) compared to that of reference casein (1.0). This was attributed to both low sulphur amino acids content and residual anti-nutrient factors that affect protein hydrolysis such as phenolic compounds. *Mucuna* protein diet did not support growth of weanling rats indicating amino acids pattern incompatible with the needs of weanling rats. Histological examination of liver and kidney tissues revealed that consumption of processed *mucuna* bean as the only source of protein caused inflammation of the organs. This suggests possible presence of other toxins in processed bean even though *mucuna* bean diet contained the recommended safe level of residual L-Dopa (<0.1 %). Processing *mucuna* bean improved the protein quality and reduced the content of anti-nutrient compounds. However, *mucuna* bean is not recommended as a sole protein in human diet.

**Keywords:** Anti-nutrient, L-Dopa, *mucuna* bean, processing, protein, quality

## Effect of Fermentation on some Properties of Sweet Potato Flour

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Sweet potato, a potentially veritable and emerging source of valuable nutrients to many countries, and especially in the developing ones including Nigeria and many west African countries, was fermented in the laboratory by a modification of the traditional method usually employed in the southwestern part of Nigeria. Some of the properties of the resulting flour from fermentation were evaluated by standard and established methods, and then compared with those of the unfermented samples. Results obtained indicated that, while the crude protein and moisture contents of the flour from the fermented samples were significantly higher than found in unfermented samples, the contents of crude fat, fibre, ash and carbohydrate were less. Flour from the fermented samples had lower values of peak and final viscosities, water absorption capacity (WAC), bulk density and swelling power, but lower values with respect to the solubility and reconstitution indices, than those from the unfermented counterpart. The fermented sample also gave flour that was slightly more acidic. Flours from both samples took approximately the same time to reach peak viscosity and their pasting temperatures were not significantly different. Microbiological analysis indicated a predominance of lactic acid bacteria (LAB) in the fermented sample. The flour of the fermented sample, with its far greater load of LAB, but a significantly lower load of coliform bacteria than the unfermented counterpart, had no faecal coliforms. Sensory evaluation of the meals prepared from the two types of flours also indicated that the fermented sample was rated better in terms of overall acceptability. Fermentation could therefore lead to significant improvement in the nutritional status of sweet potato as revealed by the proximate composition. The products of such fermentation could also be safer microbiologically as revealed by the low coliform counts and the total lack of faecal coliforms. The fermented products also scored better generally in terms of sensory attributes. The pasting properties however revealed that more of the fermented samples may be needed to produce meals of comparable consistency to the unfermented samples.

**Keywords:** fermentation, flour, pasting, properties, sensory, sweet potato

## Bioactive Compounds in Velvet Bean Seeds: A Promising High Quality Legume to Attain Food Security in Developing Countries

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In the present study, effect of certain indigenous processing methods on the levels of bioactive compounds of an under-utilised legume, velvet bean (*Mucuna pruriens*) was investigated. Ten different accessions of velvet bean seeds collected from various agro-ecological locations of the world exhibited a wide variability with respect to the levels of total free phenolics (5.24–8.65 g per 100 g DM), tannins (1.77–3.49 g per 100 g DM), L-Dopa (4.30–6.23 g per 100 g DM) and phytic acid (1.17–2.37 g per 100 g DM). Significantly higher level of total free phenolics and tannins was noticed in VB seeds collected from Zimbabwe, while Guatemala VB accession registered maximum level of L-Dopa. Among the different processing methods attempted in the present study, soaking in tamarind solution + cooking and soaking in alkaline solution + cooking treatments were found to reduce significant level of total free phenolics by 24–46 % and 36–65 %, respectively. Tannins were reduced at maximum level only under soaking in alkaline solution + cooking treatment (24–52 %). Significant level of loss of L-Dopa (6–67 %) was noticed under all the treatments of the present study. However, none of the treatments resulted in significant level of loss of phytic acid in velvet bean seeds. Further, sprouting + cooking as well as open-pan roasting were found to be optimal in retaining higher levels of bioactive compounds. Hence, such viable processing methods could be recommended for the consumption of velvet bean seeds as a natural source of health beneficial bioactive compounds, in addition to high nutritive potential.

**Keywords:** tannins, bioactive compounds, L-Dopa, *Mucuna pruriens*, phytic acid, processing methods, total free phenolics, velvet bean

## Novel Characteristics of African *Streptococcus infantarius* subsp. *infantarius* Potentially Responsible for the Predominance over other Lactic Acid Bacteria in Spontaneously Fermented Camel Milk

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*Streptococcus infantarius* subsp. *infantarius*, a pathogenic species of the *Streptococcus bovis* / *Streptococcus equinus* complex (SBSEC), was unexpectedly found to be predominating in spontaneously fermented East-African camel milk (suusac) over other lactic acid bacteria including *Streptococcus thermophilus*. Lactose metabolism of currently known SBSEC and the classic yoghurt bacterium *S. thermophilus* is reported to differ, not justifying the predominance observed. Bacteriocin production by SBSEC is described and might be a factor contributing to the predominance.

African *S. subsp. infantarius* predominate in suusac fermentation mediated by bacteriocin production and an adapted lactose metabolism that parallels lactose utilisation in *S. thermophilus* instead of previously reported SBSEC metabolic pathways. Presumptive *S. subsp. infantarius* isolates (213) were obtained at 10<sup>8</sup> CFU ml<sup>-1</sup> from 22 out of 24 Kenyan and Somali suusac on semi-selective media and subsequently typed by pheno- and genotypic methods. Primers based on *S. thermophilus* and *S. salivarius* sequences were designed for 6 genes of the *gal-lac* operon. Genes *galE*, *galM*, *lacS* and *lacZ* were detected by PCR in African *S. subsp. infantarius* strains. Sequencing of a 6.949-kb fragment of *S. subsp. infantarius* CJ18 revealed higher homology to *galE* (94.1 %), *galM* (92.1 %), *lacS* (93.1 %) and *lacZ* (97.4 %) of *S. thermophilus* than to *galE* (83.3 %) and *galM* (56.6 %) of the *S. subsp. infantarius* type strain. *lacS* and *lacZ* were not detected in the available genome scaffolds and PCR assays of all 9 SBSEC type strains. Bacteriocin screening was performed using a wide spectrum of indicator strains in buffered media. Bacteriocins active against *Listeria*, lactobacilli and streptococci were detected in 33 out of 66 tested *S. subsp. infantarius* strains.

Our African *S. subsp. infantarius* strains harbour genes for a lactose metabolism homologous to those of *S. thermophilus*, which are either absent or strongly differ in SBSEC type strains. The presence of an adapted *gal-lac* operon and the production of bacteriocin possibly explain their predominance during suusac fermentation. Our investigations are continuing to better define additional metabolic characteristics, the fermentative role of CJ18 and to identify any putative virulence factors that may pose a significant human health risk.

**Keywords:** Bacteriocin, camel milk fermentation, galactose lactose metabolism, *Streptococcus infantarius*

## Effect of Location on the Chemical Composition of Organically Cultivated Tomato (*Lycopersicon esculentum* Mill.) in Sudan

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Nowadays, safety issues and environmental concern have gained great consideration to organically-grown products for their expected health benefits. Tomato is one of the most popular and widely consumed horticultural crops grown in Sudan, having potentially nutritional compounds such as vitamins and minerals beside antioxidant components. The current investigation was established to evaluate the tomato fruit chemical composition such as dry matter, sugar concentration, total organic acids contents, as well as antioxidant capacity, lycopene, and ascorbic acid contents of organically-cultivated tomato fruits. The effect of an environment was studied for the tomato genotype Baladia, which was grown organically in 2007 at the following different locations in Sudan: Khartoum, Khartoum Bahri and Elobeid. The results from this study have shown significant variations among the locations with regard to the investigated quality parameters. Antioxidant capacity as an important quality criterion and lycopene content as the main contributor to the antioxidant capacity, were at the highest levels in tomato fruits from Khartoum Bahri. Dry matter, sugar and total organic acids contents were high in tomato fruits from Khartoum. These results might indicate a better taste of tomato fruits from this location. Fructose represented more than 50 % of detected total sugar concentration; citric and succinic acids were the dominant organic acids found in the tomato fruits from the different locations. On the other hand, ascorbic acid was at the highest level in tomato fruits from Elobeid. It could be concluded that the locations exerted the major influence on the chemical composition of the tomato fruits.

**Keywords:** Antioxidant capacity, lycopene, organic cultivation, organic acids, sugar



## Development and Evaluation of Cheese-like Product from the Blend of Soy Milk and Coconut Milk

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Cheese a popular milk product all over the world is also popularly known as ‘wara’ in Nigeria, its imitation from soybean called soybean ‘wara’ also known as ‘beske’ in some parts of the country is nutritious and is prepared by curdling of the milk from soybean. Soybean (*Glycine max*), the basic raw material for the product, has great nutritional (source of proteins, minerals, etc.) and therapeutic values (*e.g.* prevention of chronic diseases such as menopausal disorder, cancer, atherosclerosis and osteoporosis), and it is also beneficial in products like soy milk and soy cheese. Coconut (*Cocos nucifera*) milk is being used by confectionaries, bakeries, biscuits and ice cream industries worldwide to enhance flavor and taste of various products. Coconut milk has been reported to be high in minerals especially and vitamin content while total saturated fat was 10 % of the total energy. In the light of this the research was taken to promote the use of coconut in the production of ‘Wara’ (Curds). This was done by producing ‘wara’ from the blend of soy milk and coconut milk extract. Samples of ‘wara’ were produced using soymilk and coconut milk at different ratio, 90:10, 80:20, 100 Soy, 70:30 and 50:50 (Soy: Coconut) respectively. The samples were subjected to analysis for proximate composition and sensory evaluation using standard methods.

The sensory evaluation results revealed that all the samples were acceptable, with the sample comprising of 50 % soymilk and 50 % coconut milk being the most acceptable with a protein content of  $19.37 \pm 0.15$ , a fat content of  $7.15 \pm 0.02$ , a fiber content of  $0.55 \pm 0.01$ , a ash content of  $1.64 \pm 0.04$ , and a moisture content of  $50.34 \pm 0.02$ . It was therefore recommended that acceptable ‘wara’ could be produced from soymilk and coconut milk blends.

**Keywords:** Cheese, coconut, milk, sensory evaluation, soybean

## Characterisation of Goat Milk Industry in the North and Oases Region of Morocco

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In North of Morocco and oases regions of Ouarzazate and Errachidia, the dairy industry is growing significantly consequence of development programmes implemented by public authorities. Besides, and according to the results of experiences in Morocco and other Mediterranean countries, the valorisation of goat milk by cheese making seems to ensure a better profitability of dairy goat production, and constitutes a motor for its development.

In order to characterise this sector in these two areas, this study aims to characterise the local expertise in goat milk processing, the physical and chemical characteristics, and the hygienic quality of local goat milk. To meet these objectives, data on milk processing were collected from dairies in oases region and in the north, and a sampling schedule of goat milk and cheese was adopted during 9 months, with 92 samples in total.

The transformation of milk is oriented mainly toward the production of fresh cheese; the major steps are: reception, filtration, thermisation or pasteurisation, coagulation (commercial rennet), moulding and draining, salting and conditioning. Four categories of processes, depending on modalities of coagulation, were identified in north and one category in south, with a respective cheese yield of 19 % and 18.5 %.

This transformation remains traditional, seasonal and badly conducted; micro-organisms indicating the level of hygiene were high, and several cheeses failed the standards laid down by the Moroccan legislation. The obtained values of physical and chemical characteristics of goat milk in both regions were relatively similar, with minim-superiority of milk in the oases region concerning dry matters (14,49 vs. 13,38 %), ashes (0,75 vs. 0,67 %) and fat content (4,53 vs. 3,58 %) and in the north for proteins (3,54 vs. 3,98 %).

Taking account of these results, the chemical composition of milk in the two regions seems to assure a better cheese production (quality and quantity), if the process of manufacture will be well mastered in different steps.

**Keywords:** Cheese, goat, milk, Morocco

## Factors Influencing Producer Milk Prices in Peri-urban Faisalabad, Punjab Province, Pakistan

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Milk production is an important component of Pakistan's economy. It is higher during winter (December-March) than summer (June-August), while demand is highest in summer. Peri-urban dairy production has been growing constantly during the past decades and continues to gain importance; about 5 % of Pakistan's milk comes from urban and 15 % from peri-urban producers. Milk marketing is dominated by middlemen (gawalas or *dhodis*), and consumers prefer buffalo (*Bubalus bubalis*) over cattle milk. To determine factors influencing producer milk prices, a study was conducted in Faisalabad, third-largest city of Pakistan (>2 million inhabitants). Using a structured and pretested questionnaire, interviews with 142 peri-urban (4 to 9.4 km from city centre) milk-producing households (HH) were carried out from August until October 2009; HH selection followed the snow-ball method.

Two thirds of the HH (n=91) kept Nili-Ravi buffaloes and mostly crossbred cattle, the rest only buffaloes. The majority (69.7 %) sold milk to *dhodis*, one third (35.2 %) to neighbours, 2.1 % did doorstep delivery and one HH owned a shop. The 91 HH keeping both species usually sold mixed milk (96.6 %). Clients for mixed and pure buffalo milk were *dhodis* (77.9 %, respectively 58.5 %) and neighbours (27.9 %, respectively 47.2 %). Highest milk prices per litre (Pakistani Rupees, 100 PKR  $\approx$  0.8 Euro) were paid by alternative clients (43.5  $\pm$  4.1 PKR, 4 HH), followed by neighbours (40.2  $\pm$  2.8 PKR, 50 HH). *Dhodis* paid significantly ( $p > 0.0$ ) lower prices (35.9  $\pm$  3.2 PKR, 99 HH). Prices for pure buffalo and mixed milk did not differ significantly. However, HH obtaining the maximum price from the respective clients for the respective type of milk got between 20 % (mixed milk, alternative clients) and 68 % (mixed milk, *dhodi*) more than HH fetching the minimum price. Some HH (19 %) reported 7.3 % ( $\pm$  3.7) higher prices for the current summer than the foregoing winter (significant at  $p < 0.05$ ), while amount of milk sold and distance of the HH to the city centre did not influence milk prices. It is concluded that the major factors influencing producer milk prices in Faisalabad are type of client and individual marketing skills. Therefore, less successful producers might establish cooperatives to bundle their marketing power and skills.

**Keywords:** Buffalo, cattle, *dhodi*, marketing, mixed milk

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## **Fat Quality and Intramuscular Fatty Acid Composition of Brahman × Thai Native and Charolais × Thai Native Crossbred Cattle**

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Intramuscular (i. m.) fat contributes to quality of meat, including texture and flavour. I. m. fat content and its fatty acid composition are the major factors affecting human health. Fats of cattle meat are characterised by high saturated fatty acid (SFA) and low polyunsaturated fatty acid contents (PUFA) which is a risk factor for coronary heart disease for the consumers. On the other hand, meat containing high amounts of omega-3 PUFA and conjugated linoleic acid can be beneficial to human health, *e.g.* by reducing the rate of fat deposition and serum lipids. The objective of the present study was to determine the effects of genotype and slaughter weight on fat quality and i. m. fatty acid composition of Longissimus dorsi (Ld) muscle of Brahman × Thai native (BRA) and Charolais × Thai native (CHA) crossbred bulls fattened under practical farm conditions in Northern Thailand. In total 34 BRA and 34 CHA were randomly selected and slaughtered at either 500, 550 or 600 kg live weight. Carcass fat score, marbling score, contents of i. m. fat, triglyceride and cholesterol, and i. m. fatty acid composition of Ld muscle were determined. The results showed that CHA exhibited lower carcass fat scores, higher marbling scores and i. m. fat than BRA. Therefore, CHA may offer a better meat quality, especially with regard to tenderness and juiciness. However, triglyceride and cholesterol content was lower, C18:3 omega-3, C22:5 omega-3 and total omega-3 PUFA higher, and ratios of omega-6/omega-3 PUFA and C18:2 omega-6/C18:3 omega-3 lower in BRA. Compared to CHA, the fatty acid composition of BRA meat may benefit human health. Therefore, BRA should be used for fattening especially in pasture or extensive systems to produce “healthy beef” for an alternative market. Increasing slaughter weight from 500 to 600 kg had no effect on fat quality and i. m. fatty acid composition. Since the economical benefit increases with carcass weight, slaughter weights up to 600 kg can be recommended for both genotypes.

**Keywords:** Brahman, Charolais, fatty acid composition, slaughter weight

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## Carcass and Meat Quality of Red Sokoto Buck Goats Differently Dressed

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A total of eighteen good grade Red Sokoto buck goats weighing between 15.25–16.50 kg were sacrificed to evaluate the effect of scalding, singeing and skinning on yield, physico-chemical and keeping quality of goat meat in a completely randomised design. The animals were well rested, starved of feed for 16 hours, weighed, stunned and slaughtered in batches of three under commercial conditions. The samples for pH and chemical analysis were taken from the longissimus dorsi, while the loin were used in evaluating shear force value, cooking loss, water holding capacity (WHC) and modified peroxide values (mPV). The internal temperature values were taken at a depth of 1 cm at the longissimus dorsi immediately after dressing. The result showed that the dressing percentage was highest ( $p < 0.05$ ) in scalded carcasses (58.29 %) and least in skinned carcasses (46.27 %). The carcass length was least ( $p < 0.05$ ) in singed carcass (34.35 cm) and highest (44.76 cm) in skinned carcasses. Singeing imposed a higher degree of toughness on the meat while the cooking loss was highest in singed carcasses. The WHC was highest in scalded carcasses (69.35 %) followed by skinned (64.36 %) and least in singed carcasses (50.35 %). The visual colour score was highest (7.45) for singed carcasses, followed by scalding (6.16) and least in skinned (5.30). Moisture, ether extract and ash were affected ( $p < 0.05$ ) by the dressing method while crude protein was not significantly ( $p > 0.05$ ) influenced. Singeing imposed a higher temperature on the longissimus dorsi. The modified peroxide value (mPV) increased as storage period increased while in each of the storage period, meat from skinned carcasses gave the highest mPV values. Post slaughter processing methods (dressing) were found to affect the quality of meat from Red Sokoto goats.

**Keywords:** Goats, scalding, singeing, skinning

## Assessment of Current Drying Practices for South American Pepper Varieties (*Capsicum* spp) with Respect to Final Product Quality

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Worldwide fresh and dried *Capsicum* species are used as ingredients in foods and medicines. In Peru and Bolivia, with large percentages of population occupied in agriculture and living below the poverty line, capsicum is among the most important agricultural products. However, especially small-scale farmers face reduced sales due to market restrictions on low quality products. Many studies show that dried *Capsicum* especially is often contaminated with mycotoxins, secondary metabolites of microbes, which pose significant health risks to consumers. As fungal growth depends on moisture content, drying is a critically important postharvest process. The current practice is largely open-air sun drying of capsicum, a fruit with high water content, which allows for quick infection by microbes. Additional processing like milling can further increase contamination. Another aspect of *Capsicum* processing that addresses livelihood of local people is the high content of carotenoids that are responsible for the red colour. Carotenoids have an important role in human nutrition as they are metabolised to vitamin A after ingestion. In many developing countries vitamin A deficiency causes severe health problems and losses of up to 53 % of the initial carotenoid content during drying have been reported due to sensitivity to heat and UV radiation.

This study evaluated the prevailing postharvest system of the *Capsicum* drying in Peru and Bolivia with a focus on microbial contamination and carotenoid degradation. Drying processes of several locally grown *Capsicum* cultivars were observed and products were sampled at various postharvest points. Different quality parameters including moisture content, colour, microbial contamination, mycotoxin content and beta-carotene were determined by standard methods. By reverse analysis of the production chain, critical control points were identified where measures can be taken

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to improve product quality. As a result, recommendations for improved manufacturing practices are given. By analysis and optimisation of the current drying techniques, product quality can be improved and value increased, generating new market opportunities that can increase income of local farmers. Furthermore, increasing nutritional value and decreasing the presence of mycotoxins will contribute to the health and well-being of consumers of dried capsicum.

**Keywords:** *Capsicum*, drying, food safety, mycotoxins, South America, vitamin A

## Effects of Pretreatments on Drying Properties and Product Quality of Different *Capsicum* Varieties

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Dried *Capsicum* spp. are widely used as ingredients in foods and medicines. However, market restrictions exist for low quality products, mainly based on moisture content and colour. Pretreatment of raw materials before drying is known to enhance drying properties and final qualities of a variety of products. Many studies have shown pretreatments can positively affect drying behaviour and product quality of vegetables ranging from carrots to mushrooms. However, only limited studies have been made for applications to drying of capsicum so far. Therefore, an investigation was made to determine which pretreatments are most recommendable for commercial production of dried *Capsicum*. Fresh *Capsicum* samples of different varieties and quality (shape, colour, sweetness, hotness) were obtained from local markets. Various pretreatments were applied including blanching and soaking in solutions of potassium carbonate, calcium chloride, sodium hydroxide, potassium metabisulfite, citric acid, ascorbic acid, glycerol, trehalose and sucrose. Fruits were dried whole in a through-flow laboratory dryer at 50, 60 and 70°C until constant moisture content. Mass reduction was monitored during the experiments to obtain drying curves of the various treatments. Typical quality parameters such as moisture content, water activity, colour and texture were evaluated for fresh and dried products using standard methods. Based on the results, the affects of the various pretreatments on drying behaviour and product quality are presented. Comparisons are made to other results found in the literature. Recommendations are given as to which pretreatments might best apply for commercial drying of capsicum species and which would be most favourable to combine for future research.

**Keywords:** *Capsicum*, colour, drying, moisture, pretreatment, product quality, texture



## Effects of Applying Different Drying Strategies on Quality Characteristics and Post-processing of Lemon Balm (*Melissa officinalis* L.)

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In medicinal plants many physical-chemical reactions are activated by temperature and therefore the application of drying causes an acceleration of these reactions. For this reason it is important to conduct research in order to minimise the negative effects of drying. The objective of this study was to observe the influence of drying on the final moisture, colour change and loss of essential oil considering two strategies; drying of leaves and stalks separately and drying of branches (leaves and stalks jointly). For the research, Lemon balm was considered as product and the drying experiments were conducted using a cabinet dryer. For each drying test, 100 g of product was used. The initial and final moisture contents of each sample were determined by the oven-drying methodology. To determine the colour changes, a Chroma-meter® device was used, in accordance with the norm DIN 6174. For the determination of the essential oil content, the method described in DAB 10 was considered. Drying was performed at 40°C and for comparison of results a fixed drying period of 11h was considered, in this period the recommended final moisture of leaves is reached. As result of the drying tests, severe differences in moisture content (wet basis w.b.) after 11h were observed. When performing drying at 40°C of single leaves, with initial moisture content of 80 % w.b. the moisture content of the leaves was 10 % w.b, and considering the drying of branches at 40°C, with the same initial moisture, and observing the leaves in this condition their moisture was 7.98 % w.b. Moreover, in the same tests, the moisture of the branches was observed. When the branches reach the recommended final moisture of 10 % w.b, after 25h, the leaves from these branches have final moisture of 7.41 % w.b. showing over-drying, that affects severely the quality characteristics. Likewise, appreciable differences in colour change and loss of essential oils were observed, comparing among the drying strategies and conditions proposed. From these results, it is possible to define the adequate drying parameters to minimise the effects on quality characteristics and the difficulty for post-processing, for example separation of leaves and stalks.

**Keywords:** Drying quality characteristics, drying strategies, medicinal plants, *Melissa officinalis*, moisture content

## Effect of Drying on Toxic Content of Bamboo Shoots

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Bamboo, a group of large woody grasses belonging to the family Poaceae and sub-family Bambusoideae are much talked about for their contribution to the environment. Various edible species and exotic food recipes of bamboo shoots are consumed worldwide. Occurrence of Taxiphyllin, a cyanogenic glycoside in different species of bamboo shoots like *Dendrocalamus latiflorus*, *D. giganteus*, *D. hamiltonii*, *Bambusa vulagris* and *B. guadua* had been identified. The concentration of cyanide in the immature shoot tip of bamboo has been reported to be 8000 mg kg<sup>-1</sup> of hydrogen cyanide. Taxiphyllin releases hydrogen cyanide upon enzymatic hydrolysis which if consumed in excess may lead to some reproductive & behavioural defects. Processing techniques like slicing, soaking, boiling, drying etc eliminates the toxic compound to a great extent. The present study determines the toxic content in four species of dried bamboo shoots viz. *Bambusa vulagris*, *B. tulda*, *B. balcoa* and *Dendrocalamus strictus*. Fresh bamboo shoots were harvested, washed, peeled off, sliced, oven dried, powdered and stored in refrigerator at 4°C for analysis. The toxic content was analysed by Picrate method and it ranged from 45.3 to 58.6 ppm in the four species. The results revealed that drying caused reduction in the cyanide content as compared to the fresh bamboo shoots (386 ppm in *D. strictus* and 200 ppm in *B. vulgaris*). With growing global consumption of bamboo shoots and occurrence of taxiphyllin with its side effect on human health, it calls for the demand to innovate processing ways using scientific input to eliminate the toxic compound without disturbing the nutrient reserve.

**Keywords:** Bamboo shoots, drying, taxiphyllin

## **Analysis of Drying Process of Cherry Wood Chips in the Experimental Combined Dryer with Helio-collector**

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Drying is an important phase in the production of a renewable biomass into a solid biofuel (briquettes, pellets). The paper describes the technological and construction specifics of a combined biomass dryer with helio-collector and analyses parameters of the drying process on the example of the drying of cherry wood chips.

The idea of a combined biomass dryer has been materialised in the framework of the project which was implemented in the laboratory building premises of the State Agrarian University of Moldova in Chisinau. The experimental dryer was equipped with a passive solar system such as a simple three-section helio-collector. This collector heats the air which is then passed into the dryer. Calculations were done to determine the main drying parameters and the efficiency of the combined dryer. The dependence of the biomass moisture changes on drying time was observed at different locations of the solar-powered biomass dryer. Above all, the research was focused on monitoring the biomass moisture changes during the drying process. The moisture content of the cherry wood chips was observed in dependence of the drying time and at different locations of the drying chamber. Further parameters such as the relative air humidity and the air temperature were measured as well.

It was found that the combined biomass dryer with helio-collector works very well under the conditions of Central Moldova during the sunny period of the year from May till October without additional heat supply from the by-passed boiler. For the drying process acceleration it should be conducted continuously in order to increase its efficiency and to reduce its energy intensity.

**Keywords:** Biomass, drying chamber, heat energy, heat exchanger, helio-collector, material moisture, relative air humidity, reversible fan, temperature

## Relevance of Dried Meat Product ('Kundi'), an Intermediate Moisture Meat, for Food Security

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Millions of people worldwide especially in under and developing countries suffer from hunger and undernutrition. Food security means that each individual is able to obtain adequate and quality food at all times, in order to meet the body's needs. 'Kundi' is a relish intermediate moisture dried meat product, produced in the northern part of Nigeria.

2-3 years old male *Camelus dromedarius* and White Fulani animals were used for this study, 2 kg of semimenbranous muscles from each animal were used, and trimmed of all external fat, connective tissues and bones. Meat samples were cut in sizeable pieces of weight ranges 70-90 g of 6-8 cm and kept in the refrigerator for 24 hours. Fresh meat cuts were boiled for 20 minutes at 100/°C, seasoned and oven dried for 3 hours at 170/°C. This study assessed the proximate composition of fresh and dried meat ('Kundi') products and their sensory evaluation in a completely randomised design.

Results showed that fresh camel meat had a significantly ( $p < 0.05$ ) higher moisture and protein content 74.55 % and 21.96 %, respectively than fresh beef 72.69 % and 18.96 %, respectively. While fresh beef had higher ( $p < 0.05$ ) ether extract content 6.34 % than fresh camel meat 2.39 %. Laboratory prepared beef 'Kundi' (LPBK) had the highest ( $p < 0.05$ ) value in moisture content 35.09 % followed by laboratory prepared camel 'Kundi' LPCK with 30.21 %, while commercial 'Kundi' (CK) has the lowest moisture content. Protein obtained was inversely proportionally to moisture content. Ether extract for LPCK and LPBK were statistically similar ( $p > 0.05$ ) and both were lower ( $p < 0.05$ ) than value obtained for CK. Also results obtained for sensory evaluation showed that the panelist rated seasoned Kundi to have the highest significant ( $p < 0.05$ ) value for tenderness, flavour, colour, juiciness, texture and acceptability with values 6.50, 5.30, 6.50, 6.53, 6.30 and 7.00 respectively.

**Keywords:** Beef, camel, Kundi, seasoned and unseasoned Kundi

## Sorption Isotherms of Celery Leaves (*Apium graveolens* L. var. *secalinum*)

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Celery (*Apium graveolens* L.) is a plant species of the family Apiaceae. Leaf celery (*Apium graveolens* L. var. *secalinum*), also known as cutting celery, is a variety in which the usable parts are the dark-green, glossy leaves. They may be eaten fresh or processed, mainly frozen or dried.

In general leaves require less time and energy for drying than other parts of plants, which makes celery leaves more suitable for the drying process compared to the stalk or root parts commonly used in the other varieties.

Sorption isotherms define the hygroscopic equilibrium between relative humidity and moisture content at a given temperature, thus providing important information for the drying process and the storage of foodstuffs.

In this work the desorption isotherms of celery leaves were determined at 25, 40 and 50°C, and the adsorption isotherm at 25°C. The static gravimetric method was employed. Eight glass containers were partially filled with saturated salt solutions for a range of relative humidity from 11 to 84 %. For relative humidities above 60 % a test tube with thymol crystals was added to the jars to avoid microbial spoilage. The celery leaves' samples were placed in a perforated stainless steel container above the solutions, and the jars were hermetically sealed. Samples were weighed every three days until equilibrium was reached. The following models were fitted to the experimental data using nonlinear regression: Halsey, Oswin, Henderson, GAB, Peleg and BET. The coefficient of determination, the mean relative deviation and the standard error of the estimate were used to determine the models' goodness of fit, and the Peleg model was found to be the best.

The results of this study will serve to model the thin-layer drying of this product under variable conditions.

**Keywords:** *Apium graveolens*, celery leaves, sorption isotherms

## Determination of Sorption Isotherms for Shiitake Mushroom (*Lentinula edodes*) using the Dynamic Vapor Sorption Method

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*Lentinula edodes* (shiitake) is one of the major edible cultivated mushrooms worldwide which is consumed either fresh or processed. Shiitake mushrooms are recommended as an addition to the daily diet due to their nutritional characteristics and medicinal properties. They contain a natural chemical compound called ergosterol which, when exposed to ultraviolet light is converted to vitamin D2. Different drying techniques such as solar tunnel dryers and hot-air cabinet dryers are frequently employed for the preservation of mushrooms. For the optimisation of the drying process and storage, the knowledge and understanding of sorption isotherms is essential. Although the static gravimetric method is still commonly used, automated instruments for the determination of sorption isotherms have been developed to overcome some of the drawbacks associated with the standard saturated salt solution method. The dynamic vapour sorption (DVS) is a relatively new technique designed to measure the weight change caused by adsorption or desorption of the water vapour at any desired relative humidity in a short period of time. The objective of this study was to validate and optimise the DVS method examining the moisture sorption behaviour of shiitake mushrooms at a temperature of 25°C. Furthermore, it was intended to compare the experimental equilibrium moisture content data obtained by the DVS method with the existing data for mushrooms in the literature. The samples were equilibrated in the range of 0.05–0.95 water activity using a DVS-1000 analyzer (Surface Measurement Systems Ltd., London, U.K.). The GAB equation was selected to fit the experimental data by non-linear regression analysis. The accuracy of fit was based on standard error, mean relative error, and coefficient of determination. Dynamic vapour sorption working isotherms were obtained in duplicate at a total of twelve target values of water activity. Moreover, the model predicted well the equilibrium moisture content of shiitake mushrooms. Sigmoid characteristic curves, type II pattern indicate a relatively small amount of water at low values of water activity exhibiting an asymptotic trend as water activity approaches 0.95. Data on moisture sorption isotherms were provided which is important for the optimisation of different processes in the food industry.

**Keywords:** Dynamic vapour sorption, *Lentinula edodes*, sorption isotherms

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## Comparison between Different Methods to Determine Sorption Isotherms of *Capsicum* Species from South America

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*Capsicum* species are typically consumed as fresh vegetables or as food ingredients. Because of their sensitivity to storage, most fresh peppers are dried to produce a wide range of convenient food products with extended shelf life. The increasing consumer demand for high quality processed foods requires the analysis and optimisation of various processes in the food industry such as drying, mixing, packaging and storage. Since the moisture sorption isotherm predicts product stability, the proper quality during processing can be maintained by understanding the sorption behaviour of the foodstuff. Numerous methods have been reported in the literature for the measurement of the equilibrium relationship between moisture content and relative humidity at constant temperature. However, each method shows various degrees of applicability and accuracy. The aim of the present study was to produce sorption isotherms of *Capsicum* species based on variability in fruit shape and size. Also, this work was undertaken to compare the equilibrium moisture content data obtained by three different methods. The sorption isotherms of *Capsicum* varieties were measured using three methods, namely the gravimetric static, the hygrometric and a third method employing a dynamic, gravimetrical instrument developed at the department of Agricultural Engineering, University of Hohenheim. For the first method the sample was equilibrated over saturated salt solutions and its mass was periodically measured. The second was to measure the relative humidity above a specimen of known moisture content. The third was a recently designed gravimetric method where the sample was placed in a climatic chamber and exposed to stepwise changes in relative humidity while its mass was continuously measured. The sorption methods were evaluated in terms of accuracy and precision. Moisture sorption isotherms of peppers were obtained in duplicate at a temperature of 25°C. The hygrometric method indicated an uncertainty at high moisture contents whereas the salts method showed an inability to maintain high values of relative humidity. However, the comparison between the gravimetric methods showed consistent results for intermediate values of relative humidity. By employing a newly constructed experimental apparatus an innovative technique for determining sorption isotherms now appears to be promising.

**Keywords:** *Capsicum* species, equilibrium moisture content, sorption methods

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# Food intake and nutritional impact

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## **Orphan Crops and Nutrition: The Potential of Ricebean (*Vigna umbellata*) to Reduce ‘Hidden Hunger’ among Rural Women in India and Nepal**

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Among the arguments for maintenance of orphan crops as an important part of agrobiodiversity, the nutritional value and the potentials to provide food security in general and address ‘hidden hunger’ - micronutrient disorders in particular are often raised. These issues have also been a central part of the justification behind the by the EU funded Inco-Dev project FOSRIN (Food Security through Ricebean research in India and Nepal). The purpose of the paper is to document the nutritional value of ricebean and analyse how it compares to the nutritional status of women of reproductive age in four study sites in rural areas in Himachal Pradesh and Assam in India, and middle Hill areas in West and East Nepal. 800 women were involved in a 24 hour dietary recall which was carried out three times to check for seasonality. The data were analysed using WorldFood2. The study found that micronutrient deficiencies were more widespread than PEM (Protein-Energy Malnutrition). Ricebean has a good amino acid composition and is rich in several minerals compared to other grain pulses. In particular ricebean could have a potential to reduce deficiencies of calcium, potassium and iron, in addition to folate. The theoretical impact of increasing the pulse intake was shown to have substantial impact on the distribution of less severe nutrient deficiencies such as lysine, iron and some B vitamins. Due to the severity of some deficiencies such as calcium and folate, a realistic amount of ricebean would not alone be enough to bring all women above the recommended intake of these nutrients.

**Keywords:** Dietary recall, hidden hunger, micronutrient, orphan crops, ricebean

## Measuring Food Consumption using Coping Strategies Adopted by Farm Households in the Dry Land Sector of Sudan

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Previous work has shown that majority of rural households in Sudan are food insecure, that is, they lacked access to food, due to economic obstacles and low agricultural productivity which influence their food security. In spite of the efforts have been conducted by the government and NGOs since the last two decades to help vulnerable people still there is a problem of food deficit. Therefore, households are obligated to cope with shortfall in food consumption using various strategies. The paper will present detailed results of this research and evaluate various strategies to cope with food insecurity. It will also describe and measure these coping strategies when households have no access to enough food within and between the seasons. The study was conducted in 2009 in the dry land sector of Western Sudan namely North Kordofan State. Primary data using structured questionnaire administered to 200 rural households selected via multi-stage random sampling technique. Moreover, focus group discussions with the key informants were conducted to explore their perceptions on the severity of these strategies. Data analysis procedures included descriptive statistics and Coping Strategies Index (CSI), developed by CARE/WFP 2003, were used to measure food insecurity based on frequency and severity of strategies. Descriptive statistics show that 78.5 % did not have enough money to buy food whereas 76 % did not have enough food in the past 30 days during both dry and rainy seasons. The result of CSI reveals higher value of score in rainy season which indicate the deteriorating in household's food consumption caused by seasonality effect and lack of income contradictory to dry season. Nevertheless, the percentage gaps of food consumption between the two seasons are higher for selected localities; Um-Ruwaba, Sheikan and Bara with percentage of CSI scores of 89 %, 71 % and 78 % respectively. Though, the results show no significant differences in food consumption between localities. Consequently, the situation requires successful policy mechanisms so as to facilitate the access to food, improving access to market, credit and encouraging the off-farm activities. As well, food subsidy is necessary needed during the rainfall period to reduce the food gap.

**Keywords:** Coping Strategies Index, farm households, food consumption, food gap, food insecurity, lack of income, Sudan

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## Measuring Dietary Patterns Instead of Single Nutrient Intake: A Holistic Approach for Investigating the Nutritional Status of Women in Rural Tanzania

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When investigating the complexity of human nutrition and its association with health, it is less meaningful to consider single nutrients, yet, much more sensible to create and analyse comprehensive dietary patterns. However, studies on dietary patterns were mainly carried out in industrialised countries so far.

Three semi-quantitative 24-hour recalls were conducted with 252 women in rural Tanzania during three different seasons within one year. From these recalls, the mean intake of twelve main food groups was calculated and used within a principal component analysis (PCA) to establish five dietary patterns. Additionally, individual intake of seven macronutrients, eight vitamins and seven minerals was calculated for each participant.

Overall, five different dietary patterns could be distinguished that were mainly characterised by the consumption of one or more specific food groups. The patterns were called (i) ‘traditional coast’; (ii) ‘purchase’; (iii) ‘traditional inland’; (iv) ‘pulses’; and (v) ‘animal products’. They showed differences between traditional and modern or changing nutritional attitudes, and also indicated that the early stage of the ‘nutrition transition’ is already taking place in rural Tanzania.

PCA factor scores were calculated for each participant for each food pattern that indicated the affiliation of a woman to a particular pattern. These scores were associated to certain health parameters and it could be shown that the more a woman was affiliated to the so-called “purchase” pattern, the higher was her body mass index (BMI) ( $\rho=0.192$ ;  $p = 0.005$ ). Furthermore, the higher a woman’s affiliation to the so-called “animal products” pattern, the higher was her haemoglobin (Hb) level ( $\rho=0.216$ ;  $p = 0.003$ ). In contrast, no meaningful associations between BMI or Hb and individual nutrient intakes could be shown. Thus, the generation of dietary patterns appears to be suitable to conclude on dietary habits and their consequences for health of women also in developing countries.

**Keywords:** BMI, dietary pattern, Hb, nutrient intake, nutrition transition, rural Tanzania, women

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## **Adding Value to Holy Grain: Providing the Key Tools for the Exploitation of Amaranth – The Protein-rich Grain of the Aztecs. Results from a Joint European - Latin American Research Project**

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The project AMARANTH:FUTURE-FOOD ([www.amaranth-future-food.net](http://www.amaranth-future-food.net)) is a joint research project financed by the European Commission in the Specific International Cooperation Activities (INCO) of the 6<sup>th</sup> Framework Program. The project group consisted of 11 partners from Mexico, Nicaragua, Argentina, Czech Republic, Spain and Denmark. Amaranth is a protein-rich and gluten-free pseudo-cereal grain that was the basic food in South America and Mexico thousands of years ago. 60–70 Amaranthus species are known. The overall objective of the project was to provide the tools for an extensive and sustainable exploitation of amaranth. The project initiated on September 1<sup>st</sup>, 2006 and finalized on December 31<sup>st</sup>, 2009.

A number of scientific and popular papers with results from the project were published and more are on their way. A 75 pages Publishable Final Activity Report that summarises our results will be available in [www.amarant-future-food.net](http://www.amarant-future-food.net) in the near future. In this presentation selected results from our research into the industrial use of amaranth and the use of amaranth as food, feed and food additives will be presented together with our results from extensive cultivation trials on 18 different amaranth

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genotypes in five research sites with varying climate. Results from our studies on drought and insect resistance and weed compatibility of amaranth genotypes will also be presented and finally we will share our experience with the audience on our end-user focus in two Nicaraguan women's agricultural cooperatives. The members of these cooperatives are all single mothers and manual laborers (22 women in the La Bolsa community and 20 in the La Tejana community). They implemented amaranth cultivation and developed amaranth food products adapted to traditional Nicaraguan taste.

**Keywords:** Amaranth, cooperatives, cultivation practice, end-users, food security, industrial use, women

## Copper and Ascorbic Acid Content of Cooked African Indigenous Vegetables

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Increasing prevalence of micronutrient deficiency in developing countries is burdening the national and household resources. Changes in dietary patterns has contributed to the higher prevalence of micronutrient deficiencies. Indigenous foods especially plant foods are being replaced by high-fat, energy-dense diets with increased intake of animal foods and yet plant based foods especially African Indigenous Vegetables (AIVs) are rich in many micronutrients needed for healthy living. Diversification of diets through increased utilisation and consumption of these vegetables would go a long way in alleviating hidden hunger and malnutrition. The main objective of this research was to formulate recipes of African indigenous vegetables using traditional salt (lye) and evaluate their copper and ascorbic acid contents. This research sought to identify the effect of cooking on copper and ascorbic acid contents of AIVs. Four priority AIVs including: African nightshade (*Solanum scabrum*), vegetable amaranth (*Amaranthus blitum*), slenderleaf (*Crotalaria ochroleuca*) and cowpea (*Vigna unguiculata*) were randomly selected to formulate six more vegetable combinations where each vegetable had a probability of being combined with another. The four single and six combinations of AIVs were boiled for 10 minutes with or without traditional salt (lye), then fried using onions thus giving rise to twenty vegetable recipes. The formulated recipes were evaluated for copper contents using Atomic Absorption Spectroscopy (AAS) and vitamin C content using titration method. Data obtained were analysed using descriptive and inferential statistics. Cooking significantly increased copper content ( $p < 0.05$ ), however, fried AIVs had higher content compared to the boiled ones. There were insignificant mean differences in copper content between AIVs prepared with and those prepared without traditional salt ( $p > 0.05$ ). Fried AIVs recorded higher mean for ascorbic acid content compared to the boiled ones, while raw AIVs had slightly higher ascorbic acid content compared to AIVs boiled with traditional salt. Copper and ascorbic acid in these recipes were adequate to supply the recommended daily allowances (RDA). If AIV consumption is increased, this could reduce micronutrient deficiencies among vulnerable population.

**Keywords:** Ascorbic acid, copper, indigenous vegetables, lye, recipes



## The Instant Beverage Formulation Based on Small Crab Chitosan's (*Portunus pelagicus*) and Green Tea from Indonesia

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Produce chitosan from the small crab shells has become an alternative solution of some problems of water pollution in Indonesia. Chitosan, the polymer of N-glucosamine with  $\beta$ -1,4 bond, has a hypocholesterolemic properties by binding cholesterol, lipids, and several other lipid derivatives when pass through gastrointestinal tract, and secreting them into faeces. To develop a new food product using the small crab chitosan's, the formulation of instant beverage from small crab chitosan's (*Portunus pelagicus*) and green tea has been established. Green tea was selected because having a familiar taste, contrary with small crab chitosan's which is tasteless and novel. This combination has been expected to be able to produce the acceptable food product. Small crab chitosan's (degree of deacetylation 72.4 % and viscosity 19 cP) was produced by using the modified Suptijah method (1:14 vol. NaOH 50 % v/v, +140°C, 2 hours, air atmosphere, and aquadest as last washer). The instant beverage formulation has been done by running two sensory evaluation stages using 30 trained assessors. The first stage was established to formulate the most acceptable instant small crab chitosan's by using edible film technique producing 8 different recipes from full factorial design between solvent (acetic 1 % and lactic 1 % v/v) and sorbitol concentration as plasticizer (0, 2.5, 5, and 10 g l<sup>-1</sup>). And the second stage was established to formulate the most acceptable combination between instant small crab chitosan's (5 g l<sup>-1</sup>) and instant green tea (2.5, 5, and 10 g l<sup>-1</sup>). The acceptance and the preference were measured by using acceptance rating test (colour, aroma, texture, and taste) and overall simple ranking test in the both stages. The results showed that acetic 1 % v/v and sorbitol 2.5 g l<sup>-1</sup> produced the most acceptable instant small crab chitosan's. In the second stage, 5 g l<sup>-1</sup> instant small crab chitosan's and 2.5 g l<sup>-1</sup> instant green tea has been chosen as the most acceptable combination. Further assessment of functional effect from this new product still need to be developed.

**Keywords:** Chitosan, green tea, hypocholesterolemic, instant beverage, *Portunus pelagicus*, small crab

## Can Traditional Leafy Vegetables Reduce Protein and Micronutrient Malnutrition? A Look at the Nutritional Quality of Cowpea Leaves for two Landraces Grown in Uganda

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Although there are many causes of malnutrition in Uganda, adequate consumption of green leafy vegetables like cowpea (*Vigna unguiculata*) leaves, which are rich not only in protein but also mineral elements, offers a chance to reduce this prevalence especially for the resource-poor subsistence farmers. However, the nutritional contents of cowpea leaves for the two landraces (“Icirikukwai” and “Ebelat”) most widely grown in Uganda had never been documented.

This study was carried out in eastern Uganda during the first cropping season of 2008. It involved planting the two landraces in intercrop with maize at three sites in the villages of Serere, Kikota and Kogili. The trials were laid out in a complete randomized block design with three replications for each treatment. Tender vegetable leaves were regularly harvested starting at four weeks after planting and continued after every two weeks until flowering. Near Infrared Reflectance Spectroscopy (NIRS) was used to determine the crude protein content and iron concentration of sun-dried leaf samples from the second leaf-harvest of each trial.

ANOVA for the leaf crude protein content and iron concentration data was carried out using the SYSTAT procedure GLM. Mean leaf crude protein content (%) for “Icirikukwai” and “Ebelat” were 32.4 and 29.0 at Kikota, 32.8 and 31.8 at Kogili and 33.9 and 33.0 at Serere respectively. Mean iron concentrations ( $\mu\text{g/g}$ ) were 222.7 and 203.1 at Kikota, 475.0 and 428.2 at Kogili and 300.8 and 306.8 at Serere for “Icirikukwai” and “Ebelat” respectively. The absence of phytic acid in cowpea leaves increases the bioavailability of nutrients like calcium and iron, which are usually bound to phytic acid. Though not analysed in this study, Towett (2008, unpublished data) found that  $\beta$ -carotene values of young cowpea leaves of “Icirikukwai” collected from Serere ranged from 8.2 to 30.5 mg per 100 g DM.

Cowpea leaves are available as food, throughout the cropping season and thus, help to improve food security. Its nutritional benefits, thereby, make cowpea leaves an indispensable tool, when targeting to improve the nutritional health of the resource-poor subsistence farmers in Uganda.

**Keywords:** Cowpea, crude protein, dietary diversification, iron, leafy vegetables

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## Migration and Household Food Security Interlinkage: A Case Study in the Mid Hills of Nepal

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For decades achieving household level food security has been a major goal for the Government and the people of Nepal alike. The farming sector has been projected as the sector responsible for achieving this objective. However, meeting household food requirements from own production is becoming difficult due to the subsistence nature of farm production and the declining farm sizes. Therefore, in the last decade households are increasingly seeking options outside the farm sector to meet their food requirements. The weak industrial sector does not provide many opportunities to the rural farm households to make a living locally. Hence, migration is increasingly being used as an important livelihood strategy by the rural farm families. Thus, food insecurity is one of the main causes of migration and in turn, migration impacts the household food security situation.

This study focuses on exploring the interlinkage between international migration and household food security using household data from 509 farm households in two districts in the mid hill regions of Nepal. The data comprising of the migrant and non migrant households was analysed using the two stage least square regression with instrumental variables to solve the problem of reverse causality.

The findings of the study indicate that overall migration helps in improving the food security situation of the households. However, the extent of impact depends on the amount of remittances the household receives. In the richer district Syangja, with households receiving bigger remittances, migration showed significant positive impact in lowering the number of food insecure months. But in the poorer district Baitadi, with lower remittances, the impact was positive but not statistically significant.

The result of the study draws the attention of the policy makers towards the importance of migration on the farm households in fulfilling their basic food requirements. The old notion of attaining household food security through own production needs revision and consideration of other household resources such as the human resources in achieving food security seeks immediate attention. On the other hand, the results also points out to the danger of the poor falling into the poverty trap with increase in migration.

**Keywords:** Food security, migration, Nepal, remittances

## Traditional Strategies to Cope with Households Food Insecurity in Marginalized Quarters of Elobeid City, Sudan

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The focus of the current paper is to identify traditional food strategies adopted by poor households to mitigate food insecurity in North Kordofan State (western Sudan). These comprise adaptive mechanisms, coping strategies and survival ones. The paper adopted descriptive, regional, political and historical approaches towards quantifying and analysing collected data in relation to food insecurity in the region. The approaches relied on primary and secondary data. The primary data were collected using questionnaire, focused group discussion and personal observation with the aid of digital devices. Stratified random sampling technique was performed. About 50 % of households (3820) were sampled from selected marginalised quarters that accommodate poor segments of population in Elobeid city- North Kordofan State. Results revealed important traditional strategies that were practised by targeted households to cope with food insecurity. These were expressed by reducing number of meals (50 %), changing food habits (26 %), accessing informal loans (12 %) and relying on reliefs or other in-kind donations (12 %). Furthermore, income earning strategies were exemplified by involvement of large proportion (81 %) of households in multiple jobs, migration to urban centres (8 %), dependence on relatives (7 %) and liquidation of household's assets (4 %). Therefore, all these traditional strategies have acquired partial (37 %) success in mitigating food shortage and in increasing households' income in the study area. Thus, most of the adopted traditional strategies by targeted households were categorised as coping strategies rather than adaptive mechanisms or survival ones. Ultimately, the current paper reached to some recommendations for strengthening household food security in the area. For instance, improving households storage facilities for local agricultural products will presumably help in establishing a nucleolus for buffer stock at the state level.

**Keywords:** Adaptive mechanisms, coping strategies, food insecurity, survival strategies

## Is there an Urban Market Niche for Vegetables from Tribal Jharkhand, India?

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In Jharkhand, AVRDC, The World Vegetable Center, is promoting vegetable production among tribal communities with the goal of diversifying diets and improving household nutrition. Over time, farmers also may be able to generate income from commercial vegetable production if suitable market opportunities are identified. AVRDC, The World Vegetable Center's Regional Center for South Asia, advocates integrated pest management (IPM) for safe vegetable production, and when IPM is successfully adopted, suggests that vegetables be labeled as "safely produced." However, little is known about consumers' shopping preferences in Jharkhand and neighbouring West Bengal. This study focuses on consumers' vegetable shopping behaviour, their awareness and knowledge about health risks, quality labels, and criteria of importance when buying vegetables. It also elicits their willingness to pay for "safely produced" and "certified organic" eggplant and cauliflower, and integrates constructs from the theory of planned behaviour to gain a better understanding of consumer choices. A standardised questionnaire was translated into Hindi and Bengali, back-translated and pre-tested before being administered by trained enumerators. Interviews (500) were conducted with vegetable shoppers at stratified randomly selected market places in Ranchi, Jharkhand's capital, and in the closest mega-city, Kolkata. Respondents buy the majority of vegetables (86 %) at daily wet markets and purchase an estimated 289 g/capita/day of vegetables on average. An average household spends 33 % of total monthly food expenses for vegetables (US\$ 0.21 /capita/day). Important selection criteria are good visual appearance, cleanness, and low price, while packaging, the presence of a quality label, and geographical origin play a minor role. Respondents are willing to pay 9 % more for "safely produced" and 16.6 % more for "certified organic" vegetables. The theory of planned behaviour model is able to explain 35 % of the variation in consumers' intention to purchase "safely produced" vegetables. These results are discussed in comparison to models using additional variables as well as a structural equation model. While the present results hint at a potential market for "safely produced" vegetables, they must be evaluated in light of the actual costs of producing and marketing this type of quality vegetable.

**Keywords:** Certified organic, consumer preference, contingent valuation, India, pesticide residues, structural equation modelling, theory of planned behaviour

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## A Micronutrient Powder Containing a Low Dose of Iron and Zinc together with a Phytase Active at Gut pH Reduces Iron and Zinc Deficiency in South African Children

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Micronutrient powders (MNP) are often added to complementary foods high in inhibitors of iron and zinc absorption. Most MNPs compensate for this by including high amounts of iron and zinc, but it is no longer recommended in malarial areas to use untargeted MNPs that contain the RNI for iron in a single serving.

To test the efficacy of a low iron and zinc (each 2.5 mg) MNP containing iron as NaFeEDTA, ascorbic acid and an exogenous phytase active at gut pH.

In a double-blind controlled trial, iron-deficient South African school children (n=200) were randomised to receive either the MNP or the unfortified carrier (dextrose) added just before consumption to a highly-inhibitory maize porridge 5 days per week for 23 wk; primary outcomes were iron and zinc status, a secondary outcome was somatic growth.

Compared to the control, the MNP increased serum ferritin (SF) ( $p < 0.05$ ), body iron stores ( $p < 0.01$ ) and weight-for-age Z scores ( $p < 0.05$ ); it decreased TfR ( $p < 0.05$ ), the prevalence of iron deficiency by 30.6 % ( $p < 0.01$ ) and the prevalence of zinc deficiency by 11.8 % ( $p < 0.05$ ). Absorption of the iron from the MNP was estimated to be 7–8 %.

Inclusion of an exogenous phytase in a MNP together with NaFeEDTA and ascorbic acid may allow significant reduction in the iron dose from existing MNPs, while still delivering adequate iron and zinc. An additional advantage of this MNP formulation is it will likely enhance absorption of the high native iron content of complementary foods based on cereals and/or legumes.

**Keywords:** In-home fortification, iron, phytase, phytic acid, zinc

## The Effect of Bean Polyphenols on Human Iron Absorption

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**Background:** Low iron absorption from common beans contributes to iron deficiency in countries where bean is a staple food. High levels of phytic acid (PA) and polyphenols (PP) inhibit iron absorption, however the effect of bean polyphenols on iron absorption in humans has not been demonstrated and, with respect to variety selection, the relative importance of PP is unclear.

**Objective:** With the overall aim of increasing the intake of bioavailable iron from beans by plant breeding strategies, this project evaluates the relative importance of polyphenols on iron bioavailability from beans in humans. Two stable iron absorption studies were carried out. Study one evaluated the potential dose dependant effect of bean polyphenols on iron absorption and study two was conducted to evaluate if the effect of polyphenols is overruled by the inhibitory effect of phytic acid in a bean consuming population.

**Design:** In study 1, three different amounts of bean hulls, as the source of polyphenols, were added to a non inhibitory test meal and iron absorption was measured. 48 subjects were randomly assigned to three groups of 16 subjects each. Group A received 20mg, group B 50mg and group C 200mg of bean polyphenols (expressed in Gallic acid equivalents; GAE). In study 2, two different bean varieties, with the same iron and phytic acid contents, but with strongly differing polyphenol concentrations (5:1) were fed and absorption was measured. 20 subjects from Butare, Rwanda were randomly assigned to begin with the high or the low polyphenol bean.

**Results:** Study 1: Iron absorption was lowered by 14 % with 50 mg GAE ( $p < 0.05$ ); and by 45 % with 200 mg GAE ( $p < 0.001$ ). The results of study two are summarised in Fig. 1. Iron absorption from the low polyphenol bean was 4.7 % and absorption from the high polyphenol bean was 27 % lower ( $p < 0.002$ ); equivalent to 3.4 %.

**Conclusion:** In countries where beans are a staple food, PP content should be considered when selecting bean varieties for human consumption.

**Keywords:** Biofortification, common bean, iron, polyphenols

## **Afebrile *P. falciparum* Parasitemia decreases Absorption of Fortification Iron but does not Affect Systemic Iron Utilisation: A Double Stable Isotope Study in Young Beninese Women**

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Anemia affects many young women in sub-Saharan Africa. The aetiology of anemia in Africa is multifactorial, but the major cause is low dietary iron bioavailability from monotonous, cereal-based diets exacerbated by chronic parasitic infections such as malaria. Malaria causing chronic inflammation and therefore reducing iron bioavailability could be the reason for the blunted effect of iron fortification in fortification trials in sub-Saharan Africa. Many women in malaria endemic areas do not develop acute febrile malaria when infected with *P. falciparum*; rather, they exhibit asymptomatic parasitemia which has an unpredictable and often protracted course. Asymptomatic parasitemia potentially could reduce iron absorption and/or utilisation by causing subtle inflammatory changes. Therefore we measured the effect of asymptomatic parasitemia on host iron absorption and utilisation.

The study site was Natitingou in northern Benin. Subjects were: 1) female; 2) age 18–30 y; 3) body weight < 65 kg; 4) not pregnant or lactating; 5) no chronic medical illnesses; 6) no medicinal iron at the time of entry into the study; 7) a positive malaria smear (asexual *P. falciparum* parasitemia > 500/μL blood without clinical symptoms; 8) no soil-transmitted helminthes infection. Iron absorption and utilisation was measured using stable isotope technique. Subjects were studied while infected, then they were treated, and then they were restudied.

Clearance of parasitemia was associated with a reduction in low-grade inflammation, with a slight improvement in erythropoiesis and a significant 70 % increase in dietary iron absorption. No effect on systemic utilisation of iron was observed with clearance of parasitemia.

Asymptomatic malaria may exacerbate nutritional iron deficiency by limiting iron absorption from diets that are already low in bioavailable iron. Thus the benefit of intermittent treatment of malaria on anemia rates is not only due to the suppression of acute malarial anemia, but also to the periodically clearance of asymptomatic parasitemia and thereby improving dietary iron bioavailability.

**Keywords:** Anemia, benin, iron absorption, iron utilisation, malaria

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## **Malnutrition of the Children Less than Five Years as a Result of Protein and Energy Deficiency in Khartoum Province**

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Malnutrition is a common health problem in the third world of which Sudan is no exception. Most of these problems results as a consequence to the lack of nutritious food or the food mishandling. The main goal of this research was to investigate the reasons underlying the phenomenon of malnutrition of the children less than five years in Khartoum Province. To address this problem, 30 children in Khartoum hospital were subjected to investigations. Furthermore, questionnaire was prepared to obtain additional data from the mothers of the target group. The results from this study showed that malnutrition under such age was strongly linked to the social and economical situation of the families in addition to the family size and education level of the mothers. Moreover, this malnutrition was partially related to the mother's practices towards their children nutrition during diarrhea problem which is the second most common cause of infant deaths worldwide. An important finding in this research is the strong associations of malnutrition for the children at this age and the incomplete breast feeding periods. This study came out with some suggestions for the mothers as well as the responsible authorities for the improvement of the nutritional status of the children. These recommendations suggested that amelioration of the health level in the study area, this target could only be achieved by providing clean water and food to the people in addition to creation of the developmental projects which might make available more chances for work for income improvement of the families. Above all the study proposed that the health culture is essential for the mothers to be well aquatinted with these problems.

**Keywords:** Malnutrition, nutrition, Sudan, young children

## Mali's Vegetable Food System: Constraints and Opportunities

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Although vegetable production contributes to the economy of Mali, improves household income, and promotes food and nutritional security, vegetable consumption remains low. This study identified major constraints to vegetable systems in Mali and opportunities for improvement as the first step in developing a strategy to increase vegetable production and consumption for better health. Data on farmers' production characteristics, vegetable preference, and socio-cultural factors were collected through household surveys, focus group discussions, and direct observation of the living conditions of the interviewees. Eighty households were surveyed in the target sites in rural (Guena, Kirina) and peri-urban areas around Bamako (Kati, Baco Djicoroni) during the dry season from December 2009 to January 2010. Secondary information was obtained from a review of past studies and discussions with key informants (extensionists and scientists). The main vegetable production season in Mali is from December to March. The area cultivated by men is 100 m<sup>2</sup> to 1.5 ha; by women, 10 m<sup>2</sup> to 900 m<sup>2</sup>. The profile shows full-time producers in urban areas and part-time producers in rural areas. Most production is for local markets; only a small part (5–20 %) is consumed at home. Prices are variable and depend on the season: they can be as low as \$ 0.20 per kg at the peak harvest period and as high as \$15 per kg during the low production period. Revenues from vegetable gardening are used to pay for food, school fees, and family celebrations. Millet, sorghum, or maize porridge is eaten in the morning. At lunch, meals are also based on cereals, usually solidified porridge or couscous, with sauce made of tomatoes, onion, amaranth, gourd, roselle, baobab leaves, eggplant, okra, or groundnuts. Vegetable consumption is higher in towns where dietary habits are shifting due to economic status, changes in lifestyle and cultural patterns, and access to a greater diversity of foods. Major constraints to production are limited accessibility to inputs, a lack of vegetable seed, and a lack of varieties with high nutritional value. AVRDC works to address these constraints by selecting and improving vegetable lines for year-round production, and by promoting greater consumption of vegetables in Mali.

**Keywords:** Consumption patterns, food security, vegetable production

## Opportunities for Domestication of the African Baobab Tree (*Adansonia digitata* L.) in Mali

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Last decades, research on domestication of indigenous fruit and nut trees has been intensified in order to improve food security, nutritional status, household income, entrepreneurial opportunities and economic improvement of rural livelihoods. Up till now, most studies have focused on the humid tropics while semi-arid regions received much less attention. However, precisely this savannah environment is the habitat of the baobab tree (*Adansonia digitata* L.), a multipurpose, widely-used species with numerous medicinal and nutritional properties. Baobab trees remain underutilised, as production depends on unimproved, 'wild' plant material. Domestication, including the characterisation, propagation and dissemination of plant material with improved properties, will help to protect the baobab tree and the related food supply.

Baobab fruit pulp has been shown to be extremely rich in vitamin C. Therefore, baobab food products can improve food security in areas where people are still malnourished and suffer from an unbalanced diet. However, this vitamin C content seems to depend on genotype and location.

Therefore, in this study, we focused on pulp characterisation, in terms of mass and vitamin C content, as pulp is considered the most widely used and most valuable part of the fruit. 269 trees were sampled in ten provenances in Mali. From each tree, five fruits were harvested.

Across the study area, both pulp characteristics show a large variability, offering opportunities for selection of trees with improved properties. Within-provenances variability is significant, indicating that a restricted improvement in fruit properties is possible on a local scale. It seems feasible, however, to double mean pulp yield and vitamin C-content by selecting elite trees, which are only found in specific locations. Our results show the potential for the identification of baobab trees with improved properties in Mali, offering great opportunities for cultivar selection. As a consequence, an interregional and/or internationally-coordinated approach will be needed for the development of superior cultivars, focusing on a combination of both high yield and vitamin C-content of the pulp. In the end, the implementation of these cultivars in farmers' fields, should lead to socio-economic benefits, and thus an enhancement of West-African rural livelihoods.

**Keywords:** Food security, underutilised tree species, vitamin C

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## Human Zinc Nutrition in Central Iran

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Zinc (Zn) deficiency can significantly affect human health. It is a risk that mainly occurs in populations dependent on cereals and having little or no access to animal products. Bioavailable concentrations of Zn are usually low in cereal grains due to the presence of phytic acid (PA). In this study, we investigated the contribution of Zn from the dietary food supplies of two test populations in central Iran and compared it with associated international reference values.

A dietary survey was performed in 28 and 25 randomly selected households of a rural and a sub-urban community, respectively, using the method of three-day weighed food records. The consumption of meat and dairy products, providing highly bioavailable zinc, differed considerably between households, depending primarily on economic conditions. This was more evident in the suburban population, where variations in the economic conditions were larger than in the village. The Zn and PA contents of staple cereal-based foods such as bread and rice, and staple pulses, as well as the Zn content of commonly consumed dairy products and meat were determined. Although the Zn levels were moderately high in rice, bread and staple pulses, the PA to Zn molar ratios were above the levels expected to cause a major reduction in zinc absorption. While the average total Zn intake of both populations was estimated as 10 mg d<sup>-1</sup>, the bioavailable Zn intakes were reduced to 5 mg d<sup>-1</sup> and 7 mg d<sup>-1</sup> for the rural and the sub-urban populations, respectively. The total Zn intake of males and females  $\geq 15$  years of age averaged 12.5 mg d<sup>-1</sup> in the village and 11.5 mg d<sup>-1</sup> in the sub-urban area. Comparing these results with the recommended daily allowances (RDA), both groups had average intakes below the recommended values. Compared to the estimated average requirements (EAR), which represents the dietary intake level at which 50 % of individuals would meet their physiologic requirement, the male's average Zn intake was lower than the respective reference value, while for the females it was slightly higher. Serum Zn concentrations are currently under analysis as complementary data to evaluate the Zn status of the considering populations.

**Keywords:** Bioavailable, food, Iran, Zn intake

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# Natural resources Management

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# Nutrient cycling and crop nutrition

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## Improving Soil Zinc Bioavailability in Response to Crop Residues and Wheat Zn Efficient Genotype

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Zinc (Zn) is an important micronutrient in human diet because of different anatomic and physiologic functions in human bodies. Zinc deficiency in human results from diets that are low in bioavailable Zn especially when cereals and legume are stable food that are mainly cultivated in Zn deficient soils. In arid and semi-arid regions like Iran, soils are high in total zinc but readily plant available Zn is limited due to soil properties. High pH, alkalinity and phosphor are main reasons for low Zn bioavailable in these areas.

Soil organic matter has a variety of direct and indirect influence on the phytoavailability of micronutrients in soil and their uptake by plants. They are considered as an important source of several micronutrients like Zn. The affect of organic matter depend on dissolution of Zn-organic complex. In calcareouse soils like Iran, organic acids produce during crop residues decomposition may increase plant Zn uptake by dissolving Zn from solid phase to soil solution. In most of arid and semi-arid regions, very little or no crop residue is left in the field and most of them used as animal food or fired in the field. Zn availability in Iranian soils can be improved by making combination between these organic residues and Zn efficient wheat genotypes.

For this reasons a project was conducted with the following aims: 1. Evaluating different common crop residues in Iran including safflower, sunflower, bean, clover and sorghum on bioavailability of Zn during wheat cultivation; 2. Investigating the effect of Zn efficient genotypes in contrast with non-efficient genotypes on chemical properties of rhizosphere in related to Zn availability; 3. Assessing the DOC concentration in response to plant residues and wheat genotype as an important factor for Zn bioavailability. The results including Zn concentration, DOC, pH and microbial respiration in soil during wheat growth, are being analysed and will be prepared and presented.

**Keywords:** Crop residues, wheat, Zinc, Zn-efficiency



## Consequences of Sequential Leaf Harvest on Root Yield and N Export of two Cassava Cultivars in South-central Cameroon

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Cassava leaves are widely consumed in central African countries as a leafy green vegetable rich in protein and vitamins. In Cameroon, leaves are harvested sequentially at high frequencies throughout the year by breaking the shoot where the youngest mature leaf is inserted.

In a researcher-managed factorial harvest frequency  $\times$  variety trial, effects on root yield and N export were studied. The CMD resistant variety 'TMS 92/0326' produced 32 t ha<sup>-1</sup> fresh roots when shoot tips were not removed (control), 29 t ha<sup>-1</sup> when shoot tips were removed at 3 month intervals (low frequency) and 17 t ha<sup>-1</sup> when shoot tips were removed at monthly intervals (high frequency). The local, CMD susceptible variety 'Automatique' produced 21 t ha<sup>-1</sup> in the control, 13 t ha<sup>-1</sup> at low frequency and 10 t ha<sup>-1</sup> at high frequency. Cumulative fresh shoot tip yields of TMS 92/0326 were 6.1 and 16.1 t ha<sup>-1</sup> at low and high frequency, respectively. 'Automatique' produced 2.4 t ha<sup>-1</sup> and 6.8 t ha<sup>-1</sup> at low and high frequency, respectively, representing 39 % and 42 % of the yields attained by TMS 92/0326. 'Automatique' had a stronger negative response in storage root production to shoot tip removal (-8.9 t ha<sup>-1</sup> per t removed shoot tips) than TMS 92/0326 (-6.8 t ha<sup>-1</sup> per t removed shoot tips).

Nitrogen export through biomass removal (leaves, roots and planting sticks) by TMS 92/0326 was 172 % higher ( $p < 0.1$ ) than by 'Automatique' and related to higher biomass removal, not to differences in N concentration. With the leaves of TMS 92/0326 15, 89 and 197 kg ha<sup>-1</sup> of N were exported, in the control, low and high frequency treatment respectively.

Although leaf harvesting reduces root yield, it strongly increases N exports. In cassava dominated cropping systems using improved varieties and frequent leaf harvesting regimes, methods to replenish N should be given strong attention. The introduction of improved varieties should thus be accompanied by technologies supporting soil N buildup. Research on cassava - green legume rotations is underway at IITA Cameroon.

**Keywords:** Agronomy, cassava, exports, leaf harvest, Nitrogen

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## Does Combined Application of Crop Residues and Inorganic Fertiliser Lower Emission of N<sub>2</sub>O from Soil?

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Emissions of N<sub>2</sub>O were measured following addition of <sup>15</sup>N-labelled residues of *Vigna unguiculata* (cowpea), *Mucuna pruriens* and *Leucaena leucocephala* to a Ferric Luvisol from Ghana at a rate of 100 mg N kg<sup>-1</sup> soil under controlled environment conditions. Residues were also applied in different ratio combinations with inorganic N fertiliser, each combination applied at a total rate of 100 mg N kg<sup>-1</sup> soil. N<sub>2</sub>O emissions were increased after addition of residues, and further increased with combined applications of residues and inorganic N fertiliser. However, <sup>15</sup>N-N<sub>2</sub>O production was low and short-lived in all treatments, suggesting that most of the measured N<sub>2</sub>O-N was derived from the applied fertiliser or native soil mineral N pools. There was no consistent trend in magnitude of emissions with increasing proportion of inorganic fertiliser in the application. The positive interactive effect between residue- and fertiliser-N sources was most pronounced in the 25:75 Leucaena:fertiliser treatment where 22.5 g N<sub>2</sub>O-N m<sup>-2</sup> kg biomass<sup>-1</sup> was emitted over 30 days. N<sub>2</sub>O (log<sub>e</sub>) emission over the 30 day experiment from all residue amended treatments was positively correlated with residue C:N ratio ( $r=0.63$ ;  $p < 0.05$ ), and negatively correlated with residue polyphenol content ( $r=-0.59$ ;  $p < 0.05$ ), polyphenol:N ratio ( $r=-0.61$ ;  $p < 0.05$ ) and (lignin+polyphenol):N ratio ( $r=-0.61$ ;  $p < 0.05$ ), indicating the role of residue chemical composition, or quality, in regulating emissions even when combined with inorganic fertiliser. Under our controlled experimental conditions the 75:25 residue: fertiliser ratio appeared to offer the best compromise between release of N and management of N<sub>2</sub>O emission, but the positive interactive effect even in this treatment means that it is unlikely that combined applications of residues and inorganic fertiliser can lower N<sub>2</sub>O emissions, unless the residue is of very low quality promoting strong immobilisation of soil mineral N.

**Keywords:** Crop residues, inorganic fertiliser, nitrous oxide, stable isotopes, tropical soil

## **Integration of *Canavalia brasiliensis* into the Crop-livestock System of the Nicaraguan Hillsides: Environmental Adaptation and Nitrogen Dynamics**

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Due to population growth in the rural poor areas of the Nicaraguan hillsides, land use has been intensified in a way that adversely affects soil fertility. Crop and livestock productivity have therefore declined, leading to decreased income and food insecurity. Nitrogen (N) is the nutrient most limiting crop production in the area. To sustain agricultural production, the drought-tolerant cover legume *Canavalia brasiliensis* (canavalia) has been introduced as green manure and forage into the traditional maize-bean-livestock system. Different aspects of this introduction were studied in order to check the sustainability of the proposed technology. On-farm, environmental adaptation and impact of canavalia on system N budgets were assessed. On-station, its benefits for the subsequent maize were determined using <sup>15</sup>N-labelling techniques. Biomass production varied between 448 and 5357 kg ha<sup>-1</sup>, and was significantly affected by the carbon and N content of the soil surface horizon, the amount of clay and stones in the whole profile, and the soil depth. Canavalia derived in average 69 % of its N from the atmosphere. Although it increased the N balance of the rotation when used as green manure, the system N budget remained negative without mineral fertiliser application. When used as forage, it bears the risk of soil N depletion unless N would be recycled to the plot by animal manure. Maize recovered 12 % of N from canavalia residues, while most of it remained in the soil, building soil organic matter stocks.

In conclusion, it can be stated that the integration of canavalia in the Nicaraguan hillsides is on track, but there are still knowledge gaps to be filled in order to be able to make the most of canavalia attributes. Indeed, farmers will most likely use canavalia as forage but recycling of animal manure to the plot is not yet current practice and the fertiliser value of this manure has not been determined. The question of the biophysical trade-offs of using canavalia as forage or as green manure still need to be complemented with N budget studies for different rotational sequences over several years and with studies aiming at optimising N use efficiency at farm level.

**Keywords:** <sup>15</sup>N isotope techniques, *canavalia brasiliensis*, crop-livestock systems, N budget

## Site-specific Organic and Conventional Crop Yields in a Long-term Farming Systems Comparison in Sub-humid Central Kenya

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Organic farming is increasingly being taken up by farmers and agricultural development agencies in tropics. This is in a bid to improve world food security and rural livelihoods in a sustainable way. Long-term field trial that compares organic and conventional systems was set up in sub-humid central Kenya since 2006 to provide a scientific basis for organic agriculture in the region. The project seeks to gather data on how organic farming affects: yield and yield stability; stability of the agro-ecological system; and natural and economic resource efficiency. The experiments were set up at two sites namely Chuka and Thika. Both sites are at an altitude of 1500 m asl. While Chuka lies in a high potential area with 2000 mm of rainfall and good soil phosphorus availability, Thika has fair yield potential, 1000 mm rainfall and low phosphorus availability. Crop rotations include maize, beans and vegetables.” The trials compares organic and conventional systems at two input levels, namely subsistence and commercial levels, resulting in four treatments: Conventional high input, organic high input, conventional low input and organic low input.

In Chuka, organic yields were on average the same as conventional yields. On the low potential site of Thika, organic yields reached an average 55 % of the conventional yields. Organic yields on the low input level were on average 13 % lower than conventional yields on the low input level. On the high input level, organic yields were on average 26 % lower than conventional yields. Organic maize yields achieved on average 77 % of conventional maize yields, whereas organic brassica yields were 66 % lower than conventional brassica yields. No significant difference was observed between mean organic and conventional legume crop yields.

Our results suggest that: on high potential site of Chuka, organic crops can be grown without yield reduction; on low potential site of Thika, especially if low nutrient availability coincide with low rainfall, considerable yield reductions must be expected in organic systems in the transition phase; low input systems are less sensitive to conversion to organic agriculture than high input systems and relative yield levels in organic systems vary between crops.

**Keywords:** Conventional farming, high input systems and low input systems, organic farming, yield potential

## **Socio-technical Analysis of Fertiliser Use for Wheat Crop in Hyderabad District of Pakistan**

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Rapidly increasing population and changes in the eating habits of people has put a pressure on worldwide food production. It is expected that world population can increase by 40 % in the year 2050. To meet food requirements for such a larger and more affluent population, annual cereal production needs to increase by 40 % in year 2025. This much increase in food production will require intensified production since the amount of available land is finite. Mineral nutrients are the major contributor to enhancing crop production. However, imbalance and non-judicious use of nutrient fertilisers have limited crop production and quality. The objective of the current study was a) to assess in quantitative terms farmers' perceptions about fertiliser use for wheat in Hyderabad district of Pakistan and b) to evaluate how this fertiliser use improves the nutrient uptake in plants.

The northern part of the study area is cultivated with cotton-wheat rotation, which is widely practised, and the southern part is well known as sugarcane belt. A random sample of 181 farmers was surveyed for the farmer's perception about fertiliser application for wheat. Whole plant material above ground level during tillering stage of wheat and leaf sample at flag leaf stage was collected from the same farms for micro (Zn, Fe, Cu, Mn and B)- and macro-nutrient (N, P and K) analysis. The results of the survey show that 100 % of the farmers relied on urea and DAP to enrich soils with nitrogen and phosphate-nitrogen, respectively. Out of these, only 3 % of the farmers applied zinc sulfate to enrich the soils with zinc. They believe that urea and DAP would increase their yield whereas they don't apply any other fertiliser for enhancing micro nutrients. The analysis of plants is underway, however the preliminary results show that nutrients uptake in the plants is very low especially nitrogen, phosphorous, zinc and boron. Results and recommendations will be presented in detail during the final version of the paper.

**Keywords:** Fertiliser, nutrients, wheat, wine, nitrogen, Pakistan



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## Reduced Emissions from Deforestation and Forest Degradation (REDD): A Climate Change Mitigation Strategy on a Critical Track

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According to UN-FAO/ECE's Forest Resources Assessment (FRA) 2005, the world's forests store 283 gigatonnes of carbon in their biomass. The FRA 2005 however also shows that the destruction of forests adds almost two billion tonnes of carbon to the atmosphere each year. Following recent discussions, there is hope that a mechanism for reduction of emissions from deforestation and forest degradation (REDD) will be agreed by the Parties of the UNFCCC at their 16<sup>th</sup> meeting in Mexico in 2010 as an eligible action to prevent climate changes and global warming in post-2012 commitment periods. While the potential of REDD has been widely discussed, minor attention has been drawn to the implication of uncertainties and costs associated with the estimation of carbon stock changes. Countries introducing a REDD regime in order to generate benefits need to implement sound monitoring and reporting systems and specify the associated uncertainties. The principle of conservativeness addresses the problem of estimation errors and requests the reporting of reliable minimum estimates (RME). Here the potential to generate benefits from applying a REDD-regime is proposed with reference to sampling and non-sampling errors that influence the reliability of estimated activity data and emission factors.

The presentation shows a framework for calculating possible carbon benefits by including assessment errors. After the identification of several assessment errors, theoretical, sample based considerations as well as a simulation study for five selected countries with low to high deforestation and degradation rates show that even minor assessment errors may outweigh successful efforts to reduce deforestation and forest degradation. This leads to the conclusion that the generation of benefits from REDD is possible only in situations where assessment errors are carefully controlled.

**Keywords:** Deforestation, degradation, error, estimate, monitoring, REDD, RME, uncertainty

## Impact of Sustainability Standards on Jatropha Production in Tanzania: An Economic Land Evaluation Approach

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Biofuel feedstocks like *Jatropha curcas* have received a lot of attention in Tanzania in recent years. They are known for their potential to enhance rural energy supply but also as possible cash crops. With regard to exports, however, compliance with a number of sustainability standards is expected to get increasingly important.

This paper aims at (a) assessing the physical and economic land suitability of jatropha at different production sites; (b) identifying key indicators to analyse sustainability of the considered land use systems (c) expanding the analysis by including additional costs and benefits related to compliance with sustainability standards of the certification programme ISCC. The data derives from a survey of 320 smallholders in the village of Kinole (Morogoro district) as well as from a large-scale plantation in Kilosa.

Our calculations reveal that the ferral soil, which is the dominant soil in the Kinole region, is “moderately suitable” both for jatropha and banana (base-line). Given the very low rating of key indicators like cation exchange capacity, pH and base saturation, we recommend to couple the production of the feedstock with good management practices and to aim at a medium level of production intensity. This would be in line with the ISCC sustainability criteria and would require relatively low costs while simultaneously increasing the yields. However, certification costs may be considerable making it unlikely that smallholders will be able to participate without assistance from outside (e.g. through out-grower schemes). Further, even without certification, yields would have to increase substantially to reach the break-even point where exporting the feedstock out of the village gets viable.

In contrast, the monoculture system is expected to provide higher yields. All key indicators are in a good range and production of jatropha is sustainable even on a high input level as long as the detracted nutrients are replenished and the organic matter content is maintained. Compliance with the social criteria is related to higher costs for e.g. better safety practices and conducting a social impact assessment, but they are still within reason. Also here, the certification procedure itself is expected to be one of the major cost factors.

**Keywords:** Biofuels, certification, cost, Jatropha, land evaluation, sustainability

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## Performing Life Cycle Assessment and Zero Waste Application for Palm Oil Processing in Indonesia

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Palm oil which is a crucial raw material for foods and energy is one of the leading industries in Indonesia. With a yearly production of more than 19.4 million tons of crude palm oil, it is an industry to be reckoned with, also when it comes to environmental impacts. This assessment aims to perform Life Cycle Assessment on crude palm oil production in Indonesia including the stages of plantation, transport and milling. The data for the assessment was collected from different places in Kalimantan and Sumatra as main sites for palm oil production. The impact processes related to the plantation are the on-site energy use and production of artificial fertiliser. Pesticide use contributes a minor impact due to widely used integrated biological management. For transportation the only impact is from combustion of diesel and at the mill the boiler is the sole significant contributor through electricity production and negatively by emissions from the boiler. The results show that fertiliser production is the most polluting process in the system followed by transportation and the boiler emissions at a tie. The most significant impacts from the system are respiratory inorganics and depletion of fossil fuels, of which the boiler emission is the main responsible for the prior and fertiliser production and transportation are responsible for the latter. Alternative scenarios revealed that there are significant impact savings to be made by introduction of environmental investments, both regarding the overall impacts and in particularly regarding CO<sub>2</sub> emissions. Alternatives such as optimised use of organic fertiliser, approved filters at the mill boiler stack and biogas harvest from Palm Oil Mill Effluent digestion should be promoted in the industry.

**Keywords:** Artificial fertiliser, CO<sub>2</sub> emissions, life cycle assessment, mill effluent, palm oil

## **Are Livelihood Strategies Compatible with a Sustainable Management of Forest Fragments at the East Coast of Madagascar?**

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Since the first human settlement on the island of Madagascar, forest areas have continuously been decreasing, mainly due to shifting cultivation. By putting new forest management strategies and conservation activities into place, various governmental and non-governmental projects tried to counter this trend of deforestation. Until today those efforts have not succeeded to halt deforestation. A possible explanation for the failure of these projects is that most of the implemented strategies were based on western ideas of conservation and did not sufficiently take local livelihood strategies into account.

Our research project therefore focused on local livelihood systems and strategies in a forested landscape at the east coast of Madagascar. The methodology was based on the sustainable livelihood approach and we worked in four different villages situated around a large fragmented forest corridor. The aim was to understand the importance of forest fragments and its resources to the livelihood of the rural population, what influence deforestation has on people's livelihood and how they react on deforestation. Assuming changing importance of forest fragments depending on availability, we studied 4 villages situated in different distances to forest resources.

Our results show that although the overall importance of forest fragments is high, the interest to decrease deforestation activities remains very low. The awareness of the importance of forest resources only develops when forest fragments are already scarce. Most farmers, living far from forest resources have succeeded to adapt their livelihood strategies without suffering from a high impact on their livelihoods. Finally this research gives indications to what extent a sustainable forest management could be integrated in local livelihood systems. It highlights constraints and challenges to realise a successful improvement of forest management.

**Keywords:** Forest landscapes, livelihood, Madagascar, Tropical forestry

## Conservation Performance Payment Schemes: An Economic Incentive to Save the Declining State Forests in Developing Countries

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Little is known about conservation performance payment schemes in state forests in developing countries. Kakamega forest is a biodiversity-rich remnant of tropical rain forest located in a densely populated area inhabited by poor farming communities that heavily utilise non-timber forest products from Kakamega forest. To contribute to the efforts geared towards conservation of this unique ecosystem this study conducted an experiment in Kakamega forest with the emphasis of linking the forest adjacent community to the state forest. Conservation performance payment auctions were held in two villages around Kakamega forest with the main aim of enrichment planting in the state forest using funds raised from payment of forest user rights by the community. The Dutch- descending simultaneous open auction was used to allocate planting sites to the households in the selected villages that boarder the forest. The lowest bidders were awarded the contract. Payment was divided into two parts (i) Sixty percent down payment at the start of the contract (ii) The remaining 40 % was paid after a period of five months basing on the conservation score. The planted site was evaluated by the community and state agency based on the conservation score parameters. At the same time the state agency planted their sites using fixed rate payment. The results show that there was cost saving of 47 % in the community planted site and high seedling survival rate of 87 %. (Kibiri forest station) and 68 % (Kakamega forest station) for the two villages compared to fixed rate planted site with high costs and low seedling survival of 48 % at Kibiri forest station and 58 % Kakamega forest station by the state agency. Involvement of individual households in forest conservation on competitive bases could be a viable option to save the declining state of state forests in developing countries.

**Keywords:** Cost-saving and economic incentives, conservation performance payment

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## **Conflict of Use in Tropical Forests: The Impacts of Logging on Non-timber Forest Product Availability**

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Logging is a major economic activity in much of the moist tropics and increasing areas are being allocated to timber concessions. These forests, and the resources that they harbour, are also utilised by rural communities, including many indigenous forest peoples. The potential for integrating timber and non-timber forest product extraction has been discussed in the context of diversified forest management. However, where tropical forests are exploited both commercially for timber and by forest-dependent communities conflicts between these two uses may have significant implications for forest-dependant livelihoods. We draw on three case studies in Brazil, Cameroon and Indonesia to consider the livelihood consequences of commercial logging. Conflict of use, competition for resources, the facilitation of unsustainable NTFP harvesting and indirect impacts such as altered forest structure; all affect the availability of non-timber forest resources. Work in Brazil over a ten-year period of successive logging events revealed marked changes in consumption of valuable NTFPs, a consequence of both logging itself and associated fire. In Cameroon communities reported declines in the majority of exploited NTFPs, with significant income implications. In Indonesia the value of logged forest to local communities was found to be significantly reduced in comparison to primary forest. Despite significant impacts on livelihoods including income and health, we found evidence in each case of the potential for making timber extraction more compatible with subsistence use of NTFPs. These findings have significant implications for current policy aimed at reconciling timber and non-timber uses of tropical forests and we highlight specific opportunities for achieving greater compatibility.

**Keywords:** Brazil, Cameroon, diversified forest management, Indonesia, livelihood, multiple-use, NTFP, reduced impact logging, sustainable forest management, timber

## Modelling Stand Dynamics after Selective Logging: Implications for REDD and Estimations of Aboveground Carbon Pools from Forest Degradation

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Forest degradation and biomass damage resulting from logging is currently difficult to evaluate with satellite images, but contributes substantially to carbon emissions in the tropics. To address this situation, a post-logging stand development of a semi-deciduous natural forest in Cameroon was modelled for one felling cycle (30 years) after selective logging.

To simulate how different management practices influence post-logging forest dynamics, we modelled how changes in the minimum felling diameter (MFD) affect stem density, basal area and the related carbon biomass at the end of the felling cycle.

With these MFDs estimated, at 7 % logging damage rate, we found that the stem density of initially harvestable trees reduces from 12.3 (50.4 Mg C ha<sup>-1</sup>) to 6.7 (32.5 Mg C ha<sup>-1</sup>) trees per ha and the number of initial residual trees increases from 80 (18.9 Mg C ha<sup>-1</sup>) to 85.7 (36.8 Mg C ha<sup>-1</sup>) trees per ha. This corresponds to an avoided damage estimated at 17.9 Mg C ha<sup>-1</sup>. We also found that increasing mortality and damage intensity also increases the damage on carbon biomass estimated to be 8.9 Mg C ha<sup>-1</sup> at 10 % or to be 17.4 Mg C ha<sup>-1</sup> at 15 % logging damage.

Overall, our study shows that proper determination of MFD of logged species taking into consideration their capacity of reconstitution at the end of the felling cycle associated with Reduced Impact Logging (RIL) can avoid up to 35 Mg C ha<sup>-1</sup>. These estimations could be achieved if there is a combination of policy and measures allowing monitoring of forest development after logging.

**Keywords:** Carbon estimations, felling cycle, future prediction, logging damage, minimum felling diameter (MFD), moist tropical forest, species reconstitution



## Effect of the Adoption of REDD Policies on Household Fuelwood Use and its Impact on Forest Degradation: A Study of Kakamega Forest, Kenya

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Policies regarding reduced emissions from deforestation and forest degradation (REDD) currently being developed have the potential to deliver multiple benefits besides the reduction of GHGs levels such as biodiversity conservation and enhancing rural livelihoods as well as other ecosystem benefits. Like any other forest conservation policy, the adoption of REDD policies can result in the displacement of deforestation in non-targeted regions reducing the net conservation effect. While the Kenyan government largely succeeded in its efforts to control official deforestation by putting a ban on logging from public indigenous and plantation forests, illegal forest extraction continues to be a particular problem in the fuelwood sector as disperse and small scale activities are difficult to monitor. Fuelwood accounts for 80 % of Kenya's household energy use and could therefore exert major impacts on the forest resources. Studies have shown that forest degradation especially from the cutting of trees for charcoal burning is common in all public forests. We analyse potential displacement effects of more rigorous policy measures on the illegal fuelwood trade in Kakamega forest, Western Kenya. We do so by investigating the determinants of household energy use and estimating the supply and demand functions for communities living next to the forest. We further analyse the supply chain of charcoal in Kakamega town and its environs. The results of this study are derived from a stratified random sample of 300 households living in villages within five kilometres from the forest edge who were interviewed with a semi-structured questionnaire. To understand the trade in charcoal, 20 % of the charcoal traders were interviewed using a structured questionnaire. The main source of charcoal for the Kakamega region is the Rift Valley supplemented by some local production and some importation from Uganda. Preliminary results show that trees from the public forest account for more charcoal locally produced in this area than trees from private property. The small scale traders, especially those without a permanent selling point (hawkers) form the main entry point of charcoal obtained from the forest into the market.

**Keywords:** Charcoal trade, forest degradation, household fuelwood demand, Kakamega forest, REDD

## Estimation of Net Primary Production in the Transition Forest of South East Amazon

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The calculation of Net Primary Production (NPP) in tropical forests is of great importance for the estimation of the global carbon budget. While wet lowland forests are studied intensively little information is available on Amazon- Savannah transition forests despite their great ecological importance. We want to fill this gap with the investigation of non flooded (dry) and temporary flooded forest stands in the transition zone in South East Amazonia in Tocantins State, Brazil.

On an area of 2.25 ha 1227 and 1102 trees from dry and flooded forest respectively were included in the study. NPP was calculated from sum of increment of surviving trees, increment of recruits and quantity of fine litter fall. The increment of trees ( $>6.3$  DBH) was calculated by measuring height and diameter at two inventories with a time lag of five years. From this data we calculated the wood volume using allometric equations and converted this to biomass with specific wood densities. The litter fall was measured during this period monthly with 30 litter traps,

The biomass increment in dry forest areas was 70 % higher comparing to flooded areas. In both study areas the biggest part of total aboveground NPP was represent by litter fall and was 4.73 in the dry and 4.02 Mg C ha<sup>-1</sup> year<sup>-1</sup> in the flooded forest. The total aboveground NPP in the dry transition forest is calculated to 8.64 Mg C ha<sup>-1</sup> year<sup>-1</sup> what is 47 % higher compared to the flooded forest type. The quantity of NPP in dry transition forest from South East Amazon is comparable with the NPP in Central Amazon forests. The conservation of transition forest is important for regional and national forestry policies and total carbon budget.

**Keywords:** Carbon budget, net primary production, transition Amazon forest, tropical forest

## **Development and Implementation of a Holistic Assessment Scheme in the Scope of REDD: Results of a Case Study in Madagascar**

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On behalf of the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV) of Germany the Institute for World Forestry of the Johann Heinrich von Thünen-Institute (vTI) developed in collaboration with several project partners operational methods for the assessment of means of forest protection with regard to REDD in a pilot study in Madagascar.

The poster shows that implementing a viable REDD regime involves (i) initiating a system for the assessment of forest carbon stocks and their changes over time, (ii) quantifying the amount of reduced CO<sub>2</sub> emissions, which qualifies for accounting, and (iii) identifying and ranking of the relevant causes for human impact on forests, in order to derive effective measures to combat forests destruction.

The Institute for World Forestry developed an efficient inventory method for the objective periodical determination of deforestation and forest degradation and its resulting release of carbon from regional to national level. The method is based on the use of remote sensing data in combination with terrestrial inventories. Furthermore, contributions on the causes of deforestation and forest degradation (DD) in Madagascar and their potential of reduction were acquired on a regional level through interviews on the spot and through the application of statistical analyses identifying the main drivers of DD. The results of the pilot study show, that the developed methodology is applicable for reliable conclusions on a country's forest biomass stock and its development. The results for three assessment areas located in tropical wet evergreen, deciduous and dry forests in Madagascar are demonstrated and comprehensively discussed.

**Keywords:** Deforestation, degradation, driver, inventory, Madagascar, REDD, socio-economic

## **Analysis Pertaining to an Agent of Deforestation and Forest Degradation: The Smallholder Farmer on the Forest Fringe in Madagascar**

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The analysis pertains to a specific kind of agent of deforestation and degradation - namely the smallholder farmer on the forest fringe in Madagascar – and provides a basis for developing adapted incentives in the scope of REDD. In a context of poverty and of ambivalence between traditional and classic land tenure, Malagasy farmers are involved in land use change which endangers their environment and traditional way of life. The study analyses the needs of these rural households that lead to deforestation and forest degradation. It aims for developing adapted, viable and environmental friendly alternative land uses that respect the traditions of the local population and are financed through the carbon market. In 2007 and 2008, field data were collected on three regions which differ in their social and cultural characteristics and their forest types. Initially, the history of deforestation and forestry politics in Madagascar is examined. Interacting functions of the forest that respond to the needs of the farmers are described and uses of the forest are quantified. “Incomes from deforestation and forest degradation” and “non-forest income” opportunities are calculated. Afterwards, these values are compared to analyse the influence of endogenous and exogenous decision parameters and of the agent’s characteristics on forest use and farm output management. The study shows, among others, that the “poorest poor” are more dependent on deforestation and forest degradation while gaining less benefit from it than the “rich poor”. In the community forest management the “poorest poor” also have less influence on the decision process.

**Keywords:** Community forest management, farmers, incomes, land use, Madagascar, REDD

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## Study on Vegetation Structure, Biomass Production and Regeneration of Broad Leaved Forest in the Eastern Himalayan Region, Nepal

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The main aim of the study was to assess the anthropogenic impact on vegetation composition, biomass production and regeneration of tree species in mixed broadleaved forest of the Sargamatha National Park buffer zone areas. The forests were mainly differentiated into broadleaf disturbed forest (BLDF) and broadleaf semi-disturbed forest (BSDF) considering the scale of anthropogenic disturbances such as percentage of biomass extraction, logging, trampling coverage and grazing intensity. For each forest type, 10 m radius circular plots were laid for sampling trees, 5 m circular plots for sampling & shrubs, and 1 m x 1 m plots for seedling and herbs. In both forests, *Quercus semicarpifolia* and *Rhododendron arboreum* were the main dominant tree species; however, the extent of dominance of tree species differed considerably in each forest types. In both forest type density and basal area was high for *Q. semicarpifolia*. The distribution of *Q. semicarpifolia* and *R. arboreum* along with diameter classes showed high stem density mainly concentrated in 2–10 cm dbh class. In general, seedling-to tree ratio was high for *R. arboreum* in both types of forests. Seedlings of *Q. semicarpifolia* were almost absent in disturbed forest, and its ratio of seedling to tree was very low even in the semi-disturbed forest. The absence of regeneration of *Q. semicarpifolia* was reflected by the absence of seedlings in diameter class below 5 cm. The absence could be associated with the practice of biomass removal. Overall, tree species richness was high in less disturbed forest. The Shannon and Simpson indices were also high in less-human-impacted forest. The lower species diversity in the disturbed forest was probably due to comparative high human disturbance. The study found that *Rhododendron* species in the study sites were not frequently cut, browsed, or lopped due to religious believe and its ornamental value. Thus *R. arboreum* is expected to be slowly expanded if biotic pressure is maintained less. This may cause change in the vegetation structure. On the whole, managing the forest in an equitable and sustainable basis could satisfy basic needs and improve the livelihood of rural people in the study area.

**Keywords:** Broadleaved disturbed forest, broadleaved semi-disturbed forest, *Quercus semicarpifolia*, regeneration, *Rhododendron arboreum*, vegetation structure

## Stakeholder Analysis of Resource Use in Eastern Madagascar: Conflicts, Potential, Solutions

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The REDD-FORECA project researched avoided deforestation by analyzing land use patterns and agricultural behavior. This socio-economic analysis reveals the functionality and interaction of different stakeholders in their typical land use process. During two weeks 36 peoples of 8 villages in the East of Madagascar were interviewed (focus group & semi-directive interviews) to complete the quantitative parts of this project. Forests in the East of Madagascar were characterized by free access, so uncontrolled use of wooden products for daily life, deforestation for agricultural land use and unmanaged exploitation of precious hardwood were current. Forest degradation was mainly effected by slash and burn followed by erosion problems and loss of soil fertility. Perception of the population that their forest resources are decreasing becomes blurred. Anyway rainforests are seen as essential for life but local people have no idea how to manage this resource sustainably without the help of the government. Archaic methods of agricultural production (lack of fertilizer/machines/crop storage, one-sidedness of crops), lack of purchasing power and arbitrariness of some responsible persons are the main brakes of development progress in this region. Education, health care and nutrition are degrading while the population increases constantly. Furthermore the actual local political power is very focused on ancient traditions and customs. Another point is that previous projects were neither successful nor sustainable because they were not adapted to the conditions and needs of the local population. Beyond that a lack of project evaluation was visible.

Hence, this study suggests:

- Leaning first on local key persons to raise the sensitivity for sustainable resource management (forestry, agriculture, formation),
- To empower the people to engage in democracy and decentralization,
- Capacity building in agricultural management to guaranty self sufficiency by combining forestry and agriculture,
- To diversify the range of products by varying different crops, fruit trees and spice plants to diminish crop failure.

Therefore an exchange between local key persons of every village could be a motor of development as well as an obligatory evaluation period after every project.

**Keywords:** Deforestation, forest degradation, Madagascar, rice cultivation, shifting cultivation, slash and burn

## Do Planting Regimes Affect the Growth Performance of Native Timber Species in Pasture-Afforestation Systems Aiming at Improving Small-scale Farmers' Livelihood?

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Afforestation and reforestation may be considered in a new mechanism being developed under the United Nations Framework Convention on Climate Change known as REDD+ (reducing emissions from deforestation and forest degradation in developing countries). Tropical timber tree plantations established on former pasture might serve as long-term livelihood for livestock farmers providing valuable timber. Compared to exotic trees, native timber tree species may be more adapted to the local environment and show more positive effects on local biodiversity and ecosystem processes, but their successful establishment is often impeded by insect herbivores causing dramatic loss of seedlings in afforestations/reforestations. However, only little information exists on the selection of suitable species for productive performance, related key herbivore insects and their impact on the timber tree species as well as successful sustainable management strategies in reforestations.

Our study focuses on the effects of different planting regimes on establishment and performance of three native Central American timber species. Growth, survival and economical potential of *Anacardium excelsum* (Anacardiaceae), *Cedrela odorata* (Meliaceae) and *Tabebuia rosea* (Bignoniaceae) were quantified for the planting regimes 'monoculture', '3-species-mixture' and 'control' (mixture plots protected by insecticides), established in an experimental plantation in Central Panama. Furthermore, leaf damage by insect herbivores was assessed two years after planting.

Best performance was observed for *Tabebuia* in all planting regimes. *Cedrela* showed highest mortality, possibly due to high susceptibility to drought and unfavorable local conditions. Height- and diameter-growth were similar for *Anacardium* and *Cedrela*. Growth of all timber species was highest in the insecticide-protected control plots, indicating a relevant impact of insect herbivores on plant performance. This finding was supported by leaf damage patterns, which significantly differed between the planting regimes. Lowest damage, along with best tree performance, was found in insecticide-protected plots, indicating that pest control may be a major issue in reforestation of former pastures.

**Keywords:** *Anacardium excelsum*, *Cedrela odorata*, insect herbivory, pasture reforestation, REDD, *Tabebuia rosea*, timber tree performance

## Unintended Outcomes of Community Forestry Programmes in Nepal

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Nepal is one of the best known examples in the world for successfully implementing community based forest management system. It pioneered modern form of community forestry (CF) programme in 1978. Since then, CF is one of the single most prioritised programme in the country. The Ministry of Forest and Soil Conservation allocates more than 60 % of its development budget on CF programmes. Similarly, more than 75 % of the human and capital resources of the Department of Forests and related national and international forestry development projects, has been regularly involved in the development of CF programmes.

There are remarkable positive impacts of CF programmes not only within the forestry sector but also within other development sectors in the country. It has been very successful in maintaining greeneries, averting deforestation, enhancing peoples' livelihood, creating harmonious relationships between governmental agencies and rural population and more importantly advocating people participation in all forms of development activities.

Despite of all these successes, we cannot turn blind, dumb and silent towards few visible unintended outcomes of the programme and its implementation. Corruption in public funds and in sale of valuable forest products, in-transparency, inequity, massive interferences from political parties, exclusion of nearby and indigenous people, shifting encroachment and illegal activities towards government managed forest, neglecting the traditional rights of disadvantaged groups and some nomadic communities can engulf the successes of the programme in the long run.

This study is very important and new in its kind as it was entirely focused on assessing the unintended outcomes and externalities of the CF programme, reverse of the trend to run towards seeking only for achievements and successes. The study was mainly based on key informant survey, onsite observation, analysis of the coverage on public media and secondary information available on governmental and non-governmental organisations. The study will be very helpful for the concerned stakeholder to eliminate the implementing errors and policy level shortcomings. The findings will be instrumental in achieving sustainable forest management, good governance and broad based equitable development.

**Keywords:** Community forestry, governance, livelihood, participation, stakeholders



## The Impact of Non-timber Forest Products (NTFP) on the Livelihood of Rural Inhabitants: A Study of Communities in Forest Reserves in the Central Aceh and Bene Meriah, Indonesia

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This study assesses the contribution of the Non-Timber Forest Products (NTFP) on the livelihood of inhabitants in forest reserves located in the Central Aceh and Bener Meriah in Indonesia. The availability and vulnerability of the identified NTFP in the study area was also considered. A total of 25 inhabitants from 10 communities in the two districts were used for the analysis. The availability trend and the vulnerability to harvest about six important species of the NTFP were also considered. The selected species were; palm tree (*Arenga pinnata*), two rattans (*Calamus javensis* and *Daemonorops draco*), bamboo (*Bambusa* spp.) and two trees (*Aquilaria* sp. and *Pinus merkusii*). Data were obtained by using semi-structured questionnaires for open interviews with the farmers. Data analysis was carried out via descriptive and differential statistics. The results of the analysis show that NTFPs contribute immensely to the livelihood of the inhabitants in this area. For example, about 25 % of the respondents generate their monthly income through the harvest of NTF products. The study also observed that these products serve as a source of food, raw material for sugar production, crafts and other decorating materials. In addition to that, they provide aroma, colourant, equipment, and medicine for cultural purposes. The results also show that the species availability decreased e.g., *Calamus javensis* (86 %), *Daemonorops draco* (56 %), *Arenga pinnata* (50 %), *Aquilaria* spp. (28.6 %), *Bambusa* spp. (25 %), to *Pinus merkusii* resin (0 %). We observed that *Aquilaria* spp., *Arenga pinnata* and *Calamus javensis* are the most vulnerable to harvest whilst *Bambusa* spp., *Daemonorops draco* and *Pinus merkusii* are the least vulnerable to harvest.

**Keywords:** Forest reserve, livelihood, NTFP, vulnerability

## Necessity or Lucre? Poverty and Deforestation at the Household Perspective

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One of the major sources of deforestation is the expansion of agricultural areas by smallholders. The purpose of this paper is to explore the underlying factors which drive rural households to clear natural forest for the cultivation of crops. By analysing deforestation on the household level, we are able to overcome limitations of higher aggregated models of land-use change which often fail to take into account important household factors that may determine deforestation like capital endowment or access to credit.

We use panel data from three waves of household surveys conducted between 2000 and 2006. The surveys included 266 randomly selected households from 12 villages in the vicinity of the Lore Lindu National Park in Central Sulawesi, Indonesia. To account for socio-economic differences, we differentiate our analyses for three poverty groups and also integrate an index of relative poverty in our probit and tobit regression analysis.

The conversion of forest into farm land in the research area is a severe problem as approximately 52 km<sup>2</sup> of forest area were converted into farm land between 1999 and 2006 by smallholders. 50 percent of the area cleared is used for cocoa production. The cultivation of dry rice is second to cocoa cultivation. Dry rice is grown on 28 percent of the area cleared. We further found that poorer households are more likely to convert forest and that social capital (in terms of the participation in organisations) seems to foster the probability of forest clearance. The results are used to draw policy conclusions with respect to forest conservation and poverty alleviation.

**Keywords:** Deforestation, Indonesia, poverty, smallholder

## How Cost-effective are National Parks in Reducing Deforestation? The Cost-effectiveness of the Lore-Lindu National Park in Indonesia

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Deforestation in the tropics has large scale consequences for carbon sequestration, biodiversity conservation, and ecosystem services. One way to maintain the integrity of forests is to establish protected areas (PAs) such as national parks. The area worldwide under such conservation regimes increased more than tenfold over the past 4 decades with 18.8 mil. km<sup>2</sup> currently under protection. The decision, where to establish a PA, is mainly driven by only considering biological benefits without incorporating the costs of protection. Studies, however, show that the incorporation of costs can greatly increase the efficiency of conservation. Yet, due to limited data availability and methodological problems, there exists little evidence from developing countries on how cost-effective the establishment of PAs has been. The analysis of the effectiveness of national parks is, for example, often based on a comparison of deforestation rates of areas inside and outside of PAs using satellite data. Such an approach, however, might yield biased estimates when areas outside and inside PAs differ in many characteristics, which in turn influence deforestation. Instead, this study applies propensity score matching, which has in previous studies been found to be a suitable methodology to reduce the bias in the evaluation of PAs. The unbiased measure of effectiveness is then combined with the costs of protection to calculate the cost-effectiveness.

For the analysis we combined geo-referenced data on land use, elevation, slope, roads, and administrative boundaries with socio-economic data from a village survey conducted in 2001. Moreover, we obtained data on cocoa production from a detailed cocoa management study.

Investigating the case of the Lore-Lindu National Park (LLNP), Indonesia, the results suggest that the establishment of the National Park reduced deforestation by 9.4 percentage points between 1983 and 2001. This means that on average the National Park has avoided the deforestation of 1,131 ha year<sup>-1</sup> between 1983 and 2001. The opportunity costs account for the vast majority of total economic costs, but they strongly depend on the alternative use of the forested area. The costs of preventing one hectare of forest from being cut increase from USD 842 year<sup>-1</sup> in the extensive cocoa production scenario to USD 1,932 year<sup>-1</sup> in the intensive cocoa production scenario. Methodological as well as policy implications of the results are discussed.

**Keywords:** Cost-effectiveness, Indonesia, protected areas

## Adequate Perspectives of Unique Natural Walnut-fruit Forests in South Kyrgyzstan through Sustainable Management

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Walnut (*Juglans regia*) forests including other fruit-bearing trees like apple (*Malus* sp.) and pear (*Pyrus* sp.) species grow in the subtropical influenced climate in the southern part of Kyrgyzstan. The so-called “walnut-fruit forests”, which are unique worldwide, are considered a biodiversity hotspot. Moreover, they are of huge ecological and economical importance for the local rural population. Due to the pressure of the local population, the sustainable management of this forest type is currently not ensured. The main aim of our applied research project ORECH-LES is to develop silvicultural management schemes through research and to encourage and ensure their implementation by means of informing and training the local population and the forest officers. The overall research question is how to shape, optimise and practically manage the forests and the agroforestry systems. Special attention is paid to the influence of forest management both on the livelihood of the local population and on the biodiversity. Since 2001 a lot of scientific and socio-economic data has been collected within a field network of 34 trial plots. The step by step analysis of the data has indicated a high potential for the sustainable management of walnut-fruit forest. Since the beginning of the project, the stakeholders’ participation has been of great importance. The scientific results of various research disciplines such as silviculture and forest production, agroforestry, geobotany, fruit-growing, pathology and biodiversity, have been regularly disseminated in seminars and publications. In the medium and long-term, the productivity of many forest stands could be raised. Besides, the dissemination of the results has to be focused at a local, regional, national but also at an international level.

**Keywords:** Biodiversity, *Juglans regia*, Kyrgyzstan, silviculture, walnut

## Where the Land is Greener - Some Evidence from the Impact of Sustainable Land Management in the Senegalese Sahel

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Land degradation is a big concern in semi-arid landscapes and land users are applying a wide range of sustainable land management (SLM) technologies in order to mitigate this threat. Vegetation cover through tree species is important for reducing wind and water erosion through soil stabilisation, improving soil fertility and water availability and at the same time providing resources for humans and cattle. Many SLM technologies are therefore based on the improvement of vegetation cover. The WOCAT (World Overview of Conservation Approaches and Technologies) database aims at documenting the local SLM knowledge and distributing it around the globe.

Several agroforestry and forestry technologies applied by local land users in a silvopastoral and an agropastoral region in northern Senegal were documented for the WOCAT database. Parameters of woody vegetation were investigated at SLM sites and the conventional land use system in the respective area. The aim was to see if tree biodiversity parameters, canopy cover and regeneration density were higher under sustainable than conventional land management. In addition, it was tested if SLM technologies increased the availability of tree species useful to the local population.

In the silvopastoral land use system tree density, species richness and diversity and canopy cover were significantly higher at sites under SLM than under the conventional land management systems of extensive pastoralism and crop production. The same applied to tree regeneration. SLM technologies further harbored higher densities of trees providing fodder, food or medicine than sites under CLM. For the agropastoral land use system no general difference of vegetation parameters was found between SLM and CLM but single SLM technologies either had higher trees species richness and diversity or higher tree density than the CLM of extensive pastoralism. In general regeneration of tree species was rare in the majority of the assessed land use types in the silvopastoral as well as the agropastoral land use system (the two prevailing land use systems in the North). This indicates that despite the variety of sustainable land management technologies applied, vegetation cover in northern Senegal is facing decline and specific action is needed in order to avoid further land degradation.

**Keywords:** Agroforestry, land degradation, Sahel, WOCAT

## Assessment of Soil Nutrient Depletion Levels in Different Land Use Types and its Economic Implication in Gelda Watershed, Ethiopia

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Due to improper land management practices such as crop residue harvesting and erosion, soil nutrient depletion has become a major agricultural problem in central highlands of Ethiopia. As a result, it is impossible to achieve food security in the region. To counteract the problem, it is necessary to implement proper land use systems and to identify the impacts of these systems on soil nutrient depletion. Hence, the objectives of this paper were to assess the level of nutrient depletion in five adjacent land use types (grazing land, natural forest land, old farm land with scattered trees, new bare farm land and old bare farm land) and to evaluate its economic implication in Gelda watershed, South Gondar Zone, north-west Ethiopia. Soil samples were collected from 0–15 and 15–30 cm depth and analysed for physical and chemical properties using standard laboratory procedures. Some of the parameters analysed were texture, bulk density, organic matter content, moisture content, active and exchangeable acidity, total macro nutrients (N, P and K), exchangeable cations ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^{+}$ , and  $\text{K}^{+}$ ) and CEC. The results indicated that clay content, organic matter content, pH and CEC were higher in the forest lands than in the farm and grazing lands. Depletion level of the total macro nutrients and exchangeable cations were positively correlated to organic matter. Of all the land use types considered, the grazing land had higher degradation index (-140 %) and among the three farm land use types, the old farm land with scattered trees had a lower degradation index (-78 %). The annual nutrient loss from the old bare farm land through rill and interrill erosion was estimated at 1560 birr  $\text{ha}^{-1} \text{yr}^{-1}$  in monetary terms. In general, the current land management system can't sustain the nutrient level required for common food crops production. And hence, we recommend the expansion of scattered tree based agroforestry system in order to sustain the soil nutrient level.

**Keywords:** Degradation index, land use, nutrient depletion, scattered trees

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## Fuelwood Use and its Impacts on Food Crop Production and Nutrient Transport from Forests in the Highlands of Ethiopia

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Due to deforestation and human population increment, there is a severe fuelwood scarcity in Ethiopia, which in turn is forcing farmers to use cattle dung. This study investigated how the use and scarcity varied with proximity to state forest, and the impact of the use and scarcity on food crop production and on nutrient export from forest ecosystems in Suba area, central highland Ethiopia. Data was collected using questionnaire survey and key informants interview supplemented by a nutrient analysis result of the wood and cattle dung samples from a secondary source. With increasing distance from the state forest, fuelwood consumption decreased while cattle dung consumption increased. Annually,  $1.2 \times 10^6$  kg of fuelwood containing  $1.4 \times 10^3$  kg N,  $6.1 \times 10^5$  kg C, 39.44 kg Al,  $2 \times 10^3$  kg Ca, 3.33 kg Cu, 131.5 kg Fe, 766.5 kg K, 130.9 kg Mg, 92.07 kg Na, 50.57 kg P, 131.06 kg S and  $8.17 \times 10^4$  kg Zn, was extracted from the state forest and  $3.22 \times 10^5$  kg yr<sup>-1</sup> cattle dung containing  $6.14 \times 10^3$  N and  $1.1 \times 10^3$  kg P was burnt by the studied 381 households. This amount of cattle dung could potentially produce  $4.2 \times 10^4$  or  $5.9 \times 10^4$  kg of wheat or maize respectively, which could have fulfilled the annual cereal demand of 39 or 55 households with the respective crops. Generally, fuelwood scarcity is beyond energy issue, having direct impacts on food self-sufficiency and nutrient transport from forest ecosystems. Hence, alleviating fuelwood scarcity problem should attain priority in the development programs conducted in the study area for promoting food crop production and enhancing the development of the nearby forest.

**Keywords:** Cattle dung, crop production, fuelwood scarcity, nutrient outflow

## The Sustainability of Systemic Land-use Innovations in Tropical China

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In Xishuangbanna, Southwest China, rapid economic growth is coupled with a rigorous drop in biodiversity and loss of tropical rain forest. This is particular the case in the Nabanhe National Nature Reserve (NNNR), where the authors conduct their research within the joint project LILAC- Living Landscapes China.

The capacity lies in potential innovations, which ameliorate the existing monoculture systems and help to strike a balance between economic development and environmental protection.

The presentation will show the ‘critical triangle’ relationship between economic growths, sustainable land-use systems and poverty reduction in two villages in the NNNR. One village has already experienced a complete change of its land-use system through the introduction of a systemic innovation, mainly consisting of the components rubber, hybrid paddy rice and a higher level of mechanisation. The second village is still experiencing the successive introduction of a number of autonomous innovations such as various types of tea-intercropping systems.

The study has clearly demonstrated that the rubber-dominated systemic innovation has hardly left any space for options that go in other, more sustainable directions. The latter is a better choice with regard to sustainable land-use as it can be gradually and more gently adjusted to the existing natural conditions.

For farmers within the rubber production zone, possible innovations must be identified to help improve the existing monoculture and ways must be found to create a balance between economic growth and a more environmentally friendly production system. For farmers operating above an agro-ecologic ‘rubber limitation line’, more autonomous innovations are to be found, which aim to make their land-use systems and their sources of income more sustainable. Furthermore, it must be elaborated on how they also can directly or indirectly benefit from the booming rubber business.

**Keywords:** Biodiversity, China, critical triangle, economic growth, land-use changes, rubber, sustainability, systemic innovations, Xishuangbanna



## Analyzing Community Forestry Internal Governance: Evidence from Western Nepal

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There has been a rising interest in common property institution such as community forestry in natural resource management in developing countries. Among developing countries, Nepal has proved a keen leader in experimenting with participatory systems of forest governance. However, there are key problems like elite domination in decision making and misappropriation of group fund which do not allow well functioning of institutional governance of community forest in reality. This paper aims to analyse the internal structure and status of governance in community forest user group level. It tries to evaluate the main achievements and challenges of community forestry governance and provide options for future policy. Five major characteristics of governance: participation, transparency, accountability, rule of law and inclusion/equity are used and these characteristics are analysed on the basis of gender, and wealth (poor, rich and medium) status. The presentation builds upon empirical work in three community forest user groups located in Banke district of western Nepal. The data collected in this study were both quantitative and qualitative in nature. One day workshop was conducted in each group separately to find the empirical evidence of five major dimension of governance. The set of indicators explaining each governance dimension were developed before the workshop and matrix ranking was used to rank each indicator according to the set of criteria. Questionnaire (structured and semi structure) was used for household survey interview and check-list was used to get expanded data from focus group discussion, in-depth interview, and community forest user group's meeting observations. The data collected from questionnaire survey were coded and analysed by using Statistical package for social science (SPSS, version. 16.0). The main findings point to the differences in user's participation on decision making process, transparency of information and group fund, accountability of users and inclusiveness even though they were getting same support from the state and Non government organisations. This paper concludes that success of good governance depends on user's awareness' level, commitment, attitude and leadership of the group

**Keywords:** Accountability, community forestry, governance, inclusiveness, participation, transparency



# Water management

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## Key Determinants of Soil Water Availability for Agricultural Production in two Wetland Types in East Africa

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Predicted future changes of temporal and spatial precipitation patterns will affect agricultural production in East Africa, especially in rainfed upland systems. Wetlands are characterised by prolonged periods of water availability and are thus attractive land areas, which alleviate the negative effects of increasingly variable weather and changing climate conditions on agricultural production. Yet, their diverse hydrological regimes do not allow for a generalisation of their agricultural potential. This study aimed at understanding patterns of seasonal and spatial water availabilities in two distinctive wetlands under agricultural use in East Africa, comprising a floodplain in Tanzania (350–400 m asl) and an inland valley wetland in Kenya (1720–1800 m asl). The floodplain was cultivated with rice and maize with portions left used for grazing or as fallow. The inland valley was cultivated with arrowroot, maize and horticultural crops. We developed a digital elevation model and monitored soil moisture in the rooting zones by TDR probes, groundwater levels, stream discharges and meteorological parameters at both sites. Soil moisture surveys show that wetland morphology is a key determinant for soil water availability in the wetland systems. Both, the time of occurrence and the duration of soil flooding, triggered by rainfall events together with reservoir management in upstream areas, are key determinants driving the type and the intensity of agricultural landuse in the flood plain system. In the inland valley, soil moisture remained at constant high levels throughout the year due to the presence of springs and a high ground water table and variations occurred along the cross section between the fringe and the centre of the valley. The effect of other factors on water availability for crop production such as soil texture and organic carbon in the wetland and landuse of the adjacent slopes are currently examined and will be discussed. The research is seen to contribute to the development of guidelines for the agricultural use and management of wetland systems under variable weather and changing climate conditions.

**Keywords:** Kenya, soil moisture, Tanzania, TDR, wetland

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## **Rethinking Water Storage for Agricultural Adaptation to Climate Change in sub-Saharan Africa**

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Across Africa some 200 million people are poor and food insecure largely because of their dependence on rain-fed agriculture. For many, climate change will exacerbate their vulnerability through adverse impacts on crop production, seasonal water resources and other climate sensitive aspects of rural life. Water storage is widely promoted as one of the principal mechanisms for adapting to climate change. For agriculture, this storage can take a variety of forms, ranging from groundwater, enhanced soil moisture, to ponds, tanks and small and large reservoirs. In any given situation each of these has its own niche in terms of technical feasibility, socio-economic sustainability, institutional requirements and impacts on public health and the environment. To date there has been little systematic analysis of how climate change will affect existing water storage or how to account for climate change in the planning of new water storage in Africa. Appropriate storage will reduce peoples' climate vulnerability by increasing both water and food security but ill-conceived water storage may be undermined or may even worsen the adverse impacts of climate change. This paper describes preliminary results from a project being undertaken to develop guidance on how to incorporate climate change in the planning and management of agricultural water storage. The study addresses three key issues: i) how to identify the need for agricultural water storage; ii) how to evaluate the effectiveness (*i.e.* technical performance) of different storage options and iii) how to assess the suitability (*i.e.* socio-economic appropriateness) of different storage options. The intention is to develop a framework that enables comparison of different storage options in order to identify those that are most likely to be technically sound and which will maximise social, economic and environmental outcomes under both the existing and the future climate.

**Keywords:** Adaptation, climate change, sub-Saharan Africa, water storage

## Where There's Muck There's Brass — Wastewater Irrigation near Faisalabad, Pakistan

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Water scarcity is one of the most pressing problems for many arid and semi-arid regions. With regard to the need for a more efficient and sustainable use of the existing freshwater resources, the main focus must be on agriculture with its share of 86 % of the global water consumption.

The Indus Basin Irrigation System (IBIS) in Pakistan is the largest irrigation system in the world and the backbone of the country's economy. However, because of an increasing demand for irrigation water and lack of maintenance of irrigation infrastructure resulting in water losses, many farmers can no longer satisfy their irrigation water requirements with canal water.

In order to cope with irrigation water scarcity, farmers use different strategies. This study compares the coping strategies of farmers in two periurban villages in Pakistan's Province of Punjab. While in the village of Kehala, farmers had shifted from canal water to groundwater as their primary irrigation water type, the farmers of the neighbouring village of Chakera had taken a different path by using untreated wastewater from the nearby city of Faisalabad.

The fact that most Chakera farmers interviewed were very satisfied with their wastewater irrigation was not surprising in view of savings for fertiliser and a reliable, unlimited water supply. Moreover, wastewater was much cheaper than groundwater: in order to irrigate main crops like wheat and sugarcane, Chakera farmers saved up to 95 % of water costs compared to their Kehala neighbours.

A further advantage of wastewater irrigation was that it allowed the production of high-value crops like vegetables which require large quantities of irrigation water and fertiliser at frequent intervals but fetch high market prices.

Thus, in economic terms, the use of raw, untreated domestic wastewater for irrigation has had many benefits for farmers in Chakera village.

**Keywords:** High value crops, irrigation, irrigation water costs, pakistan, wastewater

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## **Modelling the Bargaining on Scarce Water Resources in the Trans-himalayan Region of Nepal**

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Irrigation in the Trans-Himalayan region, where water is a scarce commodity, is organised through local institutions. The existing social hierarchy, where the society is divided into upper-ruling class and lower-working, profoundly influences the water management in the region. Both classes assume different roles towards the management of water, both in decision making and their physical execution. The upper class is responsible for the water related decisions and investment in irrigation infrastructures while the lower class contributes labour for the irrigation system construction and maintenance. In addition, the latter class is also a source of labour in farms owned both classes. The ruling class enjoys the property right over water and make prime use of water by planting higher value crops though they share some amount of water with the lower class. Due to limited supply of water to the lower class, they plant crops having lower water demand for their subsistence, and part of their fields may remain fallow. The optimisation of economic benefits, given the social hierarchy, political power and rights on water is the aim of the study. This challenge is addressed by modelling the problem into a stylized reciprocal principal-agent model. As the upper class enjoys rights on water and lower class constitutes majority of the available labour, the former class is regarded as a principal in the case of sharing the water, while the latter is considered as a principal in sharing the labour. The water-principal provides water to the agent depending upon the labour provided by them while the labour principal allocates labour to the agent depending on water provided by them. The benefit functions, the participation constraints and the response functions of both classes were derived algebraically. An attempt is made to quantify the political power coefficients of the two classes because the problem is bargaining in scope rather than a pure principal-agent relation. The power coefficient is plugged into the net benefit function of the principals and the net benefit is maximised subject to the participation and incentive constraints which gives the optimised solution of this specific problem.

**Keywords:** Bargaining, principal-agent model, property rights, social-hierarchy

## Water Productivity as Affected by Water Management in a Small-scale Irrigation Scheme in the Blue Nile Basin, Ethiopia

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Irrigation has been practised since ancient times and, currently, it is mainly implemented in small-scale irrigation schemes, which are often characterised by low water productivity in Ethiopia. This study reports on the productivity of a typical small-scale irrigation scheme in the highlands of the Blue Nile, Ethiopia, with the objectives: to quantify canal water loss, water needed and used to produce biomass, to quantify feed and food water productivities and to identify ways to improve the efficiency and productivity of water use. Field measurements of canal water flows and the volume of irrigation water applied were done. Grain and crop residue biomass, and grass biomass production along the canals were also measured. We also closely observed the irrigation farm management and associated problems to triangulate the measurements. The average canal water loss from the main, the secondary and the field canals was 4.5, 4.0 and 26 % of the total water flow capacity of each canal type, respectively. About 0.05 % of the loss was attributed to grass production for livestock, while the rest was lost through evaporation and canal seepage. Grass production for livestock feed had a land productivity of 6190.5 kg ha<sup>-1</sup> and a water productivity of 0.82 kg m<sup>-3</sup>. Land productivity of straw and grain for tef was 2048 and 770 kg ha<sup>-1</sup>, respectively, and 1864 kg ha<sup>-1</sup> and 758 kg ha<sup>-1</sup>, respectively for wheat. Water productivities of the crops varied from 0.2 to 1.63 kg m<sup>-3</sup>. A significant volume of water was lost from small-scale irrigation systems mainly because of weak planning and mismanagement. Farmers' water application did not match with crop needs. Water price affected water management by minimising water losses and forced farmers to use deficit irrigation. Night storage mechanisms, optimal irrigation scheduling, empowering farmers on water management may improve food and feed productivity of irrigation water.

**Keywords:** Canal loss, crop residues, over irrigation, under irrigation, water price

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## **Food, Water and Poverty: Basin and Global Scale Patterns of Water Availability, Use and its Impacts on Rural Development**

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Food and water systems are under increasing pressure to meet the demands of an ever-increasing global population. Since the vast majority (up to 90 %) of global water fluxes through food systems, these two systems are tightly coupled, and together underpin nutritional food, income and environmental security for the future. Yet surprisingly little is known about the condition of this coupling, or the way it influences (and is influenced by) development.

We present detailed analysis of the food and water systems from 10 major river basins to explain conditions of water, food and poverty. We relate these conditions to development processes and indicate the types of interventions that promise improvement. At a global scale, three factors seem crucial: increasing demand for food; increasing demand for water to meet other needs, and a finite supply of available water. These three factors are starting to collide in a crisis in which water or food is increasingly unavailable and in which rivers suffer from severe overuse putting at risk ecosystems and basin dependent livelihoods of millions. We find from our analysis that while physical water scarcity is the most ostensible problem, it applies only to some basins, while other problems are more widespread. These comprise lack of access (inequitable sharing of the water resource or benefits derived from its use); vulnerability to water-related hazards; and low water productivity (benefit per volume of water consumed). Low water productivity is of particular interest to scientists seeking to improve the food system because estimates suggest that - with few notable exceptions - it is typically less than one tenth of its biophysical potential over vast areas of different cropping systems. This suggests that improved eco-efficiency holds substantial promise to enable food systems to (i) meet future demand without compromising water systems further and (ii) foster rural development in some of the poorest regions of the world. We identified institutional weakness as one of the main reasons for unsustainable and unequal water management and low productivity and we are able to show the linkages between politically guided good practice water management and improved livelihood situations for rural smallholders.

**Keywords:** Basin focal projects, food systems, rural development, water productivity

## Exploring Interactions between Water Resource Depletion and Remittances from Labour Migration: The Case of Kerala

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For agricultural productivity water is one of the most important factors. Approximately one-third of the world's population lives in countries facing medium to high water stress. Water shortages as well as the deteriorating quality of water are among the paramount natural resource problems faced in the 21<sup>st</sup> century on a global level, with frightening prospects. The paper takes on the issue by investigating the impact of migrant worker remittances on water resources. We assume that families invest remittances received by migrants in irrigation facilities and so contribute to enhanced water consumption, which lead to increased water resource depletion.

There is indeed preliminary evidence that the investments of remittances promote increased water consumption in rural areas via changing investments in water exploiting facilities. Therefore, our research area Kerala (India) is a striking example. Kerala is considered as water-rich state. However, the people in some parts of the State are suffering from severe water shortage during the dry months of the year (*i.e.* five months per annum). The paper presents the results of a Delphi survey among water and agriculture experts from government institutions, NGOs and research institutions in Kerala. Results confirm our assumption that remittances contribute to higher water consumption for agricultural purposes and this has a potential to intensify water stress. The impact of remittances as a tool to reduce poverty and to increase economic development is widely accepted. However, the research project shows that negative impacts of remittances have to take into account. The findings can help the government as well as, national and international agencies to adequately respond to socio-economic and environmental challenges from the use of remittances, seizing the respective opportunities while preventing avoidable harm.

**Keywords:** Kerala, remittances, water resource depletion

## Deficit Irrigation for Optimum Cotton Yield and Seed Quality

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Poor stand establishment of cotton seedling is one of the critical problems in Golestan Province of Iran that can reduce cotton yield. Seed quality is an important factor that can influence stand establishment. It is influenced by several factors including environmental conditions during seed development and maturation. In this study, the effects of different irrigation regimes on yield and seed quality of cotton (*Gossypium hirsutum* L.) with a drip irrigation system under field conditions in the northern Iran were evaluated along two years (2006 and 2007). After flowering, four irrigation regimes (0, 40, 70 and 100 % of Class A pan evaporation (% PE)) were applied when the cumulative evaporation amount from class A pan reached approximately 40–50 mm.

The results revealed that seed cotton yield and seed weight generally increased with increasing irrigation levels. According to the results of this experiment, maximum cotton yields were achieved with 83 and 93% PE irrigation regimes in 2006 and 2007, respectively and the lowest seed cotton yield was obtained when irrigation was stopped at the flowering stage. Also, maximum seed weights were achieved at 100 and 63% PE, in 2006 and 2007, respectively. The results of this study show that although water limitation reduce cotton yield, the highest seed quality was observed for the 0%PE treatment. Thus, the effect of irrigation on germination and vigour was substantially less than that on yield. The results also indicate that an irrigation treatment of 40% PE would be the optimum for seed cotton yield and seed quality production under drip irrigation in northern Iran.

**Keywords:** Cotton, drip irrigation, seed quality

## Climate Change Impact Assessment on Soil Water Availability and Crop Yield in Blue Nile Basin: Case Study Anjeni Watershed, Ethiopia

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General Circulation Models (GCMs), currently the most advanced tools for estimating future climate change scenarios, operate at coarse (typically 0.5°) resolutions. Downscaling of GCM output is necessary to assess the impact of climate change on local water management activities. This study was conducted to quantitatively assess variations of water availability and crop production under different climate change scenarios in the Anjeni watershed. This watershed (113.4 ha) is located in Northern Ethiopia at 37°31'E / 10°40'N. Within the watershed terracing is a common soil and water conservation practice.

In order to estimate possible climate change impacts on water availability and crop production within the watershed, climate change scenarios of precipitation and temperature were developed for the South Gojam sub basin, an area of 16,762km<sup>2</sup>, in which the watershed is located. The outputs of HadCM3 coupled atmosphere-ocean GCM model for the SRES A2 and SRES B2 emission scenarios were used to produce scenarios for the period 2011 to 2070. These outputs were downscaled to the watershed scale through the application of the Statistical Downscaling Model (SDSM). Results indicated that for both scenarios there is an overall increasing trend in annual temperature, the A2 scenario showing high increment relative to B2 scenario and significant variation of monthly and seasonal precipitation (*i.e.* decrease in average Kiremt precipitation by about 9 and 7 % in 2020 and 6 and 5 % in 2050 for both A2 and B2 scenarios) from the base period (1984–2001). These changes in rainfall and temperature were used with the Soil Water Assessment Tool (SWAT) hydrological model to simulate future water availability and crop production. SWAT was calibrated with five years of monthly flow data (1986–1990) and then the model was re-run using the scenario data as input. The results indicate that for both scenarios there is an increasing trend in potential evapotranspiration as well as a reduction in the soil water content in the watershed.

The study investigate that due to combined effect of projected variation in seasonal rainfall and increase in temperature and then reduction in soil water content there will be overall variation in crop production in the watershed.

**Keywords:** Climate change, crop yield, SDSM, SWAT, water availability

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## **Changing Water Use Institutions and Farming Strategies as a Response to Aquifer Depletion - A Case Study in Minqin County, Gansu Province, China**

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The regulation of groundwater extraction to avoid exhaustion of the resource is a vexed question worldwide. It also arises in North China where groundwater use has developed rapidly over the last few decades, in some regions resulting in aquifer depletion. Minqin County is a remote rural area in the North of Gansu Province in the North West of China, confronted with aggravating water scarcity due to the rapid withdrawal from groundwater resources. The county is located in the delta region of the landlocked Shiyang river basin. As a result of low rainfall (annual precipitation of 100–200mm) agriculture depends on irrigation. Since the 1960s the region's surface and subsurface water inflow has been diminished due to increasing water use upstream. Subsequently the abstraction of groundwater resources has been intensified to compensate for the decreased water inflow. This development was enabled by the availability of cheap drilling and pumping technologies.

Since the 1970s the increased use of groundwater resources led to falling water tables and caused related problems, such as higher pumping costs, groundwater mineralisation, desertification and exhaustion of the resource. To protect the groundwater resources the government has recently introduced a policy in Minqin County which restricts the use of groundwater for the agricultural sector by closing down wells and limiting the area of cultivated land.

In our empirical study the response of water users to aquifer depletion will be analysed through multi-level stakeholder interviews. Special focus will be given on the change of farmers' behaviour after the implementation of the new policy. In the course of 2010 both village leaders, water managers and farmers will be interviewed to understand the institutional arrangements and changes in farming strategies since the intensification of groundwater use and the implementation of the policy. Finally a conclusion may be drawn on the viability of the policy for other regions in North China, and the impact of possible alternatives to the current policy may be discussed.

**Keywords:** Aquifer depletion, farming strategies, groundwater management, institutions, North China

## Evaluating the Technical Performance of the Koga and Gomit Reservoirs in the Blue Nile under Existing Conditions and Possible Climate Change

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The aim of this study was to evaluate the possible impacts of climate change on surface water storage (*i.e.* the Koga (83.1 Mm<sup>3</sup>) and Gomit (0.74 Mm<sup>3</sup>) reservoirs) in the Blue Nile basin. Daily rainfall runoff modelling and reservoir simulation was conducted using HEC-HMS. The performance of the reservoirs was evaluated in terms of reliability, resilience and vulnerability (RRV) criteria under both existing and hypothetical future climate conditions. A digital elevation model of the study area was used to extract the physical characteristics of watersheds using Arc-GIS, Arc-Hydro and HEC-GeoHMS. Simulation of inflow to each reservoir was conducted using input data of rainfall, evaporation, watershed characteristics and reservoir water releases. After calibrating the model, the Koga and Gomit reservoirs were simulated on a daily time-step for 20 and 10 years of historical data respectively. This was done, to determine the availability of water to meet irrigation, hydropower (only Koga) and environmental flow requirements. Under historic conditions RRV values for Koga were 0.992, 0.037 and 37 respectively and for Gomit 0.95, 0.0324, and 71 respectively. Differences between the two reservoirs reflect differences in the ratio of storage to mean annual inflow. Previous studies indicate that future rainfall changes in the area are likely to lie within range of -20 % to +20 %. Hence, the effect of hypothetical rainfall changes within this range, were determined. Simulation results indicate that the RRV values at Koga varied from 0.968, 0.02, and 64 to 1, 1 and 0. Similarly at Gomit they varied from 0.874, 0.0164, and 88 to 0.979, 0.055, and 44. The RRV criteria provide an indication of how the technical performance of reservoirs maybe affected by climate change and so provide a starting point for building climate change into dam planning and management.

**Keywords:** Blue Nile, climate change, HEC-HMS, model performance, reservoir RRV



## Assessment of Adoption of Water Resources Conservation under Fluctuating Rainfall Regimes in Ngaciuma Watershed, Kenya

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Availability of water in quantity and quality affects output and economic growth. The aim of the study was to assess water resources accessibility and conservation in Imenti North District, Kenya. Unsustainable use of water resources has drastically affected the volumetric flows of Ngaciuma/Kinyaritha River rendering some of its tributaries seasonal. This has adversely affected accessibility to adequate water for both domestic and agricultural use. To improve on this situation the study sought to understand the status of water resources, water use and water conservation activities. The influence of water accessibility on water use and adoption of water conservation (WC) practices and constraints were assessed. Primary and secondary data were utilised. Descriptive statistics was used to analyse social economic data. Regression, correlation and spearman's t- test were used to compare the relationship between variables. Tree planting, roof catchment and bench terraces were the major WC practices in use. Multiple regression analysis revealed that lack of technical knowhow could explain 83.5 % variations of adoption level of WC practices. One sample t-test comparing the means of WC practices among respondents' was significant at  $p < 0.01$ . Correlation analysis between distance to water sources and water use revealed a negative association at  $p < 0.05$ . Spearman's rank test revealed a decreasing trend during the long rains (March-May) for the period 1986–2008 at  $p < 0.05$ . Spearman's rank test revealed a significant decreasing trend of discharge for Ngaciuma River at  $p < 0.05$ . The decreasing linear trend in rainfall and stream discharge calls for urgent and better management of water resources in the study area.

**Keywords:** Rainfall, streamflow, unsustainable water use, water conservation practices

## **Role of Social Capital in Coping Water Scarcity: Governance Lessons to Trans-Himalayan Region of Nepal from Pre-colonial South India**

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Social capital plays crucial role in the governance of common pool resources. The development of accepted rules and norms for resource governance takes considerable time but less time to deteriorate. An example is the tank irrigation systems in South India which was the prevalent mode of irrigation before the British colonial regime. The degeneration path of this irrigation system is the lesson for similar systems in the world. We take the case of glacier irrigation system of the Trans-Himalayan region (THR) of Nepal which is undergoing profound change in political and climatic environment which may undermine the current rules and norms resting on social hierarchy. The foundation of social capital that made the regular maintenance of tank irrigation in south India was social hierarchy. The local elites used to contribute the capital (for position) and the peasants had to contribute labour for the maintenance of tank irrigation system. British authorities used to collect taxes from the local elites and they (local elites) used to manage the irrigation systems and collect levies from peasants. The irrigation system started degenerating when British colonial government started to collect tax directly from the farmers ignoring the local power situation. The social capital in the form of the ruling-working class relationship and informal rules was lost. Finally, the tank irrigation system was collapsed. Similarly the social hierarchy and informal rules in the THR of Nepal assign distinct tasks for ruling and working class for the irrigation system. Ruling class, the manager, provides capital and working class contributes labour for irrigation system. Both parties trust each other, therefore, the irrigation system is still sustaining from centuries. The impact of climate change in the Himalayan ecosystem reduced the volume of glacier and has compelled the society to invest more on irrigation. Therefore, they require more cohesiveness and trust than the previous. The present political changes in Nepal have influenced the power relations and undermined the capital investment and labour commanding ability of the ruling class. We analyse at the historical similarity of the degeneration pathway of social capital in both irrigation systems and reveal possible measures.

**Keywords:** Climate change, political power, social capital, social hierarchies

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## **Roles and Rules of Irrigation Water Use in Khorezm, Uzbekistan: A Lifeworld Analysis**

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With an annual precipitation of less than 100 mm, agriculture in Uzbekistan's province Khorezm is bound to irrigation. The water resources that are needed for the production of cotton, rice, wheat and other crops are diverted from the Aral Sea's (now intermittent) tributary Amudarya. The extent of this diversion and the inefficiencies with which irrigation water is conveyed and applied have gained notoriety for their detrimental impacts on the environment, notably for the desiccation of the Aral Sea. In response to the environmental problems, scientific research has engaged in developing technologies that make irrigation water use more efficient and save water for alternative uses and environmental needs. While many research projects have succeeded to develop technologies, most of these have never been adopted by farmers. To shed light on why water-saving is not practised, this paper investigates the perceptions and institutions which shape the way farmers use water in Khorezm. Conceptually, the analysis draws on Schütz' lifeworld concept (Schütz and Luckmann 1974) and Berger and Luckmann's theory of social construction (Berger and Luckmann 1966). Based on empirical research in two water user associations in Khorezm, the paper describes the spatial and temporal categories in which water users attach meaning to the resource water and their water use practices and analyses typifications of roles and rules as they guide farmers' behaviour. The paper thus reconstructs the subjective everyday water lifeworlds of farmers in Khorezm. It closes by drawing conclusions on the role of water lifeworlds for the adoption of water-saving practices.

**Keywords:** Central Asia, irrigation water use, lifeworld, social construction, technology adoption, Uzbekistan, water saving

## Water Flow in Vadose Zone with Root Water Uptake: From Measurements and Models to Optimal Irrigation

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Water has been labeled ‘blue gold’, and ‘blue gold’ is destined to be the critical issue of the 21<sup>st</sup> Century. Globally, irrigation is responsible for 80 % of the world-wide spending of ‘blue gold’. Development of sustainable irrigation practices will require that we understand better the biophysical processes of root-water uptake in soil, and transpiration from plant canopies. Soil water movement with root water uptake is a key process of water and chemicals transport in the soil-plant system. In this study, a two-dimensional model of root water uptake for apple trees was developed, and linked into a soil water dynamic model to enable simulation of water movement in soil via numerical solution of Richards’s equation. The root water uptake model included root density distribution function, soil texture factor, potential transpiration and soil water stress-modified factor. The model’s parameters were optimised by minimising the residuals between simulated and measured soil water contents. A tube-time domain reflectometry (TDR) was used to measure soil volumetric water content around a surface-irrigated apple tree up to 2 m depth at 12 locations. Simulated and measured water contents were in excellent agreement, with  $R^2$  values generally ranging between 0.94 and 0.97 and root mean squared error (RMSE) of  $0.012 \text{ m}^3 \text{ m}^{-3}$ . Studies show that the maximum root water uptake was at depth 10–30 cm. The water uptake from the top 40 cm of the root zone, was on average 40–50 liters per day. Potentially the numerical model is a useful tool for various problems related to water flow transport with plant water uptake in variably saturated soils. Finally, we demonstrate how our scientific knowledge can be used to develop sustainable irrigation practices.

**Keywords:** Numerical model, Richards’ equation, root distribution, soil properties, unsaturated soil

## Mechanized Micro-catchment Water Harvesting for Improving Arid Rangelands in Syria

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Arid rangelands of West Asia and North Africa have been severely degraded due to high grazing pressure and limited but highly variable rainfall. The main objective of this research was to assess the suitability of mechanised micro-catchment water harvesting combined with shrub plantations for combating desertification in arid rangelands. Three micro-catchment water-harvesting techniques were installed on a 100-ha site in the Syrian steppe (117 mm average annual rainfall). The techniques were (i) semicircular bunds established by an up-and-down movement with a Vallerani dolphin plough, (ii) continuous contour ridges established by Vallerani plough, and (iii) continuous contour ridges established by standard plough. Micro-catchments were set up with two slope lengths, 6 and 12 m, resulting in six different water-harvesting systems. Target areas were planted with three fodder shrub species: *Atriplex halimus*, *Atriplex leucoclada* and *Salsola vermiculata*. The water-harvesting systems were evaluated by measuring and analysing shrub survival, canopy volume and soil moisture during the 2005–2008 seasons. Shrub survival rates four years after transplanting were significantly higher ( $p < 0.05$ ) for the species *S. vermiculata* (62 %) and *A. halimus* (54 %) than for shrubs of the species *A. leucoclada* (37 %). However, shrub survival was not affected by the water-harvesting systems. Spreading of seeds and germination of new plants could be observed for *S. vermiculata* shrubs. These results made up for the small canopy volumes produced by this species (0.16 m<sup>3</sup>), compared to *A. halimus* shrubs (0.53 m<sup>3</sup>). The micro-catchments provided favourable growing conditions for native annual species; 13 different species were observed in the catchment areas. Soil moisture changes after rainfall events were significantly higher ( $p < 0.05$ ) in the semicircular-bunds systems than in the four continuous systems, which can be explained by a more targeted concentration of water in the semicircular bunds. The water-harvesting effect could be observed very well after large events (>5 mm), as soil moisture change in the target areas exceeded the rainfall on six of nine measurement dates.

Mechanically established micro-catchment water harvesting is a promising technique to capture surface runoff and re-establish vegetation in degraded rangelands. However, the management of grazing remains an important challenge in these marginal areas.

**Keywords:** Arid rangelands, *Atriplex*, canopy volume, micro-catchment water harvesting, shrub survival, soil moisture, Syria

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## **Vegetation Analysis to Assess the Impact of Land Use History and Intensity on the Resilience of Small Wetlands in East Africa**

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Agricultural practices can impact negatively on the resilience of wetlands. Such effects are reflected in the species composition of spontaneous vegetation regenerated after land abandonment. Soil nutrient condition tends to deteriorate under prolonged intensive land use. Plants unable to cope or compete due to such stressors are selectively filtered out of the community causing shifts in species composition. In an attempt to use the spontaneous vegetation as an assessment tool for wetlands' degradation status, we analysed the interactions between land use properties, soil nutrient condition and species composition of the vegetation. We selected 66 plots distributed in four locations, two of them in Kenya and two in Tanzania. Their land uses were classified into three groups: unused, fallow, and grazing. Information about land use history and intensity was collected using rapid rural appraisal. To characterise the soil nutrient condition, soil samples were collected for carbon, nitrogen, phosphorous and potassium analysis. Vegetation assessment involved aboveground and underground sampling. Above ground vegetation was sampled in 10 m × 10 m plots, estimating the cover of all species occurring on them. Soil cores were collected in each plot for underground vegetation assessment. The soil cores were placed in a greenhouse for three months to quantify the germination of seeds contained into the soil. Germinated species and individuals were registered in this period. In general, low variability in the soil conditions along the three main land uses was detected. This resulted in a low capacity of the plant species to indicate them. Nevertheless, land use and its intensity are the main factors determining the species composition of the vegetation. Since seed banks are dominated by weeds of arable lands, underground floristic offers a useful tool to assess the effects of past land uses as well as the potential regeneration of the natural vegetation. Additionally, the geographical distribution of the localities is an important factor determining the species composition of the aboveground vegetation, especially in the fallow and grazing uses. The analysis of spontaneous vegetation and the indicator species can be used to determine the resilience or vulnerability of wetland ecosystems to agricultural use.

**Keywords:** Agroecosystems, biodiversity, bioindicators, wetland ecology

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## Assessing Hydrological Impacts of Wastewater Irrigation on Groundwater: A Case Study from Hyderabad, India

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In the lands adjacent to the Musi-River, downstream of the city of Hyderabad, India, waste-water reuse for irrigation of various crops is common. Studies have shown that poor water quality has been a driver for crop selection in this area and this study describes the methodological approach used to understand the hydrological impacts and processes on groundwater associated with wastewater irrigation of a variety of crop types.

A watershed (2.8 km<sup>2</sup>) comprising wastewater- and groundwater-irrigated agriculture was selected based on land-use maps and observations. The watershed was delineated using DEM and GIS data. A crop model (BUDGET) was combined with field measurements, base-line data on irrigation practices, and land use patterns, to assess the overall water balance. The suitability of the method was validated with questionnaire survey results and available secondary data. 4 Piezometers were installed to assess and monitor groundwater levels and quality.

Major crops irrigated with wastewater were found to be paragrass (20 ha), paddy (8 ha) and leafy vegetables (1.8 ha). Groundwater was used for paddy (6 ha) and leafy vegetables (1.6 ha). Discharge from 17 wells or pumps was measured. Base-line data for 23 distinct fields were collected.

The annual irrigation flux was calculated to be  $1.6 \times 10^6$  m<sup>3</sup> and comprised of 77 % wastewater, 23 % groundwater. Return-flows from irrigation were  $0.44 \times 10^6$  m<sup>3</sup> and made up of 60 % wastewater and 40 % groundwater.

There is neither a difference in the application rate of irrigation for paddy and Paragrass ( $n=12$ ,  $p = 0.12$ ) (Mann-Whitney-U-Test) nor in irrigation practices between waste-water and groundwater users ( $n=10$ ,  $p = 0.10$ ). The accuracy of survey results and crop modelling is dependant on crop type ( $p = 0.043$ ,  $n=9$ ) and season ( $p = 0.04$ ,  $n=9$ ). Piezometric measurements support differences in return-flows as modeled.

Groundwater development is low, however, the irrigation return flows constitute an important source of ground water recharge. Findings indicate further potential for groundwater-based irrigation in wastewater irrigated areas maximizing the area under cultivation and benefits from the available water resources. These preliminary findings are being verified by more in-depth studies that are presently underway and will finally allow the assessment different land and water use scenarios with regards to groundwater quality and quantity.

**Keywords:** Crop modelling, irrigation management, irrigation return-flows, waste water irrigation

## **Role of Women in Groundwater Management: A Case Study of Rural Northern Gujarat, India**

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It was only after 1991 that community based management and initiatives in natural resource management and development began to be revived in the development policy of India. A significant step for participatory and decentralised forms of decision making and fund allocation was started with the comprehensive common guidelines which were evolved for all programmes with the recommendation of the Hanumantha Rao Committee in 1994. The watershed guidelines of 1994 advocated the need for different institutional arrangements at various levels to fulfil the task of community based watershed management and to begin State-NGOs partnership to address environmental problem, to achieve best possible utilisation of natural resources, employment generation, and restoration of ecological balance and to alleviate poverty through community based watershed management. This paper illustrates a village based case study from Gujarat, India which has relatively poor endowment of water resources and suffers from permanent water scarcity due to uncertain rainfall pattern. Watershed Development Programmes (WDPs) has become a key strategy for economic development in Gujarat due to its frequent facing of droughts, dwindling groundwater resources, increasingly salinity and loss of vegetations.

This paper seek to explain the role of women in the maintenance of the water retaining structures 'check dams' build by the farmers who organised themselves in User groups, as part of the watershed activity in the case study. The watershed main activity for the village was to build water retaining structures as groundwater is the source of irrigation and for drinking water, with no government water supply in the village. This paper uses the micro level village based case study; employing qualitative methods for data collection such as semi-structured interviews, participation observation, focused group discussions, narratives. The study is based on ten months of ethnographic investigation carried out in Northern Rural Gujarat, India. This analysis helps in realising the role that local community (especially women) can play in using scarce natural resources.

**Keywords:** Community management, gender, groundwater management, India



## Irrigation Water Policies in Syria: Current Situation Analysis and Scenarios for the Future

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Water scarcity in Syria is becoming an increasingly serious concern for public authorities as present demand of water is surpassing available resources. The agricultural sector in Syria consumes up to 90 % of all available water, hence the need to increase water use efficiency in agriculture is the focal point of the nation's water policy discussions. Therefore the criteria, rules, objectives and implementation of water policies demand important changes and a careful assessment. As agriculture is a key sector in the Syrian economy (28 % of GDP), irrigation expansion has mounted over the last two decades to comply with objectives of self-sufficiency policy in essential food products and food security. At present, water policies in Syria are designed to combine the expansion of irrigation from surface water resources and reduction of groundwater irrigated areas, in addition to attain a sustainable use of water by increasing technical efficiency and by reducing future consumption. Two of the pillars of this policy are the adoption of modern irrigation technologies at farm level that is already profiting from considerable government support and the substitution of water-intensive crops. This paper describes the pressure on water resources for agriculture and analyses the irrigation water sector in Syria and its related water policies. The level of analysis to be considered in this study is the national. The methodology includes simulations of different scenarios which have been carried out to allow long term assessments of different policy alternatives for conserving water resources. Results show that current water policies in Syria may not be sustainable and that positive water balance will be reached only if irrigation modernisation is coupled with a limited expansion of irrigated areas. Present and future water policies in Syria will have to rely progressively on demand management and the introduction of incentives, such as tariffs or quotas, in order to achieve water conservation aims.

**Keywords:** Irrigation water policy, Syria, water scarcity, water use efficiency

## Linking Farmers Perceptions and Technical Solutions for Groundwater Management in Lower Amu Darya Basin, Uzbekistan

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Due to arid climate, irrigated agriculture in Khorezm region of Uzbekistan depends on water withdrawal from Amu Darya River. Along with irrigation water supplies in vegetation season (April-October), farmers apply ca.  $5000 \text{ m}^3 \text{ ha}^{-1}$  of water for leaching (February to March) the salts in the root zone. Effectiveness of leaching is questioned in past studies as leaching raises the groundwater (GW) level from 2.5 m to 0.8 m which caused secondary salinity. Farmers believe that they need to fill GW aquifer before the vegetation season so that crops can acquire in-situ crop water demands via capillary rise. Due to intensified irrigation in upstream parts of the Amu Darya basin, water availability in Khorezm is expected to become more limited. In discussion, one option to cope with this situation is raising currently low irrigation efficiency as promising strategy. As this strategy will lead to lower GW, the impacts on the current irrigation strategies partly relying on shallow GW, need to be assessed. Objective of this study was to estimate the reduction in in-situ crop water demands due to decline in GW levels in Shomakhulum water user association (WUA). Four scenarios (S-A: business-as-usual, S-B: improved conveyance efficiency, S-C: increased application efficiency, and S-D: improved conveyance and application efficiency) were developed. The impact of scenarios on GW levels was simulated by FEFLOW-3D model. Results showed that improving the irrigation efficiency would lower the GW levels by 12 cm in S-B, 38 cm in S-C and 44 cm in S-D. HYDRUS-1D model was applied to simulate capillary rise contribution for the resulted GW levels. The maximum capillary rise contribution (19 %) to the average evapotranspiration of all crops in WUA was for S-A, which reduced to 17, 11 and 9 % for S-B, S-C and S-D, respectively. This implies that farmers perception that decline in GW level would affect the in-situ crop water demand is truthful; hence contribution from GW is a viable strategy for crop production in Khorezm. Therefore, before implementing any irrigation and drainage interventions in the region, water managers needs to consider the in-situ farmers benefits.

**Keywords:** Capillary rise, drainage, irrigation, shallow groundwater

## The Impact of Wastewater Irrigation on Crop Diversity — Two Studies from South Asia

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In the increasing competition for scarce resources of fresh water, the amount of water for agriculture is expected to rise much slower than that for other sectors in spite of the fact that even now, water scarcity is one of the greatest limiting factors for food production. Faced with a lack of irrigation water, farmers in waterscarce regions have begun to make use of the ever increasing volumes of untreated wastewater created in many cities of low income countries. This practice is perceived as highly dangerous not only by many planners and decision makers but also by scientists. It was only in the last years that the topic received wider scientific attention beyond studies focussing on health risks. This has led to a debate about risks and benefits of irrigation with untreated wastewater. Beside questions relating to the impacts of wastewater irrigation on health, soils and groundwater there has also been discussion about the implications for agricultural sustainability. Based on theoretical considerations, several researchers have stated that wastewater irrigation lead to a reduction in crop diversity. This would be a negative impact as crop diversity plays an important role for small scale farmers' resilience and livelihoods. To test this hypothesis of declining crop diversity under wastewater irrigation, two studies were carried out in South Asia, one near Faisalabad, Pakistan and one near Hyderabad, India. In Pakistan, an increased vegetable production under wastewater irrigation was found. It was linked to a higher crop diversity in wastewater irrigated areas as compared to non-wastewater irrigated areas. In India, crop diversity on wastewater irrigated vegetable gardens was found to be similar to that in vegetable gardens irrigated with groundwater. Thus, the empirical data from two South Asian research areas show that wastewater irrigation has not had the expected negative impact on crop diversity there. These findings add further weight to the growing conviction among many researchers that wastewater irrigation, if properly managed, can play a beneficial role in limiting the pressure on scarce fresh water resources and contribute to food security.

**Keywords:** Crop diversity, India, irrigation, Pakistan, wastewater

## Photovoltaic Pumps for Greenhouse Irrigation in China: A New Perspective?

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Since the use of photovoltaic pumps (PVP) was first documented in the 1960s they have been applied for different application in agriculture and drinking water supply. Especially for the supply of drinking water for domestic animals in remote areas PVP have been a success story. Reliable and maintenance-free systems have been developed which guarantee water supply in dry areas where the sun is plentiful. But also drinking and household water for remote villages is often supplied by PVP.

In agriculture, however, the use of PVP was restricted mainly to very small field sizes and high value crops. The high demand for water and the comparatively low returns made the application of PVP in agriculture often uncompetitive. Generally, the size of the generator determines the price of the system. As its price increases linearly with the power output, while the marginal cost of fuel operated engines decreases with size, PVP are not competitive for larger pumping systems. Further, the high share of fixed cost in the total operation cost makes a year-round operation necessary. An institutional framework of subsidised fossil fuel for food production in many arid countries was an additional hindrance.

In China, however, economic growth and resource scarcity is changing the so-far established picture about the use of PVP for irrigation. Cheaper PV-modules and increasing prices for vegetables in suburban areas are reasons for the Chinese Academy of Agricultural Sciences to investigate on the use of PVP. Two PVP systems have been installed in greenhouses in the surrounding of Beijing. Radiation pumping performance and total water delivery are monitored, as well as agronomic parameters, such as system price and operation cost, vegetable yield, produce price and degree of utilisation.

In this paper, the experimental set-up is described with its technical details and implication for Chinese farmers. A cost comparison is done between the installed PVP and a comparable water pumping installation using fossil fuels.

**Keywords:** China, irrigation, pumps

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# Ecosystem services

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## The Impact of Ranching on a Savannah Ecosystem in Tanzania

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The success of large-scale cattle ranching in African savannah vegetation has often been limited by problems of bush encroachment and disease (in particular trypanosomiasis spread by tsetse flies). Mkwaja Ranch, occupying an area of 462 km<sup>2</sup> on the coast of Tanzania, is a recent example of a large ranching enterprise that failed within the savannah environment. It was closed in 2000 after 48 years of operation. Thanks to detailed records kept by the ranch managers, it has been possible to reconstruct how ranching activities affected the savannah ecosystem. In this paper we describe how grazing by cattle led to the encroachment of scrub, particular of *Acacia zanzibarica*, over the most intensively used parts of the ranch. We also compare the influence of domestic and wild herbivores upon soil nutrient conditions, measuring nitrogen and phosphorus availabilities along vegetation gradients within a recently abandoned cattle ranch and at sites in a neighbouring game reserve. The results show that cattle ranching led to considerable re-distribution of nutrients, especially of nitrogen and phosphorus, with depletion in grazing areas and accumulation in areas where animals congregated at night. In the dense *Acacia* stands N<sub>2</sub>-fixation enhanced N availability and caused a net annual N input. Fire was the major cause for nutrient losses from tallgrass savannah. N inputs from the atmosphere and symbiotic N<sub>2</sub>-fixation were not sufficient to compensate for these losses; our results therefore call into question the common assumption that N budgets in annually burned savannah are balanced. These results help us to understand why intensive livestock ranching as practised on Mkwaja Ranch was unsustainable.

**Keywords:** Bush encroachment, nitrogen, phosphorus, ranching, savannah, Tanzania



## The Charcoal Trap: Miombo Woodlands versus the Energy Needs of People

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Miombo woodlands cover the transition zone between the dry open savannahs and the moist forests in Southern Africa and occupy the vast area of 2.7 Mio km<sup>2</sup>. These ecosystems are highly disturbed by deforestation, mostly for charcoal production. Charcoal has become the largest source to satisfy urban energy demands. Even though when charcoal is a less energy-efficient fuel compared to firewood but by having higher energy densities and thus being cheaper to transport. Over the last decades, charcoal production has become a full-time employment for migrant workers, resulting in very different and no longer sustainable deforestation patterns. Strategies to reduce the pressure on the miombo woodlands have to take aspects of employment and energy demand into account.

The objectives of the study were to examine above- and belowground carbon losses from an intact miombo woodland (protected forest reserve) in comparison to a highly disturbed surrounding area due to charcoal production. Detection of changes in carbon concentrations and stocks were made possible by applying biomass- and soil inventories as well as the eddy-covariance method. These local results were up-scaled to countrywide estimates of carbon lost to the atmosphere by deforestation in addition to carbon losses from fossil fuel combustion. The results show, that in the worst case scenario which does not assume any regeneration, a developing country as Zambia, can easily emit as much carbon per capita as a developed Western world country such as France, when deforestation is included in the national inventory (up to 9.1 t of CO<sub>2</sub> per capita). However, regeneration is very probably when post-harvest disturbance is low. Further studies on miombo regeneration are highly demanded.

**Keywords:** Carbon dioxide, eddy covariance, inventory, southern Africa

## **Changing Land Cover, Changing Ecosystem Services: How Land-cover Change affects Ecosystem Services in Savannah Watersheds of the Bamenda Highlands, Cameroon**

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Land cover and its configuration in the landscape are crucial components in the provision of biodiversity and ecosystem services. In savannah watersheds, natural landscapes mostly covered by a mixed of montane forest, grassland, shrubs and grasses have been to a large extent transformed into cultural landscapes since long time ago. We investigated land cover changes in Kilum/Ijim Mountains and surrounding watershed using multi-temporal satellite imagery taken in 1978, 1988, 2000 and 2008. The major trends in this dynamic landscape were reduction of water bodies, transformation of primary forest and conversion of shrubland/grassland to intensive land uses such as farmland. The average net annual deforestation rate was 5.6 %, and shrubland reduction occurred at an annual rate of 2.3%; agriculture, residential areas and timber plantations increased at annual rates of 0.3 %, 0.85 % and 1.6 %, respectively, during the 1978–2008 period. Total forest and shrubland loss rates were partly offset by passive revegetation following the institution of community forestry in the 2000s. However, most of the areas that were passively revegetated remained as shrubland and did not turn into forests due to a low capacity of forest recovery. This resulted in a progressive loss and degradation of forest and water resources over the entire region. Overall, the documented land cover changes increase provisioning services such as crops, cattle, and timber that are characteristic of cultural landscapes in the area but may cause an irreversible loss of biodiversity and a depletion of other ecological services provided by forests and shrubland. The implications for conservation of this area and the need for territorial planning and adapted land-use strategies are discussed.

**Keywords:** Ecosystem services, deforestation, Kilum/Ijim Mountains, remote sensing, savannah watersheds

## Bee Pollination and Coffee Production in the Context of Various Management Practices

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Agricultural productivity, particularly in the tropics, is at least partially dependent upon natural ecosystem services such as pollination, pest control, and water and soil conservation. While empirical studies have shown that the productivity of coffee is enhanced by insect pollination, rarely have management practices been included in such analyses. This omission means that the value of pollination services cannot be set within the range of management interventions available to farmers. Without this broader context it is difficult to evaluate how farmers might respond to calls for managing land to secure pollination services. In Kodagu, a major coffee-growing region in southern India, we investigated the contribution that insect pollination makes to coffee production in the context of fertilisation, irrigation and shade management interventions, as well as environmental variables.

Our results show that even taking into account management decisions, bee abundance contributes more to coffee production in terms of number of berries harvested than other management practices, such as liming. Bee abundance, however, is highly contingent upon management actions, particularly irrigation, rather than the nature of the surrounding habitat matrix. Raising awareness among coffee growers of the role of asynchronously irrigating can potentially contribute to improved quantity and quality of coffee yields.

**Keywords:** Bee pollination, *Coffea canephora*, ecosystem services, irrigation, management practices, production

## **Participatory Community Mapping and Assessment of Key Pastoral Resources and Areas in Baringo District, Kenya**

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Key pastoral areas and resources in Baringo district of north-central Kenya, which include dry season grazing areas, water points, riverine areas, swamps, flood plains and elevated grazing areas have been misused for a long time causing some of the resources to be lost and others to face the risk of being lost from the system. This loss affects the ecological functioning of the system and in turn the food security in the area. The project objectives were to identify the key areas and resources in Baringo, map their spatial extent and location, and to determine their condition and rehabilitation needs. Socio-ecological methods were employed in data collection. Focus group discussions were conducted to identify and assess the level of vulnerability to loss of these key resources. Global positioning system (GPS) was used to locate the spatial extent of the resources and a Geographic information system (GIS) map developed. The communities and the researchers classified the condition of the key resources based on attributes that are inherent in their traditional management systems. Ecological techniques which included an index of conservation needs of the sites based on coefficient of relative abundance and dominance of the vegetation species, the amount of seed stock in the soil and the range condition class was used to assess the characteristics and the conservation needs of the sites. More than 80 percent of the 6,869 sq. km of pastoral and agro-pastoral land surveyed were found to be in various stages of deterioration producing less than 20 percent of tropical livestock units (TLU). The major factors causing this loss were identified as climatic, annexation of the key areas, socio-economic, and lack of controlling institutions. Water was ranked as the most vulnerable critical resource, followed by the flood plains. The study recommended that the key resources need to be rehabilitated depending on their level of depletion and the identified key resources be properly managed by restricting the season of use and the number of animals that utilise the areas.

**Keywords:** Indigenous knowledge, inventory and monitoring of resources, rangeland conservation

## Highlighting Threats of War on Biomass and Carbon Stocks using Remote Sensing : Case Study of Darfur Crises

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There is a growing concern about the environmental impact of Darfur's conflict upon limited forest resources. The conflict led to a death of more than 100 000 people and displacement about 2.7 million. The national and international efforts are intending to resettle the displaced people to their home places. Most displaced people were from rural areas where houses are constructed from wood, straw and grasses. As the forest resources are limited, some measures are needed to be taken in advance to the resettlement. Therefore, the study attempted to highlight the threats of expected resettlement upon biomass and carbon stocks of Darfur area using remote sensing, field survey and reports.

Stratified random sampling based on remote sensing data was used to estimate above-ground biomass for selected areas. Diameters and heights of trees inside plots were measured. Models and equations were developed to estimate the number of stems and wood volume. ERDAS Imagine, ENVI ArcGIS, SPSS and CarbonFix Standard were used for data analysis and carbon estimate.

Results showed that Darfur has a total area of 81.3 million ha, of which 22 million ha consists of a woody resource. The total number of displaced households is 308 571. Each household needs about 0.5 m<sup>3</sup> of wood and 0.45 tons of grass in order to build their house. The study concludes that the total amount of wood expected to be removed is estimated at 155 000 m<sup>3</sup> and this would release 100 000 tons of CO<sub>2</sub>. In addition to that about 138 000 tones of grass would be needed which equivalent about 638 000 tons of CO<sub>2</sub>. Thus, it can be stated that there is an expected threat for Darfur's environment in terms of biomass needed for the resettlement of the displaced population. Hence more research and environmental measures are needed before the resettlement should take place.

**Keywords:** Biomass, CO<sub>2</sub>, resettlement, war

## Estimating the Water Conservation Value of Forest Ecosystems

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Forests are one of the most valuable terrestrial ecosystems that provide variable goods and services. There is no market value for most of forest ecosystem services. One of the most important functions of the forest ecosystems is regulation of surface runoff water in watershed by holding the water and its gradual distribution to the rivers. To calculate the value of this function, it is necessary to estimate the forest contribution in surface water runoff controls, and then it is possible to calculate the value with using economic valuation methods. In this study, height and volume of surface runoff in the current status of the study area (natural forest) was calculated with using Justin experimental methods. Two scenarios have been defined including converting the forest area into degraded forest, and into an eroded pasture. The amount of water that has been hold in each scenario was calculated separately. Research results indicate that converting the study area into degraded forest will make the amount of surface water more than twice, and changed into eroded pasture will make the amount of surface water more than six times; this means reduction in amount of water stored in underground water table. The value of this forest ecosystem function has been estimated by using replacement costs method. The results shows that each hectare of the study area has a value as 102 Thousand Rials in the protection of water resources, compared with a degraded forest, and 464 thousand Rials compared with an eroded pasture. The map of this ecosystem service has been made by using geographic information system.

**Keywords:** Caspian forest, economic valuation, forest ecosystem services, replacement cost method, water resource conservation

## Role of Various Plant Species in Methane Emission from Soil: A Functional Group Based Large-scale Screening of Wetland Plant Species

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Methane is a potent greenhouse gas and wetlands — along with paddy fields — are its single largest natural source. Plants are one of the major biotic factors influencing methane fluxes from wetlands. Various plant species can have a positive or negative impact on methane fluxes, by affecting different mechanisms viz. production, consumption and transport. Therefore, a shift in species composition may have drastic effect on carbon balance of wetland ecosystems. Current knowledge about relative behaviour of species in relation to methane emissions is rather poor. A relationship between methane emissions from wetlands and plant functional groups, if any, may help in estimating current scenarios and also in making model-based predictions, which in turn could assist in designing appropriate mitigation strategies. It is evident that plant species differ in their ability to transport methane. Plant species-specific or growth form-specific differences in transport rates may be acting as an important control on CH<sub>4</sub> fluxes. There have been various attempts to investigate the role of plant species in methane emissions, but generally only a limited number of species were compared, or data were derived from different experiments and conditions making it difficult to come up with general conclusions. We conducted a functional group based, large scale screening study with an aim to evaluate the influence of different plant species on methane emissions from soil, and to find out whether there is a correlation between plant functional groups and the emissions. We also aimed at assessing the variation in plants' ability to transport methane from rhizosphere to atmosphere. The set of plant species comprised of 20 European wetlands species including both forbs and graminoids selected over a range of habitat preference i.e. from low to high productivity. Plants were grown on intact peat cores collected from a nature reserve in northern Switzerland. This experiment has revealed interesting results, which we would like to present in Tropentag 2010.

**Keywords:** Emissions, fluxes, gas transport, methane, species, wetlands

## Rapid Inventory in Oak-Beech Woodlands: Implications for Conservation Management in Coed Dolgarrog Nature Reserve in North Wales

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Coed Dolgarrog is a rare example of semi-natural oak woodland in the northeastern side of Snowdonia (North Wales). The site has been subject to various patterns of disturbance over the centuries becoming a National Nature Reserve (NNR) in 1959. The Study's objective was to understand trends in natural regeneration by comparing patterns of succession between two canopy gaps of different ages and a site with undisturbed under-canopy conditions; using rapid inventory approaches. The "younger", "older" and "undisturbed under-canopy" zones were identical in all other aspects (*i.e.* topography, aspect, soil type, hydrology, past land management). Although, oak (*Quercus petraea*, *Q. robur* and hybrids) is the dominant canopy tree, no signs of regeneration was observed in the sampling areas. This clearly concurs with other studies and reports on Coed Dolgarrog which underline the low levels of oak regeneration. It seems plausible that Oak was successful in large part due to planting and management practices which favoured its dominance. It has also been noted that Beech was, in all likelihood, introduced deliberately to the site at a subsequent time and presumably also managed for timber purposes. Unlike the Oak population, beech (*Fagus sylvatica*) appears to be regenerating successfully in the absence of any management. The presence of beech and its perceived threat as a future dominant canopy species in Coed Dalogorrag is linked to its classification as a non-native species in North Wales and to its 'highly shade tolerance', being the aim of the conservation management to limit its dominance and spread. Although we had observed high densities of Beech seedlings and saplings in the surveyed plots, it would be unwise to over-interpret this trend as indicative of regeneration patterns for the site as a whole. Therefore, however, data from this survey shows that beech seems to be more favoured than other species in young gap conditions, in later stages ("older gap") this situation is attenuated and the relative height dominance of Beech decreases in later stages of succession, for both seedlings and for saplings.

**Keywords:** Coed Dalogorrag, conservation management, North Wales, oak-beech woodlands, rapid inventory



## The Role of Indigenous Highland Tree Species on Soil Fertility Management

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Nutrient cycling is a key process in forest ecosystems as it maintains the availability of nutrients for vegetation growth. Several studies have been reported on the influence of trees on soil fertility improvement however, there is much less information on indigenous high-altitude tree species regarding their ameliorative role on soil physical and chemical properties. *Hagenia abyssinica* (Bruce) J.F. Gmel. is one of the highland native tree species of Ethiopia with tremendous values. The study was conducted in order to assess soil quality indicators (physical and chemical properties) under this tree. Soil samples were collected beneath *H. abyssinica* trees growing in the dry Afromontane forests of Ethiopia. Soil analysis was carried out in the laboratory following a standard procedure. Soil texture was characterised as clay, silt clay, or silt clay loam with pH ranged between medium to slightly acidic type. The study found out that *H. abyssinica* trees were capable of enriching the soil with N, and organic C. Superb soil organic matter content, exchangeable base forming cations, and CEC was exhibited. This suggested that the studied soils can act as reservoirs for basic elements due to high organic matter content which resulted from greater volume of litter inputs, and high biomass production under trees. High rate of addition of litter may facilitate temporary nutrient pool in the surface soils which has important implications for long-term productivity of land. Provided that the litter cover is maintained, the organic matter will be retained consequently, the essential nutrients required by plants could be derived from this organic matter. Therefore, it can be recommended to integrate this tree species of great potential in agricultural land for fertility management. Given the low soil fertility status of the farms in the Ethiopian highlands associating such important trees is vital. Moreover, knowledge on such important tree species encourages farmers to incorporate them in their farmland. Therefore, it is imperative to take measures to protect *Hagenia* from being deforested.

**Keywords:** *Hagenia abyssinica*, soil fertility improvement, soil physical and chemical properties

## Human-wildlife Conflicts Around Exclosures: The Case of May Ba'ati, Douga Tembien Woreda, Tigray, Ethiopia

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This study was conducted to assess the human—wildlife conflicts around exclosures as perceived by farmers in Tigray, Ethiopia. Individual interviews of sixty respondents which were selected from the list of households using stratified random sampling, and focus group discussions were conducted in data collection. Chi-square test was used for data analysis. The study revealed that there were human-wildlife conflicts of different forms which could influence the co-existence between large wild mammals and man. Among the conflicts mentioned by the respondents, damages on crops and domestic animals by large wild mammals were the most common. There is a variation in the opinions of respondents on the extent of damages caused by large wild mammals as 40 % of the respondents rated the damage very high while 40 % rated less. Killing of the dangerous large wild mammals and using different preventive measures such as smoke at farmlands and around houses were considered by the respondents useful to reduce the damage by large wild mammals. It is found that the relationship between age and education level of respondents with advantage of wildlife and killing animals as a strategy to solve conflicts were not significant ( $p > 0.05$ ). This could be due to the absence of wildlife related courses in elementary schools. The respondents perceived that the establishment of exclosures near human residence and existence of hiding places for large wild mammals were the two main causes of the conflicts. Thus, during exclosure establishment, distance to human residence should be considered to minimise the potential conflicts between large wild mammals and villagers, and thereby ensure the sustainable conservation of biodiversity and forest rehabilitation through establishing exclosures. Awareness creation and incorporation of wildlife education in elementary schools are important to enable the local people understand the short and long-term benefits of exclosures and wildlife resources.

**Keywords:** Biodiversity, conflicts, conservation, exclosure, forest rehabilitation, large wild mammals

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## Satellite-based Analysis of Forest Fragmentation and Land Use Dynamics in the Atlantic Forest of Rio de Janeiro

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The Brazilian Mata Atlântica is one of 25 world wide hotspots of biodiversity, with a high degree of species diversity and endemism. Historical land use has reduced the Mata Atlântica biome to about 11.5 % of its original extent. Efforts in nature conservation in the Mata Atlântica of Rio de Janeiro are part of an overall plan to protect larger forest patches in the biogeographical corridor of Serra do Mar. Smaller forest fragments in the bordering agricultural landscape of the lowlands play an important role as stepping stones to aid connectivity to the corridor. Apart from these biological functions the forest fragments provide important ecosystem services for food production, such as water storage, purification and erosion prevention. Therefore, protection and sustainable management of these small fragments are of outmost importance. Recent landscape dynamics has been characterised by small losses and gains at the forest edges. To better understand the small scale changes of the forest cover, an analysis of land use / land cover dynamics was carried out. Former studies based on medium-resolution imagery were not able to identify these small changes in the forest cover. Therefore the present study, which focusses on the municipality of Cachoeiras de Macacu, is based on the interpretation and analysis of high-resolution SPOT 5 imagery from the years 2003, 2005, 2007, 2008 and 2009, using ENVI 4.7/IDL 7.1 and ArcGIS 9.3. We present the methodology used, identify and quantify the small scale changes of the forest cover, and discuss the consequences for forest connectivity and land use management. The study is embedded in the interdisciplinary research of the Brazilian-German cooperation project DINARIO/MP2.

**Keywords:** Atlantic forest, ecosystem services, forest fragmentation, land use dynamics, remote sensing

## Developing Strategies for Managing Andean Agroecosystems in Colombia

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The Otun basin river is located in the central range mountain of the Colombian Andeans. This area includes an interesting complex of relationships and dynamics between natural ecosystems and human population. Highlands between 2000 and 4000 masl are important for providing ecosystems services and lowlands between 2000 and 900 masl represent the territory for urban settlements and rural activities. Approximately 500.000 people settled in the coffee region of Colombia (city of Pereira) depend on goods and services provided by natural ecosystems and agroecosystems. Most of the highlands surface (above 4000 abs) belong to protected areas conformed by paramo ecosystems which fulfil significant ecological functions of regulating water resources. Buffering areas of paramo ecosystems (2000–4000 abs) are covered by Andean tropical cloud forest with high although breakable biodiversity. Lowlands (2000–900 abs) conform a mixed landscape with agriculture, livestock and remnants of forest. Remnants of forest accomplish important ecological functions such biodiversity refuge and stepping stones for ecological restoration processes as well. Currently conditions of this significant area in Colombia are threatened by degradation of natural resources and lately by climate variability. As a consequence ecological processes are being shaken and some changes have been elucidated.

Territorial security is now a priority which permits to face integrally ecosystems degradation. Currently, politics, institutional strengthening as well as strategies of adaptation through planning and incorporation of adequate practices within farm systems, are being implemented for contributing to territorial security and additionally to increase agroecosystems resilience. Information generated when monitoring biodiversity (functional groups), soil and water, has permitted to define agroecosystems vulnerability and elucidate measures of adaptation. In this sense, actions addressed from different sectors and stakeholders, taking in account particularities of each farm systems, are providing the bases to develop strategies for managing properly agroecosystems.

**Keywords:** Agroecosystems, ecosystems services, forest fragmentation

## Impact of Resettlement and Refugees on the Natural Vegetation: The Case of Abobo and Fugnido Sites in Gambela, Ethiopia

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The direct environmental impact of resettlers and/or refugees in their destination areas is deforestation, which is common phenomenon exacerbating land degradation in Ethiopia. The aim of this study was to examine the impacts of resettlements and refugees on the natural vegetation resource in resettlement and refugee sites in western Ethiopia. Remote sensing and GIS has been used to quantify and analyse the land use land cover change (LULC) as well as the dynamics using Landsat images of MSS 1973, TM 1987 and ETM+ 2002. A survey of the vegetation has been conducted to assess the impacts on the structure, composition and diversity of the vegetation. The result of the LULC analysis showed that the natural vegetation cover, particularly the forest, has been dwindling at a rate of 3 792 ha per year in the past three decades. Besides the dynamics shows that much of the forest land has been converted to spars woodland and the woodlands have been changed to shrub lands and grasslands. The major drivers are uncontrolled cutting, expansion of settlements and agriculture. The vegetation analysis shows that a total of 20 woody species in 10 families are found in the study area. However, as compared to the intact sites outside of the resettlement and refugee areas, the vegetation in and around the resettlement areas are poor in diversity, structure and species composition. The diversity index ( $H'$ ) of resettlement and refugee areas in Abobo and Fugnido sites is 1.95 and 1.82 as compared to  $H'$  of the intact areas, *i.e.* 2.21 and 2.55, respectively. The regeneration of the major species in the resettlement and refugee areas is significantly affected ( $p < 0.05$ ) and many of the species are poorly represented. The study generally shows the natural vegetation in the resettlement and refugee areas are under immense pressure of degradation and policy interventions are necessary to prevent and control further degradation.

**Keywords:** LULC dynamics, refugees, resettlement, vegetation structure

## Developing an Operational Method for Assessing Forest Resources in *Abu Haraz* Reserved Forest in Kordofan, Sudan

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Forest resources in Sudan play different roles in characterising the ecological and environmental changes as indirect benefit and satisfy a wide range of needs for the rural population (food, shelter, energy, income). The area under forest reserve is five million hectares, which is equivalent to 2.2 % of the total area of the country. Forests in Sudan contribute to 82 % of the total energy consumption in the country. Due to decline in forest resources in Sudan and the expected bad consequences, quantifying and appraising of the existing resources and their sustainable management is needed. The aim of the research is to develop an operational method to assess the forest resources in *Abu Haraz* natural reserved forest in Kordofan using cluster sampling method. *Abu Haraz*, which is selected as the study area, is the biggest natural reserved forest in Kordofan and located in low rainfall woodland savannah. Six systematic cluster sampling were used and distributed in the forest with equal distances. Each cluster covers an area of 60 ha, and includes 25 circular sample plots. Tree parameters such as tree specie, diameter, height, crown diameter were collected from trees with dbh  $\geq 7$  cm. Step-wise regressions was used for developing the operational equations of tree species. Results showed that the reserved forest is dominated by two species, *Albiza amara* and *Lannea humilis* with 34 % and 46 %, respectively. The density of the trees is found to be of 37 trees ha<sup>-1</sup>, volume is 24.13 m<sup>3</sup> ha<sup>-1</sup> and basal area is 2.25 m<sup>2</sup> ha<sup>-1</sup>. 72 % of the growing stock is found in diameter class between 27–31. Two equations were developed for the dominant species using volume as dependent variable and height and diameter at breast height as dependent variables. The sampling error and intracluster correlation coefficient error were found to be  $\pm 10$  % and 0.07, respectively. The study concludes that the forest is under heavy pressure of local use so a management plan must be formulated in order to reduce the degradation of the area.

**Keywords:** *Abu Haraz*, cluster sampling, forest reserve, step-wise regression

## Estimation of Aboveground Biomass Across Forest Types at Different Degradation Levels in Central Kalimantan (Borneo) using LiDAR and Field Inventory Data

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The quantification of tropical forest carbon stocks is a key challenge in creating a basic methodology for REDD (Reducing emissions from deforestation and degradation in developing countries). Small-footprint LiDAR (Light Detecting and Ranging) systems have proven to successfully estimate above ground biomass (AGB) in boreal and temperate forests. Their applicability to forest types of Central Kalimantan, Indonesia, were tested using two approaches: (1) linking single tree parameters via allometric equations, and (2) developing a multiple regression model at plot level using point cloud characteristics. Inventory data barely exist for Kalimantan's forests. In order to achieve the requirement of a high number of field plots the faster angle count sampling was applied. Fixed-area plots were used as a control and approved the use of the angle count method. 415 out of 1034 field-positioned trees could be identified in the LiDAR canopy height model. Diameter at breast height (DBH) measured in the field and LiDAR derived crown diameter and height could be successfully linked by allometric equations (lowland dipterocarp forest:  $R^2 = 0.63$ ; peat swamp forest:  $R^2 = 0.77$ ). TreeVaW, a tree detection software for LiDAR data, was used to identify individual tree parameters of whole LiDAR tracks. AGB values were generally underestimated due to the non-detectable understorey biomass. The plot level approach emerged as more adequate and effective than the single tree approach. Several AGB-predicting models were established for each forest type using statistical values of the laser canopy height distributions within a 1-ha-plot. The 65<sup>th</sup> percentile and the total number of laser points explained 82 % of the variation in lowland dipterocarp forest plots (RMSE = 21.75 %). The best model for peat swamp forest could only explain 42 % of the AGB variation (RMSE = 34.88 %). Taking both types altogether explained 68 % (RMSE = 37.71 %). Regression application showed reasonable results in two control areas. The models have high potential to be implemented in REDD projects which will contribute to the protection of forest ecosystems throughout Kalimantan, to ensure a sustainable way of living for the local people and improve their living conditions by the means of fair payments from the industrialised countries.

**Keywords:** Aboveground biomass, forest inventory, Indonesia, LiDAR, REDD, tropical forest

## Land Use and Population Dynamics in a Mountain Watershed of Nepal: A Case Study from Salakhukhola Watershed

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The amount, the rate and the intensity of land use and land cover change are very prominent in least developing countries like Nepal. The human impact upon the land is enormous and still increasing. This study analyses the nexus between population dynamics and land-use practices in Salakhu Khola watershed, a micro-watershed in the mid-hill region of Nepal. The spatial and temporal change patterns of land use were quantified by interpreting remote sensing (RS) data and use a geographical information system (GIS). The paper mainly focuses on spatial and temporal changes in land use between 1989 and 2006 in this typical watershed of Nepal where community forest projects were implemented by the government 15 years ago.

Time serie data regarding demographic and socio-economic parameters of the study area from primary and secondary sources were also used. The dynamics of population, land use, and land cover within the Salakhu Khola watershed are investigated by performing spatial analysis of digital land use maps in ArcGIS. The results show there is a significant increase in forest cover of 63 percent and agricultural land of 8 percent in the watershed with a corresponding decrease in shrubland and grassland during the length of 17 years. The number of people living in the watershed has been reduced because of internal migration to the plain areas and temporary labour migration to India and Gulf countries. The annual rate of population growth is 1.62 % in the study area. This has resulted in significant reduction of grassland and shrubland in the watershed area.

**Keywords:** GIS analysis, land-use change, Nepal., population dynamics, watershed



## Assessing Topography-related Determinants of Soil Carbon Stocks in the Mae Sa Noi Subwatershed in Northern Thailand using a Geostatistical Approach

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Carbon stocks form a very important component of a larger set of ecosystem services, provided by South East Asia's watersheds under sustainable land use. Quantifying these carbon stocks under changing land use is one objective of sub-project C4.2 in the SFB 564 Uplands Program. Data on aboveground carbon stocks is relatively easy to obtain and is available for many ecosystems. Few datasets exist however, for soil carbon stocks, particularly for (re)forested parts of the Mae Sa Noi sub-watershed. Detailed geological and soil information has been gathered as part of the Uplands Program, but this information has been limited to the more easily accessible agricultural lower parts of the subwatershed. This gap in field data has been a major limitation in modelling carbon stocks under different land uses in the area.

Top- and subsoil auger samples will be collected along a spatially representative layout for the 2 km<sup>2</sup> area and analysed for organic and carbonate carbon, total nitrogen, pH and texture. Soil carbon stocks will be calculated considering horizon thickness and bulk density. Georeferenced carbon values will be entered into a GIS and the major part used to derive regressions of organic C contents to topographic features (elevation, slope, exposition, wetness index, among others), which will be combined with kriging or other interpolation techniques. The remaining samples will be used for model validation.

Expected outcomes of this study are to produce a comprehensive map layer for carbon for the Mae Sa Noi sub-basin by integrating new data with the existing data and by applying weighted interpolation techniques. This will allow to draw conclusions on the impact of different land uses (agriculture, reforestation) on carbon stocks. Map layers for nitrogen, pH and horizonation will be obtained by interpolation. Soil carbon data will serve as inputs and for calibration and validation of a spatially explicit dynamic Land Use Change Impact Assessment model (LUCIA), which includes plant growth and erosion processes.

**Keywords:** GIS, soil carbon stocks, spatial variability, topography

## How REDDy is African Agriculture? Supplying Robust Carbon Estimates for Agricultural Landscape Mosaics in Western Kenya

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The international debate on climate change mitigation has shifted from its traditional focus on forest activities as REDD+ actions to recognising the significance and hence including agriculture and other land use (AFOLU). This creates new opportunities to couple mitigation with adaptation actions and for rural farms in the tropics to participate. Agricultural land in many regions of sub-Saharan Africa harbors a considerable amount of trees (87 % have tree cover >10%), hence the contribution to stabilise or even increase carbon sequestered in agriculturally dominated landscapes can be key to a holistic biomass carbon assessment, while simultaneously reducing risks of leakage in terms of REDD+ and address issues of food security.

In this context, robust and viable methods are needed to assess biomass carbon in agro-landscapes. While species specific ways of estimating carbon in trees through allometries are available, the tree cover in agro-landscapes is commonly not monospecific. Hence, this project on carbon benefits (CBP) aims at

(i) developing a generic allometry covering the biodiversity of the western Kenyan landscape mosaics through empirical, destructive measurements on a randomised layout within three 100 km<sup>2</sup> benchmark sites,

(ii) improve the knowledge base on root:shoot ratios by harvesting of below-ground biomass

(iii) explore correlations of the empirical data with non-destructive methods for estimating wood volume and biomass such as the fractal branching approach (FBA).

We present the advantages and constraints of this approach and present the first results for above and below-ground carbon stocks in western Kenyan agro-landscapes and their implications and relevance for non-destructive biomass assessments. The impacts of this research for carbon projects as well as local stakeholders in terms of readiness for tapping into carbon benefits will also be discussed.

**Keywords:** Allometry, carbon, climate change, fractal branching, Kenya, REDD, sub-Saharan Africa

## Estimating CO<sub>2</sub> Sequestration Potential in Northwest Viet Nam: Combination of Field Measurements and Remote Sensing Analysis

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Increasing population density and economic development have forced people to expand agricultural production into upland areas in Vietnam. This resulted in decreasing natural forest cover with a conjoint increase of tree-based plantations and a replacement of traditional swidden farming systems with commercial cropping systems. Our study aimed at reconstructing past land cover based on remote sensing imagery, and combined this information with primary quantitative biomass and C stocks data of perennial vegetation to quantify and evaluate communal CO<sub>2</sub> sequestration potential.

To generate land cover maps of Chieng Khoi commune, Northwest Viet Nam, LANDSAT 1993, 1999 and IRS LISS III 1C 2007 were used. 262 Ground Truthing Points (GTP) were collected, and farmer interviews and group discussions were conducted to gather information per GTP in past times. Hybrid classification methods were applied to classify land cover maps. Land suitability information, cropping season calendar, participatory soil maps and local stakeholder interviews were used to classify crop cover. To quantify C stocks, 10 perennial land-use systems were surveyed using a nested sampling plot design. Aboveground biomass parameters of overstorey trees were measured non-destructively, parameters of mid-, understorey vegetation and coarse litter were sampled destructively. Allometric equations for early succession species were developed.

Land cover maps for 1993, 1999 and 2007 were generated, overall accuracies were 81.1 %, 98.5 % and 82.5 %, respectively. Even though forest areas decreased by ‘only’ 36 %, based on the map of 2007, our results showed a reduction of 61 % in total communal carbon stocks during the last 50 years. This shows the different carbon storing capacities of natural forest vegetation and tree based plantation systems and limited usefulness of C stock estimates based on rough land cover categories without site-specific ground measurements.

The study combined methods to quantify biomass and carbon stocks over time at landscape scale. It also provided input data for a spatially explicit and dynamic Land use Change Impact Assessment tool, which can be applied to assist land use planners to mitigate climate change and improve the management of natural resources.

**Keywords:** Allometric equation, carbon stocks, land cover maps, remote sensing, Viet Nam

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## Determinants of Forest Cover Dynamics in the Margins of Protected Forest Areas

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The Lore Lindu National Park in central Sulawesi Indonesia hosts a unique collection of endemic species. They are very important for biodiversity and conservation. However, land use in this region has continued to change substantially, and conversion to agriculture by the rural communities is the major source of deforestation in this area. Since rural communities at the forest margins certainly should however play a significant role in maintaining the stability of the rainforest, a better understanding of the socioeconomic dynamics is beneficial in decelerating the pressure on forest degradations. This paper aims to assess the socioeconomic and geophysical factors that drive changes of land use from forest to non-forest. We use non-linear spatial panel econometric models. For this purpose, we applied spatial panel econometric models for the first time to the study of land use. Our analysis presents the dynamics of forest covers using spatial and socioeconomic data from 2001 and 2007, obtained from Landsat images and surveys in 80 randomly selected villages respectively. The land use persistence between the two periods indicates that 83.7 per cent land that was not forest before remained as non forest the next period, while 95.2 per cent land that was forest before remained as forest the next period. The results show that population density, share of irrigated land at the villages and the mean of annual rainfalls were significant to influence changes of land use from forest to non-forest. To maintain the sustainability of the environment and thus to ensure rural welfare, the suggested policy options such as investment on irrigation scheme and population growth control should be implemented.

**Keywords:** Deforestation, forest cover dynamics, land use change, Lore Lindu National Park, spatial panel analysis

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## Vegetation and Soil Dynamics in the Fallows Around the Biosphere Reserve of Pendjari in Northern Benin (West Africa)

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Always considered as the hotspot of biodiversity in Benin, the Biosphere Reserve of Pendjari has been safe from human pressures for long time. The demographic increase is constraining more and more the reserve in terms of land need for agriculture. This work aims to study the vegetation of the fallows around the Reserve, to determine the ecological characteristic parameters of the different stage of the fallows, then to deduct the ecological optimum of fallow duration. 132 phytosociological measurements have been made with the Brawn Blanquet method inside sample areas of 900m<sup>2</sup> in different age of fallows. Appropriated soil sample analysis permitted to study the ecology of the different succession phases. The measurements have been ordinate by non metric scaling method with the statistical software R. For soil data, first order position parameters have been calculated with Microsoft Excel. The cycle of the secondary succession varies between 10 and 15 years. The passage from a stage to another is characterised by the appearance of new species, the disappearance of others related to the soil parameters. The rate of species appeared and extinct decreases with the age of the fallow. From the 242 plant species counted for this survey, 22.3 % are present along the cycle. More than 70 % of the species disappear after the first three years of the succession. This stage is 90 % constituted by yearly species as *Digitaria horizontalis*, *Indigofera pulchra*. The phases evolved of the succession (7 to 10 years) are characterised by the appearance of perennials (*Andropogon gayanus*) and woody (*Combretum micranthum*, *Terminalia avicennioides*) species. With 24 % of total species richness only 4 % are exclusive to this stage. The species achieve their maximum at the end of the cycle. The sandy soil in the beginning of the succession with a very low rate of organic matter (2.42 %) is poor in exchangeable bases ( $Mg^{2+} = 1.34 \%$ ;  $Ca^{2+} = 2.10 \%$ ). At the end of the succession, soil is sandy clay with the most elevated rate of organic matter (4.69 %). The ecological optimum is gotten after 8 years of fallow.

**Keywords:** Biodiversity, fallow, Pendjari reserve, secondary succession, vegetation

## Protection of Water Resources in Cattle Ranching Areas of Colombia through Riparian Corridors and Silvopastoral Systems

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Cattle ranching is a key economic sector of the Colombian economy, contributing 27 percent of agricultural and livestock GDP and 28 percent of rural employment. This activity occupies about 38 percent of Colombia's total land surface, an area that has expanded from 14.6 to 38 million hectares during the last fifty years, mainly at the expense of tropical forest. Through its impact on Andean and Amazon Basin forests, ranching-induced deforestation has historically been one of the main causes contributing to the loss of unique plant and animal species in Colombia. A great proportion of the deforested area is nowadays covered by degraded pastures. This has affected not only biodiversity but also soils since 66 percent of the land used as permanent pasture is degraded and otherwise unsuitable for grazing. The destruction of forests and the degradation of soils, among other factors have resulted in a degradation of water resources which has affected not only water quality but also aquatic habitats from springs and small streams to rivers, wetlands and estuaries.

Although studies of the impact of cattle ranching on water environments are scarce, several investigations have demonstrated that the activity negatively affects water environments in the Andean and Amazon regions, mainly by reducing the quality of the physical habitat in streams and by increasing organic matter and reducing oxygen concentration in the water. However, there are alternatives for reducing damage by cattle which include the protection of springs and water courses, reduction of the effect of diffuse pollution and the transformation of homogeneous pastures into silvopastoral systems. With these practices, cattle grazing can contribute to improve water quality and regulate the hydrological cycle at micro-watershed level with benefits for the environment and local population.

This work briefly describes the history of cattle occupation in Colombia, explains the environmental impacts of this activity with particular reference to aquatic environments and presents the effect of riparian corridors and other measures based on silvopastoral systems on the reduction of soil degradation, and improvement of water quality, habitat properties and aquatic biodiversity in the Andes of Colombia.

**Keywords:** Cattle, environmental impact, pastures, tropical streams, watersheds

# Biodiversity

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## Role of Traditional Enclosures on the Diversity of Herbaceous Vegetation in a Semi-arid Rangeland, Southern Ethiopia

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The use of traditional enclosures locally known as *kalo* is widely practiced by pastoralists in East African rangelands for dry season grazing by calves. Traditional range enclosures can be used as a method of rangeland restoration where rangelands are often heavily grazed to allow the herbaceous vegetation diversity to recover. Generally, grazing management and seasonality strongly influenced the recovery potential of herbaceous vegetation in semi-arid rangelands of southern Ethiopia after history of heavy grazing. Despite the expansion of range enclosures in the communal rangelands of southern Ethiopia, only few studies have documented the role of range enclosures and seasonality on the conservation of herbaceous vegetation diversity. We investigated effects of management (enclosures versus grazed landscapes), age of enclosures and seasonality related to rainfall (*i.e.*, independent variables) on herbaceous biomass, grass basal cover, herbaceous species abundance, species richness and diversity in a savannah rangeland of southern Ethiopia. We further assessed the relationship between the herbaceous biomass and species richness. Management significantly affected most of the herbaceous response variables (*i.e.*, comparing enclosures and open grazed). Herbaceous biomass, grass basal cover, herbaceous species richness and diversity were greater in enclosures than in grazed areas. Rainfall was also influential on herbaceous biomass, grass basal cover, abundance of herbaceous species, herbaceous species richness and diversity. Herbaceous biomass, abundance and diversity did not however vary with the age of enclosures, while herbaceous species richness appeared to decrease as the age of enclosures advanced. Grass basal cover initially decreased and later on increased with the age of enclosures, so that the older enclosures disclosed improvement of grass basal cover.

**Keywords:** Herbaceous layer, rainfall variability, savannah, southern Ethiopia

## Does Commercialisation Affect Tree Species Richness and Diversity in Urban and Peri-urban Gardens of Niamey, Niger?

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Homegarden-like systems are regarded as sustainable based on their high diversity of annual and perennial plants. This makes them also suitable for *in situ* conservation of plant genetic resources (PGR). Commercialisation of gardens is often related to increasing dominance of annual vegetables at the expense of trees, thus, threatening their agrobiodiversity. However, little is known about consequences of such transformation processes on tree species richness and diversity in an urban/peri-urban setting. Focussing for the first time on a Sahelian, West African city, this study aimed to answer the following questions: (i) Do commercial vegetable gardens have a lower tree species richness and diversity than subsistence gardens?; and (ii) Which garden type harbours high tree species richness and diversity and is, thus, more suitable for PGR conservation?

In 51 urban and peri-urban gardens randomly selected in 10 districts of Niamey, Niger, diversity parameters of all trees (also including shrubs and vines) were assessed. Socio-economic household data were gathered through individual interviews of the gardeners. In the surveyed gardens, a total of 63 tree species were grown. Almost 60 % of these species were of exotic origin; abundances were mostly low, and 29 species were each found in one garden only. On average, 5.8 tree species (including 1.8 indigenous ones) were grown per garden (range 0–42). Highly commercial vegetable gardens (57 % of the sample) did not harbour less tree species than semi-commercial or subsistence ones. Multivariate regression analysis revealed the positive influence of garden and household sizes and portion of annual cash crops on tree species richness. Cluster analysis based on species abundances resulted in four garden types, significantly differing in mean species richness, density and diversity indices. High richness and abundance of tree species were found in clusters grouping urban, large gardens of male gardeners that cultivated large numbers of annual cash crops.

In conclusion, commercialisation did not threaten tree species richness in urban and periurban gardens of Niamey. The value of both commercial and subsistence gardens for *in situ* conservation of tree species, however, may be questionable due to low species abundance and frequency of occurrence, particularly of indigenous tree species.

**Keywords:** Abundance, cluster analysis, *in situ* conservation, multivariate regression analysis, plant genetic resources, species richness

## **A Biodiversity Evaluation Tool for the GMS - Modelling Concept for Conservation and Planning**

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Within the framework of the “Living Landscapes China” LILAC project, we have developed a biodiversity evaluation tool based on the combination of approaches from landscape ecology and empirical data into a Geographic Information System. Detailed data on floral species diversity and distribution has been combined with quality criteria like endemism or invasiveness to form spatially explicit indices for different land use type in various elevation classes. Similarly, data on arthropod diversity and movement patterns have been assessed in key location, to enable us to draw conclusion on insect distribution throughout the research area, a watershed in south-western Yunnan province, PR China. Habitat characteristics and distribution was included into the analysis of the land use map derived from remote sensing to allow the assessment of fragmentation and landscape matrix structure.

Similar approaches have proven useful in extending field observations in areas where topography or other factors constrain more detailed empirical analyses. Our assessment covers a multitude of land use systems and natural land cover types, including rapidly expanding low-land rubber cultivation in various stages of development.

All throughout the Greater Mekong Subregion, natural landscapes are under great pressure from developing infrastructure and rubber plantations, its’ impact on local species diversity might prove considerable.

The aim of this tool is to provide scientists and policy makers with information about the current state of biodiversity in their research area or administrative region and enable them to predict the likely impacts of agricultural land use changes on structural and ecological diversity when evaluating possible future land use scenarios.

**Keywords:** Biodiversity indices, conservation, ecology, landscape metrics

## **Vegetation and Geobiocoenological Typology of the Soqotra Island**

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During the years 2001–2004, complex field observations on more than 250 localities of Soqotra Island were made. As a result, a geobiocoenological typological system describing vegetation of the island has been produced. Five altitudinal vegetation zones, five trophic ranges and three inter-ranges (expressing soil conditions), five hydric ranges (expressing water condition in soil), 26 groups of geobiocoene types and within them (with respect to their actual condition of vegetation) 39 biotope types were delimited. Classification of biotopes is based on differences in physiognomy, structure and species composition of the vegetation component of present biocoenoses. Biotope types are divided according to differences in the species composition of dominant species, groups of geobiocoene (biotope) types are divided according to physiognomy and vertical structure of vegetation. Biotope types are usually named according to key species of plants in the Soqotra language and English.

The method of classification and names of biotope types make possible to complete other types or to use more detailed classification of subtypes. Types of biotopes with natural and seminatural conditions of the vegetation component of biocoenoses are most valuable from the viewpoint of preserving the biodiversity and their segments form the framework of ecological stability, a basis of the ecological network of Soqotra. Each of the biotope types is characterised not only by the intensity of anthropic effects, woody species composition and the canopy closure of the main crown level of trees but also by the geobiocoene type, number of classified plots, function importance, degree of threat, protection priority, distribution and spatial structure.

**Keywords:** Biotops, geobiocoenology, Soqotra, vegetation

## Plant Community and Vegetation of Nandi Forest, Western Kenya

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This study focuses on the description of plant communities and vegetation of South and North Nandi Forests in western Kenya. A total of seventy six 20 by 20 metre plots from both forests were used to collect vegetation and environmental data. These plots were distributed 100 meters apart along transects of 1 km to 1.6 km length and the distance between transects is 500 m. All woody plants greater than two cm diameter at breast height (DBH) and taller than 2 m were measured using diameter tape and hypsometer respectively. Herbaceous plants and seedlings of all woody plants were recorded in five three by three m plots within the bigger plot, at the four corners and the centre. The height of the seedlings was measured using marked stick. Each plant was identified at species level when first encountered in the forest. For those plants which were difficult to identify in the field, voucher specimens were collected, pressed and later identified at herbarium. Multivariate statistical analysis method was used to analyse the data. Cluster analysis and ordination were undertaken using PC-ORD. In this study a total of 320 plant species from 100 families and 242 genera were identified. Tree species accounted for 25 % shrubs, herbs, climbers and epiphytes comprised 15.9, 35.5, 18.0 and 5.0 % respectively. The cluster analysis coupled with indicator species analysis resulted in three different plant communities. The species check-lists resulting from this research is the first of its kind for Nandi forests. This study aims to contribute to the conservation and development endeavour of this valuable tropical forest.

**Keywords:** Cluster analysis, description of vegetation, Kenya, Nandi forest, ordination, PC-ORD, plant community

## Tree Richness and Forest Structure of the Forests around Yongsu Dosoyo, Jayapura, Papua, Indonesia

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It is estimated that Irian Jaya (Papua) contributes to more than half of Indonesia's biodiversity and that Papuan rain forests harbor high species diversity and a high degree of endemism, but this area remain poorly studied. This survey was designed to examine tree richness and forest structure of the tropical rainforests at Yongsu Dosoyo, Jayapura. Two altitudinal sites were considered: from 100–200 m (site 1) and from 300–400 m (site 2). Tree species richness was recorded along 4 transects of  $20 \times 125 \text{ m}^2$  located randomly, while forest structure was studied on 2 transects of  $10 \times 50 \text{ m}^2$  at each site. Tree species diversity was calculated using Shannon-Weaner Index and species composition between transects was calculated using Morsita Index. A species accumulation curve were constructed to determine whether our 4 transects adequately sampled the forest diversity at each site. Results showed that there were 125 tree species ( $\text{DBH} \geq 10 \text{ cm}$ ) belonging to 41 families, and 71 sapling species ( $2 \leq \text{DBH} \leq 9.9 \text{ cm}$ ) from 31 families. Almost the same number of species was found on each site (93 at site 1 and 92 at site 2). The total number of stems increases from 295 in site 1 to 327 in site 2. Shannon-Weaner Index was respectively for site 1 and site 2 (4.31 and 4.45 for trees), (3.87 and 3.93 for sapling). A species area curve showed that the number of species is still increasing when the total area sampled is over 1 ha. There was no difference on tree richness for the 10 “dominant” families between site 1 and site 2, except for Chrysobalanaceae, Clusiaceae, and Euphorbiaceae. Similar pattern on species richness was observed from sampling stage. These results indicate that tree richness is similar to tropical lowland rainforest elsewhere.

**Keywords:** Biodiversity, Indonesia, Irian Jaya (Papua), plant richness, tropical rain forests

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## Ethnobotanical and Ethnoecological Knowledge of Natural Resource Use and Management: A Case of Hani People from SW China

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Nabanhe National Nature Reserve (NNNR) with total area of 266.6 km<sup>2</sup> located in Xishuangbanna Dai Autonomous Prefecture, SW China is rich in biological and cultural diversity. Plant diversity includes 1954 species of vascular plants, 896 genera and 50 families, many of them being endemic to the area. NNNR is topographically mountainous especially in its western part and more than 55 % of the totals area is above 1000 m asl. With exception of Han Chinese, five ethnic minority groups are living in NNNR including Dai, Lahu, Bulang, Yi and Hani. Hani are living in 7 villages in highlands of the area. Ethnobotanical survey was conducted to document and analyse plant knowledge of Hani. Data collection was done through conducting freelist interviews, semi-structured interviews, field walks and botanical sample collections. Botanical samples were identified scientifically and cultural importance of useful plants has been calculated. A total of 143 species of wild food and 199 medicinal plants are used by Hani in NNNR. Most culturally important food plants for Hani are *Callipteris esculenta* (Retz.) J. Sm. (Salient Index: 0.509), *Oenanthe javanica* (Bl.) L. (0.431), *Solanum americanum* Mill. (0.381) and *Musa acuminata* Colla. (0.356). Most salient medicinal plants include *Dendrobium crepidatum* Lindl. ex Paxt. (0.41), *Aristolochia* sp. (0.306), *Microstegium ciliatum* (Trin.) A. Camus (0.129), *Eupatorium coelestinum* L. (0.119) and *Litsea martabanica* (Kurz) Hook. F. (0.116). Used plants were categorised based on habitats and collection sites. The results shows that most of the food species are collected from farm edges, road sides or stream banks near rice fields whereas most of the medicinal plants are collected from collective or secondary forest. The presented data could be used in land use planning and management as well as sustainable harvest planning in the area.

**Keywords:** Ethnobotany, ethnoecology, Hani people, wild medicinal and food plants

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## Rural Communities' Exploitation from Surrounding Biodiversity in Khamin Protected Area: An Ethnobotanical Survey

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Diverse linkages between people's lifestyles, their local knowledge and their utilisation of the surrounding biodiversity can be observed. Khamin mountainous protected area with a domain of 25 586 ha is located in southwestern Iran in tension of the Zagros Mountains range. In order to study the exploitation of local inhabitants of the surrounding phyto-society, an ethnobotanical survey was conducted from April to September 2008. By using a semi-structured questionnaire and through interviews with local informants, information on exploitation patterns was gathered. Altogether 75 species belonging to 35 plant families were utilised by the local population. These species were mainly shrubs and perennial herbes. The most utilised plant families were Umbelliferae, Compositae, and Rosaceae with 11, 7 and 7 species respectively. The analysis of the utilisation patterns showed that from the 75 recorded plants, 43 species (57.3 %) had food uses, and 38 species (50.7 %) had medical uses. This demonstrates the important linkages and dependency of local people with their surrounding natural phyto-society. Also a magnitude of plants, were employed for producing instruments and as construction material, but only two species *i.e.* *Quercus brantii* Lindl. and *Tamarix* sp. were used for preparing fuel. Persian oak (*Quercus brantii* Lindl.) as dominant cover, was the most utilised plant species for local inhabitants, although local informants declared their local knowledge as quickly disappearing. Some species were conserved in rural farming systems and some such as *Pyrus syriaca* Boiss., wild varieties of *Ficus carica*, *Celtis caucasica* Willd., *Pistachia atlantica* Desf., and *Rhus coriaria* L., were at transition to domestication in gardens and rural homegardens. It seems that more attention and considerations should be paid on local communities in protected areas and their knowledge should to be more esteemed.

**Keywords:** Ethnobotany, local knowledge, protected area, rural community, sustainable management



## Linking Gene Banks and Small Farmers to High Value Markets – The Example of *Capsicum* Diversity in Peru and Bolivia

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A key strategy in reaching Millennium Development Goal 1, which aims at eradicating poverty and hunger, is the generation of additional income; this is especially fundamental for improving the livelihoods of poor farmers. According to a recent assessment, 1.4 billion people still live in extreme poverty. In Latin America, 123 million people subsist on less than US\$2 per day, with poverty pockets in the Bolivian and Peruvian Andes, and in the Upper Amazon.

Except for major crops such as wheat and maize, most crop diversity in its centre of origin is still poorly studied, let alone utilised. This is also the case for *Capsicum*, which most likely originated in the Interandean valleys in Central Bolivia, despite the clear interest in this crop from both consumers and farmers. Local project partners in Peru and Bolivia have already collected and conserved native *Capsicum* materials, and have made improvements in local cultivation and processing. Nevertheless, the introduction of high-value varieties targeting specific niche markets, selected from genebank materials, is beyond their reach, as this requires a multidisciplinary approach, including the diversification of existing value chains. In the past decade, socio-economic research and development work has been increasingly oriented towards market studies and upgrading value chains. So far, this work has focused on linking farmers to commodity markets, but has neglected the exploitation of high-value materials conserved in genebanks for differentiated products.

This new GTZ financed project will combine innovative germplasm-selection methodologies with multidisciplinary market and value-chain assessments in order to demonstrate how chili pepper farmers' income can be increased by exploiting diversity that is currently underutilised. The research is designed to bridge the gap between supply and demand by bringing together different types of research institutions that can provide critical knowledge. Although the project focuses on a specific geographic region and crop, this case will demonstrate approaches and technologies to address constraints to effectively harnessing agricultural diversity around the world. Farmers growing mangoes in India or sweet potatoes in Uganda are also struggling with declining commodity prices, and are looking for opportunities to increase their incomes through a transition into high-value, high-quality markets.

**Keywords:** Agricultural biodiversity, high value differentiation, neglected and under-utilised crops, value chain analysis

## Tree and Shrub Species at Lower Atbara River Basin, Northeastern Sudan

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This research represents a study of the vegetation of Lower Atbara River, which is located in eastern Sudan, and the northward areas. Eastern Sudan, which is divided between desert and semi-desert regions, includes Al Butanah, the Gash Delta, the Red Sea Hills, and the coastal plain of the Red Sea. Although Eastern Sudan is very rich in natural vegetation, very few flora studies were conducted in this region. Except for some studies elaborating on fodder trees in Butana area, Atbara River area has not been studied vegetationally.

The main objective of this study is to document the tree and shrub species of Lower Atbara River. A general field survey to the area that included the terrain, soil, climate, the population and a survey to the trees and shrubs was also conducted using Geographical Position System (GPS) with the aim of making a full description to these tree and shrub species on the two banks of Atbara River. Recent field samples (young branches, leaves, flowers and some fruits) of the trees and shrubs were collected, each sample kept separately in a small cloth kit. Botanical check list was used to identify species.

Nineteen (19) tree and shrub species in the area are documented and briefly described focusing on the pattern of growth and the distinguishing characteristics of the plant. The study has resulted in one new species *Prosopis chilensis* that was not yet mentioned in the study area in previous Sudan Flora references.

The study recommends the preservation of the rare and important tree species in the area especially *Hyphaene thebaica* and its re-cultivation and updating of the flora of Sudan.

**Keywords:** Lower Atbara river, shrubs, Sudan, trees

## Study of Antibacterial Activity of Plant Species in Golestan Province

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Ability of medical plants to inhibit growth of pathogen is an untapped resource for bacterial control in humans that could revolutionize medical crop production. Bacterial resistance to antibiotics is a serious global problem and includes strains of beta-lactam-resistant *Staphylococcus aureus* and methicillin-resistant *S. aureus* (MRSA). Novel antimicrobials and/or new approaches to combat the problem are urgently needed. The aim of this study was to investigate the antimicrobial activity of alcohols and aqueous extract of 23 medical plants species of Golestan province on clinical and standard strains of MRSA and MSSA. 23 medicinal plants were collected from their natural habitat in Golestan province in north of Iran. Their ethanolic and aqueous extract obtained by percolation methods. The study was conducted at medical science of Gorgan University during the years of 2007 and 2008. Antibacterial effects were assessed by disc diffusion method against 14 clinical and standard strains of methicillin resistant and sensitive strains of *Staphylococcus aureus*. The result of antibacterial activity of these plants revealed that, ethanolic and aqueous extract of eight, three plants showed best effect. The ethanolic extract of *Artemisia herbaalba*, *Nigella sativa*, *Punica granatum*, possessed the most outstanding *in vitro* antibacterial activity which the maximum inhibition zone was 22.4–18 mm respectively. The results showed that ethanolic extract had better antibacterial effect than aqueous extract and anti-staphylococcal activity of ethanolic extract of plants against MRSA was better than MSSA strains. Ethanolic and aqueous extract of *P.granatum* had the best antibacterial activity against microorganism. The results obtained from these plants might be considered sufficient for further studies.

**Keywords:** Antibacterial effect, ethanol and aqueous extract, medicinal plants, *Staphylococcus aureus*

## Protected Area: Present Situation and Future Conservation in Sudan

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For the representing of the actual status of Sudan Protected Area management and contributing in the review of this issue, focusing in the Dinder National Park as an example this work is carved out giving an overview of the conservation history of the protected areas in Sudan.

The history of conservation areas and national parks in Sudan has always been closely linked to the historical and political evolution of the country. Sudan is the largest country on the African continent. The area of the Sudan is 2.5 million square kilometers; the population totals 33 million, comprising 540 tribes and a number of sub tribes that speak a total of 150 different languages. Due to the war in Southern Sudan the development projects were concentrated in the north and discouraging the integration of the people of the North with the black tribes of the South. The civil war has spread since the 1980's from southern Sudan to the Nuba Mountains, Blue Nile, Kassala and Dar Fur State.

According to the information available to UNEP, northern Sudan has six actual or proposed marine protected sites with a total area of approximately 1 900 km<sup>2</sup>, and twenty-six actual or proposed terrestrial and freshwater protected sites, with a total area of approximately 157 000 km<sup>2</sup> nominally protected areas thus cover approximately ten percent of northern Sudan, with three sites – Wadi Howar, Dinder and Radon – accounting for a large portion of this figure. While this is significant and worthy of support, the actual level of protection provided and ecosystem integrity are more important than sheer size from their original condition as to potentially warrant de-listing. The UNEP investigation of Dinder National Park, for example, found that this major site was not only badly damaged and under severe stress, but was also being starved of the requisite funds for proper management.

**Keywords:** Natural resources, protected area ,conservation

## Traditional Medicinal Knowledge in Costa Rica

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Over one decade the Portuguese Tropical Research Institute has worked on the issue of natural resources preservation and traditional medicinal knowledge compilation in Latin American metropolitan areas; so far we have researched six countries: Brazil, Chile, Mexico, Peru, Cuba and Costa Rica. Costa Rican rainforests are among the richest world's tropical forests. Some recorded species are common to the Amazon rainforest as field research has proved, though. The tropical forest serves as a storehouse for medicines collected by traditional healers and herb traders that provide a diversity of species highly appreciated by the less wealthy urban residents and plant therapy believers. San Jose, Costa Rica's capital city is no exception, as observed, for Costa Ricans use a wide range of barks, roots and herbs to mitigate pains and treat traditional illnesses. During the year 2009 we have obtained a sample of forty-three interviews to three categories of informants within San Jose: Thirty urban gardeners from Mexico, Sabana and Fatima neighbourhoods; twelve medicinal species traders from several local markets; and one officially recognised plant therapist. Together with the plant species farmed, sold or recommended by suppliers, users and healers for all sorts of diseases we have systematically collected the domestic and ancestral prescriptions so as to make traditional medicinal knowledge available for a wider public. Our objective for compiling the vernacular names and the taxonomists' identification of flora together with their therapeutic uses is to provide a comparative guide of non-conventional medicines focusing Latin America. Hope is to contribute for sustainable use of medicinal resources and supply poverty alleviation formulas.

**Keywords:** Ethnobotany, Costa Rica, medicinal natural resources

## Similarity and Diversity Indices in Sugar Beet Weed Communities

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A common method in calculating  $\beta$  plant diversity is by using evenness and unevenness coefficients. Jaccard and Sorensen coefficients are examples of evenness indices usually used for qualitative data and Steinhaus or Czekanowski indices and coefficient of Squared Euclidean Distance are suitable for both quantitative and qualitative data. These indices are based on number of present species or unique species comparison within community and suited for different habitats. Jaccard and Sorensen coefficients are based on common species within two communities. Steinhaus coefficient is based on species frequency and calculation of numerical (quantity) differences of a community with more precision. In weed ecology, Shannon-Wiener index is a common method for plant community diversity evaluation. This index is valid when sampling can be done and identify all species within the ecosystem. The Shannon-Wiener equation is based on species richness and frequency.

In this research, Jaccard Similarity Index, Sorensen Coefficient, Steinhaus coefficient (Czekanowski Coefficient), Shannon-Weiner, McIntosh, Margalef, Simpson Dominance and Evenness indices were studied in the major sugar beet production fields in different cities of Khorassan Razavi and Khorassan Shomali provinces, Iran. The results showed that the cities of Chenaran and Khauf had the most (27 species) and the least (5 species) species richness, respectively. Sorensen and Steinhaus similarity indices showed that the cities of Chenaran and Ghouchan had the highest similarity (0.9 %) whereas, Ghouchan and Khauf showed the least similarity index (0.2 %). The comparison of weed community in Bojnord fields showed the most relationship with Shirvan. In these cities, Steinhaus index was 59 % and Sorensen was 67 %. The cities of Chenaran and Fariman also had a high similarity coefficient: 78 % for Steinhaus and 62 % for Sorensen. Sorensen and Steinhaus coefficient for the cities of Shirvan and Ghouchan were 65 % and 59 %, respectively. Since the climate of each area is one of the major factors affecting weed population diversity, it seems that microclimatic similarities have an important effect on the similarity of the weed population comparison.

**Keywords:** Diversity, dominance, evenness, similarity, sugar beet, weed diversity

## Impact of Land Use on Vegetation Communities and their Floristic Composition in the Small Wetlands of East Africa

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Demographic growth, degradation of upland soils and increasingly variable climatic conditions have resulted in an increased intensity of agricultural land use of small wetlands in East Africa. These practices have led to negative impacts on natural vegetation patterns and composition. Some wetlands are vulnerable to anthropogenic interventions and hence at risk in case of agricultural use. While abundant in East Africa, little work has been done on the vegetation communities and the distribution and the role of vegetation on small wetlands. Vegetation changes may provide an important tool to assess the potential and vulnerability of wetlands. We determined the relation between habitat factors and species composition, and the impact of land use changes and wetland disturbances on plant communities and their floristic composition. In addition, the origin and life forms of dominants species were documented. Vegetation sampling was carried out based on land use and land cover changes in four representative wetland systems. Releve's were used during a reconnaissance survey to determine the minimal area required for detailed studies to capture the maximum number of species within the vegetation. Rapid Rural Appraisal was used to collect information from the local people about the characteristics vegetation types as well as past and current land use activities. Preferential and stratification methods were used to describe plant species composition in wetlands with different biophysical characteristics (climate, soil and hydrology). Floristic composition and species cover and abundance were assessed from 10 m×10 m. The vegetation was characterised and classified using statistical, syntaxonomical and ordination approaches to link species composition to environmental and land management factors. Effect of wetland use changes on species composition, the characterisation of wetlands plant communities and their floristic composition will be presented.

**Keywords:** Community analysis, floristic inventory, Kenya, Tanzania

## Phenotypic Variability between Cultivated and Natural Populations of Indigenous Fruit Species *Inga edulis* Mart. (Fabaceae) in Peruvian Amazon

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The Amazon rain forest forms one of the most precious ecosystem and provides a habitat for more than 50 % of described plant and animal species. Increasing population density and human activity are destroying the forest landscape and inflicting the loss of biological diversity. The genus *Inga* (Fabaceae) is an ubiquitous component of lowland and highland rainforest throughout the humid tropical zones from Mexico to Uruguay. *Inga edulis* Mart. is one of the most widely distributed and economically useful in the whole Amazon region. Due to the fact of domestication, which has been improved through the history by the human selection of the species in the agricultural landscapes of the region, it is said to show growth variability on different environmental sites. An understanding of the level, structure and origin of morphological variation within and among populations is essential for devising optimum management strategies for sustainable utilisation and conservation of *I. edulis*. Objective of the study is to indicate, if there exist any phenotypic variability between natural and cultivated tree populations in Peruvian Amazon. The field work was conducted from November 2009 to April 2010 in departments of Pasco, Junin, Huanuco, Ucayali and Loreto. In total, altogether 200 trees were sampled, 170 trees cultivated by farmers in different urbanized areas, or agricultural landscapes; 30 wild growing, where 20 in untouched lowland rain forest in National Reservation Pacaya - Samiria and 10 in urbanized areas; 155 sampled trees were collected in the lowland jungle, whereas 45 in the highland jungle ecoregion. All trees were randomly selected and morphologically evaluated by using specific descriptor focused on qualitative and quantitative features, developed especially for *I. edulis* species. The leafy material of each accession was also collected. The statistical analysis of gathered data was done and completed by Neural Network Analysis. The subsequent primary screening of DNA was done using PCR method. Tree polymorphism will be detected using ITS primers. The results show morphological variability, between tree populations cultivated in lowland and highland jungle and also high variability of qualitative and quantitative features, between cultivated and natural growing populations of *I. edulis* in the region.

**Keywords:** *Inga edulis*, morphological variability, peruvian Amazon



## Diversity, Uses, and Distributional Patterns of Legume Species in the Major Community Types of Northeastern Mexico

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From the 259 species of legumes recorded, the distribution of 242 wild species of legumes over 224 locations within 12 plant communities was examined in northeastern Mexico. Objectives were: (1) to determine diversity of legumes in the mountains and plains of northeastern Mexico, (2) to elucidate distributional patterns of legumes in this region, and (3) to know what are the main legume species and their main uses in northeastern Mexico. The subfamily *Papilionoideae* had the largest number of wild genera (47) and species (167), followed by *Mimosoideae* (13 and 44) and *Caesalpinioideae* (10 and 31). Genera with the largest number of native species were *Dalea* (28), *Desmodium* (16), *Astragalus* (13), *Senna* (13), *Acacia* (11), *Phaseolus* (10), *Crotalaria* (9), and *Lupinus* (8). Of wild legumes, 24 genera had  $\geq 3$  species each and 21 species were endemic to this area; most were *Lupinus* (5 species), *Astragalus* (4), and *Dalea* (4). Almost all of the 21 endemic species were  $>1\,500$  m in elevation in oak-pine forests (7), oak forests (5), and cool-temperate forests (5). Only one endemic species occurred  $<1\,400$  m in elevation. Of the endemic species, 90.5 % were in the subfamily *Papilionoideae*. There were 17 cultivated legumes, most of them in *Caesalpinioideae*. Similarity and dissimilarity matrixes using the Sørensen coefficient were assessed using minimum-variance clustering. Using diversity of legumes, three assemblages of plant communities were recognised. Oak, oak-pine, mesic-conifer, and cool-temperate forests harbored the highest diversity of legumes, while rosetophyllous and xeric scrublands and halophytic communities contained the lowest diversity. Species of the subfamily *Mimosoideae* were the most used, main uses includes, forage, fuel, charcoal, handcrafts, furniture, the main genera are *Prosopis*, *Acacia*, *Havardia*, *Leucaena*, and *Ebenopsis*. *Caesalpinioideae* includes 17 species used as ornamentals. All toxic legumes recorded belong to the subfamily *Papilionoideae*, and includes mainly species of the genera *Astragalus* and *Lupinus*. Some species of *Papilionoideae* are used as medicine (*Eysenhardtia texana*, *Indigofera suffruticosa*) and several of them are used as food (*Phaseolus vulgaris*, *Cicer arietinum*, *Pisum sativum*, *Vicia faba*, and *Lens culinaris*).

**Keywords:** Distribution, diversity, legumes, Mexico

## Assessing and Compensating the Biodiversity Impacts of Agricultural Products in the North-South Context – “myEcosystem”

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Many products consumed in industrialised countries (the Global North) originate from developing and emerging nations (the Global South). Multi-faceted environmental impacts occur along the production chain. Among the most severe is the loss of biological diversity, which frequently occurs in the country of origin and is not reflected in the market price. Agricultural products are responsible for a major share of this impact through land and water use. Competition between energy production (*e.g.* biofuels), higher standards of consumption (*e.g.* fodder for livestock) and meeting food security needs (*e.g.* staples and subsistence farming) places more and more pressure on natural ecosystems and the services they provide. The project “myEcosystem” aims to develop novel methodologies to assess biodiversity loss associated with agricultural products from the Global South. We apply Life Cycle Assessment (LCA) to estimate these impacts and transfer the information along the value chain (*e.g.* as a “biodiversity footprint”). Land-use impacts on biodiversity will be assessed on an ecoregion scale using global data on species diversity and combining them with cause-effect relationships between specific land use classes and biodiversity loss derived from meta-study. Water use impacts on biodiversity are explored on watershed scale using available data on groundwater and vegetation characteristics such as rooting patterns, as well as information on groundwater-dependency of key fauna (*e.g.* birds). This will supply decision-makers with the necessary tools to evaluate such environmental impacts, to define strategies for reduction, and finally to compensate remaining impacts through North-South payments for biodiversity conservation. Such payments would reward local land stewardship, strengthen and enlarge protected area coverage and restore critical habitat in the affected areas. Yet questions on the appropriate scale, metrics of measurement, and socioeconomic effects make this an extremely challenging task. In the poster we will elaborate the “myEcosystem” framework using a set of regional case studies, developing more detailed methodology based on higher quality land, water and biodiversity data. The outcome is expected to provide a possible model in which biodiversity loss and conservation may be integrated with agricultural production and trade.

**Keywords:** Agriculture, biodiversity, compensation, ecosystem, land, North-South, water

## **Biodiversity as Adaptation Strategy for West African Farmers Towards Climate Variability**

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There are no clear previsions for climate change in West Africa, except that seasonal variability will increase. This is a feature which farmers already acknowledge. The question arises how West African farmers, who are in the majority subsistence oriented, can adapt to this situation in order to increase resilience, food security, and even income?

One option is biodiversity, which in the plant domain can be tackled at three levels: crops, variety and intra-variety. The BMZ-funded interdisciplinary CODE-WA project with the main partners ICRISAT and University of Hohenheim addresses farmer organisations via national research organisations in Niger, Burkina Faso, Mali and Ghana. Two approaches have been developed in order to increase on-farm plant agro-diversity, namely the Opposite Pyramid Approach and the Vertical Farmer Exchange Visit. The first addresses the fast introduction of promising crops and varieties in a participatory approach. Starting with a great number of crops and researcher determined protocols from year to year the number of tested options is decreasing upon farmer decision. In the same timeline freedom of farmers to select management options and crop surface are increasing. The second is based on the exchange of farmers across agro-climatic zones making use of the fact that farmers are willing to learn with priority from other farmers rather than from scientists. Assisted by researchers farmers select and present their own topics.

The first two years experience shows that it is possible to increase plant agro-diversity in relative short periods (3–5 years) and at the same time introduce economically viable and ecologically sound options using adapted and participatory approaches.

**Keywords:** Crops, plant agro-diversity, plant breeding, R4D, soils, varieties



# Land and soil use

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## **Arsenic Cycling in Irrigated Paddy Soils in Bangladesh: Long-term Risks to Food Security**

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Arsenic (As) in groundwater poses a major health risk to millions of people in south-east Asia. The main exposure pathway is via drinking water extracted from shallow groundwater wells. However, there is also an increasing use of As-rich groundwater for irrigation of Boro rice cultivated during the dry season. Meanwhile, a large percentage of the agricultural land area in Bangladesh is irrigated with As-rich groundwater, and Boro rice production accounted for 48 % of the total rice production of Bangladesh in 2005. It was estimated that ca. 0.4 kg ha<sup>-1</sup> of As are applied each year to rice paddy soils with irrigation water. Thus, there is major concern that As may accumulate in paddy soils and lead to (i) increased As uptake by rice and increased exposure of the local population to As via rice consumption, and (ii) yield decreases due to the phytotoxicity of As.

In a three-year field study, we investigated the cycling of As in an irrigated rice paddy system in Munshiganj district, Bangladesh. Our objectives were (i) to understand the spatial distribution of As in irrigated rice fields, (ii) to quantify the gains and losses of As during irrigation and monsoon flooding, and (iii) to assess possible long-term effects on rice yields and As uptake into rice grain.

Soil samples were collected twice a year on a rice field and analysed for total As. Soil As decreased with increasing distance from the irrigation water inlet within paddy fields. Gains and losses of As during the irrigation season and monsoon flooding could be documented and quantified. Analyses of rice grains sampled along a gradient in soil As, in combination with controlled pot experiments, showed that elevated soil As leads to increased As uptake by rice, and eventually, decreased rice yields. First trend estimates suggest that average As contents in rice grain produced at the site may increase ca. 2.5 fold by the year 2050.

**Keywords:** Arsenic, food security, groundwater, paddy soils, rice

## Importance of Mycorrhizal Symbiosis for Maize in a Cameroonian Soil

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Mycorrhizal symbiosis is assumed to play an important role in plant nutrition, growth and stress tolerance. Arbuscular mycorrhizal fungi colonize roots of many plant species including agricultural crops such as wheat, maize, rice, bean, cassava, banana, and improve acquisition of nutrients such as phosphorus (P), especially under low-P soil conditions. Mycorrhizal symbiosis is nowadays recognised to be integral part of the soil-plant systems. However, precise quantification of its contribution to plant growth and nutrition is still rather poor in many situations due to many potentially confounding factors.

Here we tested whether possible shift in mycorrhizal community composition and activity due to agricultural management can be claimed responsible for rapid productivity decline of maize following forest clearance in southern Cameroon. This was addressed by a cross-inoculation experiment that was carried out with soils collected from different land use systems in Cameroon (forest, short-term fallow, continuous cropping). The soils were first sterilized by gamma-irradiation and then inoculated with small amounts of non-sterile soil from the same or from a different land use system. Maize was growing poorly in the sterilized soils, and its biomass and P acquisition improved greatly upon inoculation with soil from the short-term fallow or from previously cropped field. Surprisingly, the improvement of maize growth and P nutrition following inoculation with forest soil did not reach the levels achieved with the other soils. Quantitative PCR with mycorrhizal species-specific markers showed significant differences in mycorrhizal communities in the roots of maize due to the origin of inoculating soil. However, these differences could not be made responsible for a yield decline following forest clearance, since the forest soil had the least stimulatory effect on maize growth and nutrition in our experiment, indication that some other factors are responsible for the system productivity decline after few cropping cycles on these soils.

**Keywords:** Arbuscular mycorrhizal community, fallow, land use systems, molecular quantification, phosphorus



## Performance of Maize under Conservation Agriculture in Salt-affected Irrigated Systems of Uzbekistan

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Intensive tillage and mismanagement of irrigation and nitrogen (N) fertiliser application in conventional crop production systems is causing decline in soil fertility and increased soil salinity in the irrigated drylands of Uzbekistan. Reduced tillage, proper crop rotation, and optimum amount of residue retention combined with application of optimum nitrogen fertiliser can help to mitigate the adverse effects of conventional farming practices. Thus, an experiment was conducted to study the performance of hybrid maize under conservation agriculture practices in a salt-affected region of Uzbekistan in 2009. The site has sandy loam to loamy soil with high soil salinity (EC 2–20 dSm<sup>-1</sup>), shallow groundwater table (0.5 to 2 m), less than 100 mm annual rainfall, and low soil organic matter content (0.40–0.80 %). The experiment was started in April 2008 with cotton followed by winter wheat and maize (summer 2009). to evaluate the combined effects of tillage (permanent beds (PB) and conventional (CT)), crop residue retention (with and without), and nitrogen fertilisation (0, 100 and 200 kg N ha<sup>-1</sup>). Maize grown on permanent beds gave 40 % higher grain yield compared to conventionally tilled soil. Permanent bed has 85 % N recovery which is 120 percent higher N recovery compared to conventionally tilled soil. Retention of residues resulted in 10 % yield increase. Permanent bed with residue retention has significantly lower soil salinity up to 30 cm soil depth compared to conventional and bed without residue. Thus, permanent bed with residue retention has potential to increase yield and nitrogen use efficiency of maize in salt affected irrigated regions of Uzbekistan.

**Keywords:** Conservation agriculture, crop residue, nitrogen use efficiency, permanent bed, tillage

## Economic Valuation of Land Restoration: The Case of Exclosures Established on Communal Grazing Lands in Tigray, Ethiopia

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Converting degraded grazing lands into exclosures is one option to restore soil nutrients and to sequester carbon from the atmosphere. We estimate the economic value of such a conversion and assess the perception of local communities concerning exclosures in the highlands of Tigray, Ethiopia. Our research combines a soil and vegetation study with a socio-economic survey, and a financial analysis. Over a period of 30 years, sequestered carbon dioxide was  $246 \text{ Mg ha}^{-1}$ , total soil nitrogen increased by  $7.9 \text{ Mg ha}^{-1}$  and additional available phosphorous stocks amounted to  $40 \text{ Kg ha}^{-1}$ . The Net Present Value of exclosure's ecosystem services under consideration was about 28 % (837 US \$) higher than alternative wheat production. Carbon revenues alone added up to only about 44 % of the net revenues of wheat production. This indicates that (i) carbon market revenues only, would not generate sufficient incentives to establish additional exclosures, and (ii) if all benefits are taken into account and financially rewarded, exclosures are competitive to alternatives land uses. We also identified substantial opportunities to mobilise the local communities in efforts to establish exclosures, given that more than 75 % had a positive view on exclosures effectiveness to restore degraded soils and vegetation. We conclude that a comprehensive analysis is necessary to consider the ecological as well as economic and social impacts of exclosures. Our findings are important information for local decision makers and may provide incentives for the establishment of further exclosures in the northern highlands of Ethiopia, thereby contributing to a sustainable local development process.

**Keywords:** Carbon revenues, carbon sequestration, crop production, economic valuation, local communities, rehabilitation of degraded areas, soil nutrients stock.

## The Effect of Crop Residues on the Dynamism of Soil Microbial Communities

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Residue management and its recovery in soil is an available option to sustain agroecosystems especially in arid and semiarid regions. In order to investigate the effect of different residues on microbial activities, a four-replicated field experiment performed as a CRB design on wheat. Five crop residues with different C:N ratio (including cotton, soybean, alfalfa, wheat and corn) in companion with pure urea and control treatment (without residue or fertiliser) were incorporated as <5 mm particles. The rate of residue and the amount of measuring the nitrogen needed to avoid immobilisation were determined by C:N ratio and nitrogen index to provide 90 kg N ha<sup>-1</sup>. The microbial biomass carbon was measured at 49, 83, 99, 127, 165 and 175 days by fumigation-extraction method. The results indicated that microbial biomass changes considerably during time without a predictable trend. Our findings revealed that the dynamism of microbial communities is highly correlated to temperature, but is not affected by soil moisture content. Also, we found that C:N ratio can not be considered as the best index to interpret biological activities during decomposition process. We found that cellulose and hemicellulose also should be analysed. Our analyses on nitrogen dynamism in wheat also showed that residues could provide nitrogen demands of the plant adequately as urea treatment. This demonstrated that using the crop residues as internal-inputs could be considered as an option to provide soil fertility. Albeit, it is important to provide nitrogen to cover the demand by microorganisms via exact calculations to avoid N immobilisation. Undoubtedly, finding the best management scenarios to optimise bioactivities in the soils will be one of the main goals to sustain agroecosystems, conserve the environment against pollutants and provide food security and safety for humans for current and next generations.

**Keywords:** Crop residue, decomposition, microbial community, nitrogen

## Slash-and-Mulch in Amazonia does not Result in Significant Soil Carbon Sequestration

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Slash-and-burn land-use is associated with significant C-emissions during the burn. Substitution of fire by slash-and-mulch has been proposed as an alternative management option which could potentially reduce emissions and improve soil quality by increasing C-stocks in SOM. This implies that part of aboveground biomass, transferred to the soil surface as mulch, actually is incorporated into the topsoil OM-pool. Here we investigate if slash-and-mulch of fallow regrowth immobilises significant amounts of biomass and increases topsoil OM-contents for prolonged time-spans.

Research was conducted in the SE-periphery of Amazonia in Zé Doca and Sta Luzia do Paruá counties, representative of clayey and sandy Oxisols respectively. Slash-and-mulch operations were conducted with the bushchopper technology (SHIFT-capoeira / Embrapa-Tipitamba). Sites were subsequently cultivated with maize-bean and maize-water melon cropping sequences. We investigate (i) the velocity of decomposition of the mulch layer, by comparing biomass of secondary forests (5 sites, 2–15 y-old) with mulch biomass after 1 year, and (ii) the incorporation of mulch biomass into topsoil (0–10 cm and 10–20 cm) OM, by comparing physical OM-fractions of topsoil in 15 secondary forest and paired 1-y-old slash-and-mulch sites.

One year after slash-and-mulch, a mere 30 % of original forest biomass remained as mulch. This percentage was not affected by fertiliser and liming treatments, nor by the aboveground biomass of the preceding forest.

No significant effects of the mulch layer were discernible on topsoil total or heavy-fraction OM-concentrations after one year. There was a slight and near-significant increase in light ( $< 1.7 \text{ g cm}^{-3}$ ) SOM concentration, but this increase did not increase SOM-stocks, due to the simultaneous decrease in topsoil density.

Our results give clear evidence that the extremely rapid decomposition of the mulch layer – consequence of the favourable conditions for microorganisms in humid-tropical climate – impedes any significant long-term incorporation of mulch into SOM. The slight increase of light fraction OM is irrelevant in quantitative terms, and likely ephemeral due to the labile nature of this fraction. Thus, substitution of slash-and-burn by slash-and-mulch as an isolated management feature is inadequate for C-sequestration and SOM buildup in the humid tropics.

**Keywords:** Amazonia, bushchopper, C-sequestration, slash-and-mulch, soil organic matter

## Compound-specific Stable-isotope Analysis to Trace Carbon Sink-and-Source Relationships between Areas of Critical Land Degradation and Deposition Areas in the Chieng Khoi Catchment

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Innovative technical and progressive approaches are strongly required to adequately trace soil organic carbon (SOC) sink-and-source relationships between areas of critical land degradation and deposition areas. This is in particular crucial for many fragile mountainous landscapes of South East Asia in which cropping systems have encountered a radical change in the recent past due to enhanced agricultural commercialisation as well as a growing population and migration processes. Consequently, this agricultural intensification in upland areas is leading to rampant water erosion promoting severe losses of SOC which has been acknowledged as central determinant of soil productivity. It is therefore of central importance to study such sink-and-source relationships between areas of critical land degradation and also deposition areas in the lowlands.

The application of stable isotopes (*i.e.* stable  $^{13}\text{C}$ ) has been proved to be very useful in investigating SOC dynamics in cultivated soil ecosystems. In the present study, we introduce a compound-specific stable-isotope (CSSI) approach which is currently under development at the Department of Plant Production and Agroecology in the Tropics and Subtropics of the Hohenheim University to investigate source-and-sink relationships of SOC in the Chieng Khoi catchment, Son La Province, Viet Nam. By applying the CSSI approach, we use natural abundance signatures of plant-specific organic compounds (*e.g.*,  $\delta^{13}\text{C}$  values in fatty acids and lignins) originating in upland soils in the studied tropical catchment including a range of different crops (*e.g.* maize, cassava), as well as natural and secondary forests. These CSSI-biomarkers will be then traced in the lowland soils (*i.e.* paddy rice soils) to estimate the dynamics of landscape SOC stocks at catchment level and to assess how land use intensification has changed the spatial and temporal distribution of the respective C from uplands to lowlands.

**Keywords:**  $^{13}\text{C}$ , Chieng Khoi catchment, stable-isotope analysis, erosion, source-and-sink relationship, soil organic carbon, Viet Nam

## **Spatial Variability of SOM and its Impact on Yields of Upland Crops Grown in the Chieng Khoi Catchment of the Son La Province, NW Viet Nam**

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In Viet Nam most of the land area is located in mountainous regions and uplands covering almost 75 % of the national territory. With rising population and high world market prices for crops such as maize, the pressure on upland fields for agricultural production has strongly increased over the past decades. Forests have been converted into tree plantations or crop land and relatively sustainable swidden agriculture systems were substituted by continuous upland cropping of maize and cassava. Deep slopes, decreasing soil productivity and high erosion rates, however, did not hinder farmers of using such fields in mountainous regions. Erosion causes translocation of soil material and in consequence spatial variability of soil parameters which may have positive or negative impact on crop productivity. The goal of this study was to better understand the impact of spatial variability in SOM on yields of maize and cassava. Therefore maize- and cassava-based cropping systems were monitored during 2008 and 2009 in the Chieng Khoi Catchment of the Son La Province, NW Viet Nam. In total 12 fields were included in this study. Soil and plant samples were taken in top, middle and footslope positions of each field. SOM was determined by using Mid Infrared Spectroscopy (MIRS) and statistically related to maize and cassava yields. Preliminary evaluation indicates a strong impact of land use history on SOM content and its distribution across slopes which correspond well with the yield performance of both crops. Detailed evaluation, however, is ongoing. This study will contribute to recommendations on an improved crop management. Additionally, it will provide valuable insights on the impact of land use intensification on soil fertility in ecologically fragile and economically disadvantaged mountainous region of Southeast Asia.

**Keywords:** Cassava, field accessibility, land use history, maize, soil degradation, SOM, spatial variability

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## Extending the Knowledge of Soil Organic Matter Stabilisation through Fractionation and Mid-infrared Spectroscopy

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Soil organic matter (SOM) is important in agricultural systems for improving soil fertility and maintaining a source of plant available nutrients, especially in highly weathered tropical soils. Traditionally, investigating SOM has involved time consuming fractionation procedures. This study examined SOM dynamics under long term management through the use of SOM fractionations in combination with diffuse reflectance Fourier transform mid-infrared spectroscopy (DRIFT-MIRS) to gain information on SOM stabilisation and provide a more cost effective way to analyse samples. It was proposed to use DRIFT-MIRS on soil samples in order to identify different stabilities of SOM by specific absorbance ranges in the mid-infrared wavelengths. Soil samples were from the long term experiment Bad Lauchstädt treatments of farmyard manure (FYM), mineral fertiliser, combination, and no fertiliser inputs. Bulk soil was extracted with hot water and fractionated by size and density methods. Bulk soil and fractions were additionally analysed by mid-infrared spectroscopy with the selection of wavelengths for peak area integration. These included  $2930\text{ cm}^{-1}$  (aliphatic C),  $1620\text{ cm}^{-1}$  (aromatic C and  $-\text{COO}$ ),  $1530\text{ cm}^{-1}$  (aromatic C), and  $1159\text{ cm}^{-1}$  (C-O). DRIFT-MIRS peaks were found to differ significantly with treatment. The relative peak area (rA) of  $2930\text{ cm}^{-1}$  was highest in FYM and mineral fertiliser treatment (36.5 % relative area) and lowest under no fertiliser inputs (17.6 % relative absorbance). Conversely the peaks at  $1620\text{ cm}^{-1}$  had the opposite trend with a rA of 53.0 % in the manure and mineral fertiliser treatment compared with 69.8 % in the no inputs. Positive correlations were found between SOM fraction C contents ( $<1.8\text{ g cm}^{-3}$  C  $r=0.86$  and hot water extractable C  $r=0.93$ ) and  $2930\text{ cm}^{-1}$  and negative correlations between the same fractions ( $<1.8\text{ g cm}^{-3}$  C  $r=-0.95$ , and hot water extractable C  $r=-0.79$ ) and  $1620\text{ cm}^{-1}$ . After 29 years,  $2930\text{ cm}^{-1}$  peak areas increased in the FYM treatments, but declined in the non-FYM treatments, indicating a continual buildup of labile organic compounds under manure inputs, but a decline in non-manure treatments. These results showed the utility of combining DRIFT-MIRS with fractionation procedures for studying SOM of different stabilities under long term management.

**Keywords:** Fractionation, long term experiment, mid-infrared spectroscopy, soil organic matter, stabilisation

## Soil Organic Carbon Dynamics in Northwestern Viet Nam

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The majority of people in the northwest of Viet Nam live in poor conditions and depend on lowly modernized slash-and-burn agriculture. Thus, reduced yields as a consequence of soil degradation are a serious threat. For quantification of the dramatic soil fertility decline and the potential carbon sequestration in the steep slope lands of northwestern Viet Nam we investigated soil organic carbon (SOC) dynamics. SOC content and  $^{13}\text{C}$  abundance were measured in soils with varying ages of maize cultivation since deforestation of primary forest. Our aims were to quantify (1) the SOC loss due to cultivation, (2) the newly established SOC as well as (3) carbon turnover rates of both functional SOC pools and bulk SOC. Three chronosequences (each including one reference site under primary forest) have been established in slopes on limestone, clayey shale and marl. Three functional SOC pools (labile, intermediary and passive), with varying turnover times and varying stability against decomposition, were analysed using physical SOC fractionation methods. Soils have been sampled in 0–10, 10–20 and 20–30 cm depth, as well as horizon wise in soil pits. The results suggest that the maize derived SOC is low ( $<2\%$  per year), while soil erosion by water leads to high losses of SOC derived from both maize as well as forest. With increasing soil depth bulk SOC declines, while  $^{13}\text{C}$  increases. Compared to forest soils, SOC pools are expected to be enriched in  $^{13}\text{C}$  due to maize cultivation, with the labile pool is expected to show the highest enrichment.

**Keywords:**  $^{13}\text{C}$  abundance, C pools, chronosequence, erosion, land use change



## The Effects of Different Land Use Types on Soil Compaction and Infiltration Rate in the Drylands Vertisol of Gadarif Region, Sudan

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The dryland vertisol of Gadarif region in Sudan produced more than one-third of the national production of sorghum – the main food stuff in the country. In the past three decades, different land use types were occurred throughout the region. Soil strength and infiltration rate are important variables for understanding and predicting a rate of soil processes. This study investigated the effects of three different land use types namely; cultivated land, fallow land and woodland on soil compaction and infiltration rate. Remote sensing data was used to map land use/cover for the study area. The penetration resistance of the soil was measured into three depths using manually operated cone penetrometer. Infiltration rate was measured in the field using a double-ring infiltrometer. In addition to reference soil profiles, soil samples were collected to determine the variables that affect soil strength and infiltration rate viz. particle size, dry bulk density, soil moisture content and organic carbon content. All field measurements and soil samples were collected for each of the land use types. The results showed that with compared to the woodland, the soil penetration resistance was 29 % and 14 % larger and infiltration rate was 60 % and 45 % smaller for the cultivated land and fallow land respectively. Interestingly, it has observed that dry bulk density was increased and soil moisture content was decreased in the cultivated land and fallow land compared to the woodland. Tillage operations at constant depth and animal trampling in wood and fallow lands coupled with a smaller soil organic carbon content are likely to be the main factors causing the decline in the infiltration rate and increasing the hazard of soil compaction after changing of woodland to cultivated and fallow lands.

**Keywords:** Gadarif region, infiltration rate, land use types, soil compaction, Sudan

## From the ICOPLAST, Bio-geotextile to IWAM: A Promising Technique for Building Sustainable Highland Rainfed Agriculture

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The Shasea, Borassus and Uplands projects were conducted to find out the best technique for building a sustainable highland rainfed agriculture in northern Thailand during 2000–2009. The 1<sup>st</sup>-Shasea project focused on using the INCOPLAST, (Incorporated plastic and straw mulching technique), while the 2<sup>nd</sup>- Borassus and the 3<sup>rd</sup>-Uplands projects used biogeotextile or biodegradable materials for surface mulching, to decrease soil erosion and increase water use efficiency. The studied cultural practices in the 3 projects were: conventional contour planting (CC or CP), contour ridge with and without plastic mulching (CR and CRP or INCOPLAST), alley cropping with hedgerows of mixed fruit tree varieties (AL), cultivated furrow (CF) and mulching (M) with *imperata* grass panel/ bamboo mat/ banana leave/ bamboo grass/vetiver grass (Im/B/Bn/Bg/Vg). The studied treatments in the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> trials were CC, CR, CRP, AL, and CP, CP-BM, CF-BM, CF-AL, CF-BM-AL and CP, CP-Bn/Bg/VgM-AL, CF-AL, CF-Bn/Bg/VgM-AL respectively. The annual relay crop rotation were corn, upland rice and lablab bean.

The 1<sup>st</sup> trial-results showed that AL conserved most soil and water by reducing soil loss and runoff, while CRP or INCOPLAST induced higher runoff during the wet seasons but effectively reduced soil water evaporation during the dry period when compared to CC or CR. The 2<sup>nd</sup> experimental results showed that furrow cultivation mulched with *imperata* grass panel (CF-IM-AL) or bamboo mat in alley cropping (CF-BM-AL) gave the lowest soil loss and runoff, leading to the highest crop yields when compared to the other contour cultivations. However, bamboo mat and *imperata* grass panel were not practical due to high cost investment. The results of the 3<sup>rd</sup> trial indicated that contour furrow cultivation mulched with any biodegradable material (CF-Bn/Bg/Vg M-AL) gave the lowest amount of runoff and soil loss, leading to the highest crop yields, when compared to the other treatments. The above results indicated that the most practical technique for building a sustainable highland rainfed agriculture was the “Integrated Water harvesting, Anti-erosion, and Multiple cropping” technique called “IWAM”. It consisted of contour furrow cultivation with mulching and multiple cropping for increasing a permanent crop productivity and income flow for the farmer.

**Keywords:** Alley cropping, furrow cultivation, Biogeotextiles, INCOPLAST, IWAM

## Bioaccumulation and Distribution of Heavy Metals in Gray Mangrove (*Avicennia marina*): Case Study of the Tropical Areas of Persian Gulf

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This paper presents the first research on bioaccumulation and distribution of heavy metals in three cohort of Mangrove species (*Avicennia marina*) in tropical area along the Persian Gulf in Qeshm Island of Iran. Mangrove forests grow in vicinity of urban areas in the southern islands of Iran and have close relation to the local life where a most sensitive marine ecosystem has emerged due to oil spills and petroleum discharges. Mangrove systems have the capability to act as a sink or a buffer and immobilise the entrance of heavy metals into the ecosystem. Three cohorts of mangrove ages (ages hypothesised by elevation of plants; (1) Juvenile, (2) less than 3 m, and (3) less than 5 m) were used to analyse heavy metals copper (Cu) and lead (Pb) in roots, leaves, and sediments. There was no relation between different ages and Cu and Pb accumulation.

The accumulated Cu and Pb was higher in the roots of the 3 cohorts than in their leaves. Concentration of heavy metals in sediments adjacent to nutrient roots exposures to heavy metals did not show significant difference. Essential metal (Cu; translocation factors (TF); ratio of leaf metal to root metal concentration of 0.79, and leaf bio-concentration factor (BCF) of 0.84), showed greater mobility than non-essential metal (Pb; TF of 0.84 and leaf BCF of 0.71).

**Keywords:** Bioaccumulation, ecotoxicology, heavy metals, mangrove

## Production Potential of Wetland Soils of the Kafue Flats in Zambia

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Despite the general belief that wetlands are more robust to anthropogenic interventions than uplands, degradation phenomena and productivity declines have been observed in some intensively used wetlands where sites have been abandoned. We hypothesise that the effects of cultivation on resource base quality and production potential in the wetlands of Kafue are likely to depend on the type and hydrologic conditions of the soil as well as on the type, intensity and duration of land use.

Soil samples (0–20 cm) were collected under different use types and durations. These were analysed for diverse physio-chemical soil parameters, including carbon fractions and the N supplying capacity. Additionally, rice biomass accumulation and nutrient uptake were determined in a greenhouse pot experiment under both flooded and aerobic soil conditions. Both type and duration of land use affected rice performance and soil quality parameters. Total N and C were highest in undisturbed soil (2.5 % C and 0.2 % N) and declined to 1.1 % C with cultivation under vegetables and 0.04 % N under rice. This decline was more pronounced under paddy rice than maize or vegetables. The labile C content and the soil N supplying capacity reacted most sensitively to cultivation history. Labile C declined from 2 to <0.8 mg kg<sup>-1</sup> and the net N supply never exceeded 10 mg NH<sub>4</sub>-N kg<sup>-1</sup> in soils used for >5 years, irrespective of the type of crop. Similarly exchangeable K and available P declines were most pronounced in rice soils. The aboveground biomass accumulation and mean nutrient uptake by pot-grown rice differed among land use types and was 1.5 to 2 times higher under flooded than aerated soils. Irrespective of soil aeration status, the highest biomass and NPK uptake of rice were observed in uncultivated soil. The negative effects of cultivation duration on plant growth and nutrient uptake was more in soil previously cultivated to rice and higher in aerobic than anaerobic conditions.

In summary, current land use in Kafue Flats results in decline of soil quality. The associated effects on crop production were more pronounced under aerobic than flooded soils.

**Keywords:** Kafue flats, plant nutrition, wetlands

## Salinity Development during three Decades in the Oasis of Ktoua, South Morocco

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Water scarcity in the Draâ Valley, South Morocco, has led to an excessive increase in the use of groundwater for irrigation in the Draâ Oases, and consequently accelerated the natural soil salinisation process. Combined with water shortage, salinity had major negative impact on yield in the area. To assess the development of soil salinity, three monitoring studies were conducted in one of the six Middle Draâ oases “Ktoua” in 1968, 1981, and 1995. A total of 130 sites were sampled representing a study area of 7 341 ha. Results were originally presented as tables and manually interpolated maps. Data are presented here differently. Measured electrical conductivities were interpolated using geostatistical Ordinary Kriging method. The resulting interpolated surface was classified into 5 salinity classes: non-salinized R1, slightly salinized R1, moderately salinized R3, strongly salinized R4, and severely salinized R5; representing 0–4, 4–8, 8–16, 16–32, and  $>32$  mmoh cm<sup>-1</sup> respectively. Results showed that Beni-Sbih and Sidi-Saleh in the south and west of Beni-Hayyoun were particularly affected from 1968–1981. Approximately 20 % of R1 and R2 classes became R3 during that period. Excessive implementation of groundwater pumps in the 80s and 90s led to further salinisation of 40 % of R1 and R2 classes into R3. Also 11 % of R3 became strongly salinized soils R4. Groundwater salinity and lack of surface water lead to land abandonment since mid 90s, especially on the right side of the Draâ. On the basis of the above results, a smaller sampling campaign was held in October 2009 to update the salinity status in the currently used agricultural lands. Results will be integrated in oasis-scale modelling to test field managements and agro-political scenarios to combat salinity and mitigate its effects.

**Keywords:** Draâ valley, epic, kriging, Morocco, regional modelling, salinity

## Land Suitability Evaluation for Selected Trees using GIS Technique: A Case Study on Salt Affected Land of Southern Pakistan

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This study was to investigate the applicability of the GIS techniques in combination with FAO land evaluation approach for analyzing the land suitability for certain trees in Badin district southern Pakistan. At first, the databases for GIS analyses had to be developed. The data were obtained through scientific literature review, expert opinions, interviews, different national and international organization and professional officers. The suitability assessment in the studied area has been done by parametric FAO/ ITC-Ghent evaluation method.

On the basis of the established GIS databases, in the Badin district a total area of 669,027 ha, and salt affected area 391,619 ha, 27 land units could be distinguished after overlaying the thematic maps. Firstly, the classification of land suitability for trees *Acacia nilotica*, *Eucalyptus camaldulensis* and *Prosopis juliflora* revealed that there is area of high-suitability level (S1) is 277,408 ha (not salt affected), the area of medium-suitability level (S2) is 279,365 ha for selected trees and 44,280 ha of low-suitability level (S3) The area of non-suitability level (N) is 67,974 ha on salt affected soils. The limitations of suitability included three dominant factors as soil salinity and sodicity, topsoil depth and two additional factors as soil texture and soil type. The final result shows that the total area of Badin district 669,027 ha in which 391,619 ha is salt affected (slight to high salinity levels) and 277,408 ha is not affected by salinity / sodicity so it could be more suitable area for growing above selected trees.

Integration of GIS and multi-criteria approach for land suitability analysis could be a useful methodology for further research in Badin district. This approach makes it possible to select suitable land use types and trees for each administrative unit at commune level.

**Keywords:** Badin district, GIS, land evaluation, land suitability, trees

## Mapping and Assessment of Sand Encroachment on the River Nile, Northern Sudan, by Means of Remote Sensing and GIS

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Wind erosion is the most widely spread soil degradation process in the arid and semi-arid zone of Sudan affecting over 40 % of the 64 million hectares of degraded land. Sand encroachment on the Nile river in north, on productive first terrace alluvial soils, on villages and infrastructures are additional manifestation of land degradation. Desert encroachment has been recognised as the most serious environmental problem in northern part of the country. In the last two decades remote sensing proved to be a powerful technique for monitoring and assessment of natural resources in large areas. The aim of this research is to investigate the potential use of remote sensing and GIS in assessing and monitoring of sand encroachment as desertification indicator in Nile river, northern Sudan. The study was conducted in Kannar area in northern Sudan on the eastern bank of the Nile river. Three cloud free landsat images MSS (1972), TM (1987) and EMT+ (2001) covering the study area were acquired for the research. The MSS (1972) and TM (1987) images were geometrically co-registered to rectified EMT+ (2001) image (UTM north zone 36N) using ground control points (GCPs). Supervised classification and change detection were used for the analysis of the images. The study showed that the erosional forms (sand dunes active and stabilised) in the area in 1972, 1987 and 2001 cover about 47.2 %, 52.2 % and 49.9 % of the total area, which indicate that half of the area is affected by sand dune encroachment (is degraded by sand invasion). This degradation is related to wind erosion (physical environment and harsh climatic conditions) and human misuse (*e.g.* cultivation). Sand encroachment threatens the highly productive agricultural land and settlement in Kannar area, the course of the River Nile and endangers the livelihood of inhabitants in the area. The study concluded that, remote sensing and GIS are helpful techniques in studying, assessing and monitoring sand encroachment.

**Keywords:** Mapping, remote sensing, river Nile, sand encroachment





# Nutrient cycling and crop nutrition - Poster session I

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## Litter Decomposition and Nutrient Release from two Forest Species in the Southern Bakundu Forest Reserve Cameroon

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The decay of organic matter returned to the soil via litter fall is an important source of nutrients for vegetation uptake. Leaf litter decomposition and nutrient dynamics of *Irvingia gabonensis* and *Ricinodendron heudelotii* were studied in the tropical forest: Southern Bakundu forest reserve, South West Region of Cameroon. These two tree species are of great nutritional importance to the farmers and consumers in this region and they serve as a major source of income for farmers and producers.

The rate of decomposition ( $k$ ) of organic matter was measured using 80 litter bags (40 treated with a probiotic, LMO and 40 untreated). Litter bags were placed on the forest floor fastened by iron wires on the 20<sup>th</sup> of April 2009. Four litter bags of each treatment were collected monthly and taken to the laboratory where they were washed, dried and weighed to get the final mass. Chemical analysis were conducted for N, P, K, Ca, Mg and K. The two-way ANOVA was used to compare the treatments and species followed by the Student-Newman-Keuls test at 5 % level of probability to compare the decomposition rates between the two species at 8 weeks of decomposition.

The decomposition rate of *R. heudelotii* was faster ( $0.69$  and  $0.63 \text{ week}^{-1}$  for treated and untreated litter respectively) than that of *I. gabonensis* ( $p < 0.0001$ ). Potassium and calcium were the fastest elements released in both species, phosphorus, sodium and magnesium showed immobilisation in *I. gabonensis*. A 100 % decomposition and release of all nutrients was observed after the 8<sup>th</sup> week in *R. heudelotii*. Treated leaf litter decomposed faster than untreated leaf litter in both species although there was no significant difference at the 5 % level of probability.

Conclusion: It was deduced from this study that *R. heudelotii* could be the preferred species of agroforestry for this tropical region of Southern Bakundu and could thus be used to enrich impoverished soils and close forest gaps since it decays and grows faster than *I. gabonensis*.

**Keywords:** Cameroon, *Irvingia gabonensis*, litter decomposition, Light Matrix Organics (LMO), nutrient release, *Ricinodendron heudelotii*, southern Bakundu forest

## **Integrated Application of Fertilisers and Biocane (Organic fertilisers) to Enhance the Productivity and Juice Quality of Autumn Planted Sugarcane (*Saccharum officinarum* L.)**

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An experiment was conducted to study the effect of different levels of fertilisers and biocane on the growth, yield and juice quality of sugar cane Var. SPSG-26 at the Agronomic Research Farm, University of Agriculture Faisalabad, Punjab, Pakistan during the year 2007–2009. The experimental design was a completely randomised block with four replications and a net plot size of 7.5 m × 7 m. The study comprised of five treatments viz. T1= N:P:K- 170:85:85 kg ha<sup>-1</sup>, T2= biocane 2.5 l ha<sup>-1</sup>, T3= biocane 2.5 l ha<sup>-1</sup> + N:P:K- 170:85:85 kg ha<sup>-1</sup>, T4= biocane 2.5 l ha<sup>-1</sup> + N:P:K- 85:42:42 kg ha<sup>-1</sup> and T5= biocane 1.25 l ha<sup>-1</sup> + N:P:K- 170:85:85 kg ha<sup>-1</sup>. All doses of P, K and ½ N was side dressed at the time of sowing and remaining ½ N was top dressed at the time of 3<sup>rd</sup> irrigation while Biocane was sprayed as foliar fertilisers in December after seedling establishment. Cultivar SPSG-26 was used as test crop for this experiment.

All growth and yield parameters were significantly affected by biocane application along with synthetic fertilisers. The highest cane yield of 109.5 t ha<sup>-1</sup> was found for treatment T3. Also the number of mill able canes, can length, can diameter, number of internodes per cane, internodal length, trash weight, weight per stripped cane, tops weight and stripped can yield were all significantly affected by this treatment as compared to the other treatments. The sucrose contents non-significantly differed among the treatment means and varied between 7.7–12.78 %.

The present study concluded that in case of sugarcane variety SPSG-26 the application of biocane 2.5 l ha<sup>-1</sup> + N:P:K- 170:85:85 kg ha<sup>-1</sup> proved to give the highest cane yield. Integrated application of synthetic and biofertilisers can improve the soil physical conditions, microbial activity, plant growth and helps to sustain the environment, therefore, reducing the fertiliser pollutants in to the atmosphere and ground water.

**Keywords:** Biocane fertiliser, biofertilisers, sugarcane, synthetic fertilisers

## Effect of Composted and Vermicomposted Cotton Residue on Ryegrass (*Lolium Perene* L.) Growth

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Unrestrained use of synthetic fertilisers can lead to economic and environmental difficulties. Alternatively, agricultural wastes for instance, can be recycled to provide a source of plant nutrients and improving soil health. The study was aimed at understanding the effect of different amendments to soil on the plant growth and to test the reliability of the N fate predicted by incubation experiment, simultaneously performed with the same materials, to assess potentially mineralisable nitrogen from the organic wastes. Cotton straw was used as compost and vermicompost corresponding to 4 and 8 g N/pot in addition to the control in different pots planted with ryegrass. Plant biomass was highest in compost treated pots followed by vermicompost and lowest in control ( $p < 0.0001$ ).

The results showed that the attributes of the tested materials in providing nitrogen to a ryegrass crop can be predicted by investigating their performance through aerobic incubations. The encouraging experimental results despite the fact that, cotton residue is a lignocellulosic residue with slow nutrients release, which obtained from the pot trails were in accordance with nitrogen net mineralisation trend observed in the mineralisation incubations.

The significant positive correlation between biomass accumulation and nutrient mineralisation pattern ( $r = 0.6$  and  $p < 0.0001$ ) and significant positive correlation between nitrogen uptake and available nitrogen ( $r = 0.4$  and  $p = 0.005$ ) was observed. The work unveiled that amendments differ in their composition affected crop differently and the processing of cotton residue like for instance, composting and vermicomposting are obviously of great beneficial effects and contributed to crop growth and soil productivity.

**Keywords:** Biomass and ryegrass, compost, cotton residue, N incubation, vermicompost

## Effect of Organic, Chemical and Integrated Fertilisers on Quantitative Traits of Sunflower (*Helianthus annuus* L. cv. Alestar)

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A study was conducted to evaluate the effects of organic manure (farmyard manure (FYM), biofertiliser (*Azotobacter* and *Azospirillum*)), green manure (winter wheat), and chemical and integrated fertiliser systems on the quantitative traits of sunflower (*Helianthus annuus* L. cv. Alestar). The experiment was carried out on the experimental farm at the faculty of agriculture of the Tarbiat Modares University (35°44'N, 51°10'E, and 1352 m asl) of Iran in 2008. This location is located in a semi arid zone and characterised by warm and dry summers. The experimental design was a split plot with randomised complete blocks and three replications, in which seven fertiliser treatments were the main plot units: F1 (100 % organic, *i.e.* FYM at a rate of 48 t ha<sup>-1</sup>), F2 (75 % organic + 25 % chemical), F3 (50 % organic + 50 % chemical), F4 (25 % organic + 75 % chemical), F5 (100 % chemical, *i.e.* urea at a rate of 240 kg ha<sup>-1</sup>), F6 (50 % organic + 50 % chemical + green manure), F7 (75 % organic + 25 % chemical + green manure) , and two levels of biofertiliser I1 (inoculation) and I0 (control) were the sub plot units.

Grain yield and yield components (head diameter, seed number per head, 1000 seed weight), plant height, leaf area, biological yield and harvest index (HI) were measured. The results showed that the grain yield in the integrated systems was significantly higher than in the organic and chemical systems (F6>F3>F4>F7>F2>F5>F1), also all yield components were the highest in the F6 treatment. The results also revealed that inoculation of biofertiliser improved the quantitative traits of sunflower and significantly increased grain and biological yield (by 6 % and 5 %, respectively). Also leaf area (11 %), plant height (5 %) and yield components were significantly higher as compared to the plants without biofertiliser. It can be concluded that an integrated system (the use of chemical, organic and biofertiliser) and the planting of winter cereals as a green manure can not only increase sunflower grain yield but will also reduce the usage of chemical fertilisers and bring us closer to sustainable agriculture.

**Keywords:** Biofertiliser, grain yield, green manure, integrated systems, sunflower

## Soil Nitrogen Status and Nitrogen Mineralisation during Secondary Succession in a Subtropical Forest Ecosystem in China

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The world's forest ecosystems deliver numerous services like carbon sequestration, erosion control, climate regulation and flood protection. Thus, the functioning of forest ecosystems plays a crucial role for livelihood, health and security of human populations. Chinese subtropical evergreen forests are so far underrepresented in biodiversity and ecosystem functioning research. This vegetation type is one of the most prominent biodiversity hotspots in the northern hemisphere and has experienced strong conversion into cropland and plantations in the past.

Within a recently initiated biodiversity ecosystem functioning experiment (BEF China) we investigated the influence of successional stage and woody plant species diversity on nitrogen (N) and carbon (C) cycling in natural subtropical broad-leaved forest stands. We aimed to identify impacts of stand age and tree diversity on biogeochemical transformation processes and pool sizes of N and C. Our study was conducted in the Gutianshan National Nature Reserve located in Zhejiang Province, East China. In 2008, 27 permanent vegetation plots were established in three successional forest states ranging from early (<20 years) to late successional (>80 years). Total N and C as well as seasonal changes of plant available ammonium ( $\text{NH}_4^+$ ) and nitrate ( $\text{NO}_3^-$ ) were measured in the mineral soil for five depth increments. In parallel, we determined net N mineralisation rates in the upper 10 cm of the mineral soil by *in situ* incubation of soil cores. We observed considerable seasonal variations of net N-mineralisation rates and plant available  $\text{NH}_4^+$  and  $\text{NO}_3^-$ . Soil C and N concentrations were significantly influenced by successional forest stage. C concentrations increased during succession whereas total N was highest in young forests and lowest in middle-aged forest stands. Our first results indicated pronounced changes in N and C dynamics in the course of secondary succession and strong seasonal fluctuations of mineral soil N concentrations.

**Keywords:** BEF China, Gutianshan National Nature Reserve, nitrogen cycling, nitrogen mineralisation, secondary forest succession

## **Quantifying Native Soil N Losses at Watershed Scale in West Africa using the Crop Simulation Model Stics**

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The current intensification of land use in inland valleys of sub-Saharan Africa for food crop production exacerbates the leaching of nutrients. Recent publications describe a nitrogen fertility which is stolen from upland slopes to the bottomlands where it can be irreversibly lost in drainage water. A detailed study conducted in a representative inland valley in the forest-savanna transition zone close to Bouake (Côte d'Ivoire) showed exponential losses of soil N in relation with increasing valley surface. These N losses were also found to be amplified with rainfall and land use intensity. A quantitative understanding of this loss mechanism and its extrapolation may improve the spatial targeting of technical options aiming at conserving soil fertility and maximizing water/nutrients use efficiency.

The mathematic model STICS was identified as a suitable tool to highlight, quantify and predict the influence of the factors involved in the N loss mechanisms. A recent assessment and literature review were used to gather data of minor factors required for the use of the model STICS. These data are expected to validate the results obtained in the three-year study conducted in a 130 hectare model watershed in the mentioned transition zone where half of the valley bottom was used for permanent lowland rice cultivation (8 ha). The land use of the slopes gradually changed from natural vegetation to maize cultivation: in 2001 around 5 % and in 2002 around 10 % was converted into maize fields.

STICS is basically a crop simulation model caring about the use efficiency of nutrients input (particularly nitrogen) and its loss in drainage water. Its accuracy in the soil-plant nutrients transfer helps to highlight the fate of N from various sources. Preliminary obtained results through the model application show the relative importance of physical soil factors (grain size, infiltration and surface runoff, as well as soil roughness) which are related to the soil type and have to be considered in the N losses mechanism. The effectiveness of these results will be discussed.

**Keywords:** Land use, N-dynamics, rice, STICS modelling, West Africa

## Split Daily Applications of Ammonium can not Ameliorate Ammonium Toxicity in Tomato Plants

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Ammonium is the safer and more reliable source of nitrogen fertiliser for agricultural applications in terms of use efficiency and environmental impacts. However, many plants show severe toxicity symptoms with ammonium nutrition in hydroponics systems. Finding some techniques to overcome this problem is in crucial importance. Tomato is a typical ammonium sensitive plant in solution culture, showing severe toxicity symptoms. In this study, we hypothesised that by gradually adding 2 mM N-NH<sub>4</sub> (as final concentration) during four days period of nutrient solution change, plants would have enough time to assimilate ammonium, and consequently results in less toxicity symptoms. So, different treatments were applied as follows: nitrate as Ca(NO<sub>3</sub>)<sub>2</sub>, ammonium as control (once application), three split applications and six split applications of ammonium as (NH<sub>4</sub>)<sub>2</sub> SO<sub>4</sub>. When plants were treated with ammonium, in both control and split applications, they had severe toxicity symptoms. No significant difference was found in growth parameters when plants received 3 or 6 split applications (660 and 330 µM, respectively) of a final volume of 2 mM N-NH<sub>4</sub> in a four days nutrient solution change compared to control plants. Independent of application method, ammonium resulted in shorter roots and shoots, less root and shoot dry weight, less chlorophyll in leaves as well as fewer lateral shoots and lower transpiration, compared to nitrate grown plants. These results indicated that even a low daily µM (330 µM) concentration of ammonium in nutrient solution can result in severe toxicity on tomato plants, and despite the importance of other factors, this toxicity seems to be mainly due to low pH of root medium.

**Keywords:** Ammonium toxicity, nitrate, nutrient solution, split application, tomato



## Effect of NAA, KNO<sub>3</sub> and Fe on some Characteristics of Leaf and Fruit of Peach (*Prunus persica* L.) cv. Early Coronet

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This study was carried out in 2008 to investigate the effect of three treatments containing different concentrations of Naphthalene acetic acid (NAA) purity 98 % (0 and 5ppm), KNO<sub>3</sub> (36.5 % K) 0, 0.1 and 0.2 %, and Fe (NaFeEDDH) Technical Sodium Ferric ethylenediamine dio-hydroxyphenyle acetate (Fe approx. 6 %) 0, 30 and 60 ppm. Trees used for this investigation were four years old peach (*Prunus persica* L.) cv. Early coronet, budded on seedling peach rootstocks. Trees were selected from an orchard in Seije, Kurdistan Region, Iraq. At one month after fruit set the trees were sprayed at two times (24/April/2008 and 25/May/2008) till run off with the NAA, KNO<sub>3</sub> and Fe.

Raising the levels of NAA to 5 ppm, KNO<sub>3</sub> to 0.2 % and Fe to 60 ppm led to a significant increase in the value of leaf area, chlorophyll (a), fruit pulp thickness, seed weight, and fruit dry weight as compared with untreated trees. NAA, KNO<sub>3</sub> and Fe sprays caused a significant increase in leaf nutrient contents (P, K, Ca, and Fe) as compared to the control. On the second of February 2009 foliar spray with 0.1 % and 0.2% KNO<sub>3</sub> caused a significant increase in the percentage of flower bud initiation, whereas flower bud initiation was not affected by NAA and Fe application. The interaction between foliar spray of 5 ppm NAA × 0.2 % KNO<sub>3</sub> × 60 ppm Fe significantly increased leaf area, chlorophyll (a), fruit pulp thickness, seed weight and fruit dry weight, also caused significant increase in leaf nutrient contents (P, K, Ca, and Fe).

**Keywords:** Fe, Fruit, KNO<sub>3</sub>, NAA, peach, spray treatment,

## Effect of *Azotobacter* Inoculation, Dry Bread Yeast Suspension and Varying Levels of Urea on Growth of Potato cv. Desiree

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The present study was carried out at the research field of the Agriculture Research station, Zakho, Duhok Governorate during 2005 and 2006 growing season. A factorial randomised complete block design was selected for the experiment which contained 24 treatments with three replicates to test the effect of *Azotobacter* inoculation, dry bread yeast suspension and different levels of urea on the growth of potato (*Solanum tuberosum*) cv. Desiree. Duncan multiple test at 0.05 level was used to detect differences among means. The experiment counted three factors: un-inoculation and inoculation with *Azotobacter*, four levels of dry bread yeast suspension (0, 2, 4 and 6 g ml<sup>-1</sup> and utilisation of nitrogen mineral fertilisation (urea) at rates of (0, 25, and 50 kg donum<sup>-1</sup>; 1 donum equals 2 500 m<sup>2</sup>).

The results showed that the vegetative growth was significantly increased in terms of plant height, areal stem number, leave area, total chlorophyll content of leaves and dry matter percentage as a result of *Azotobacter* inoculation, bread yeast suspension, and the application of urea as compared to the control during both growing seasons. The dual interaction between *Azotobacter* inoculation and bread yeast suspension, *Azotobacter* with urea, and yeast suspension with urea improved the vegetative growth of potato during both growing seasons.

Inoculating potato plants with *Azotobacter* in combination either with a suspension of bread yeast at a rate of 6 g ml<sup>-1</sup> or fertilising them with 50 kg urea donum<sup>-1</sup>, appeared to be the most effective treatments in improving the vegetative growth traits of potato.

**Keywords:** *Azotobacter*, bread yeast, potato

# Nutrient cycling and crop nutrition - Poster session II

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## **Effect of different Salinity and Potassium Levels on Saffron (*Crocus sativus* L.) Morphophysiological Characteristics**

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In order to investigate the effect of salinity stress and amount of potassium on root and shoot biomass accumulation of saffron a greenhouse study was carried out in 2008–2009 at Faculty of Agriculture, Ferdowsi University of Mashhad, Iran. The experimental design was factorial of salinity and potassium based on completely randomised block with three replications. Treatments included 4 levels of NaCl (0, 30, 60 and 90 mMol) and 3 levels of potassium (50, 100 and 150 % of Hoagland solution base). Results indicated that salinity imposed a significant effect on different growth characteristics, leaf dry weight, number of leaf, root dry weight, root volume, root density and physiological characteristics of saffron ( $p < 0.01$ ). Potassium significantly controlled the negative effects of NaCl on length and number of roots as well as fresh weight and number of leaves per plant. Potassium and NaCl interactions were also significant. It was also observed that at different levels of NaCl, adding K to the root medium caused an increase in root numbers per plant. But this trend was only observed up to 60 mMol of NaCl, at 90 mMol NaCl potassium showed no modifying effects. Relative water content and electrolyte leakage were drastically decreased by increasing NaCl salinity up to 90 mMol of NaCl as compared to the control. The best growth parameter and root to shoot ratio was found with 30 mMol of NaCl. It seems that the application of extra potassium in the rhizosphere of saffron (up to 150 %) can reduce the damaging effects of NaCl up to 60 mMol of NaCl in soil solution.

**Keywords:** Electrolyte leakage, morphophysiological characteristics, relative water content, saffron, salinity stress

## The Effects of Irrigation Regimes and Nitrogen Rates on some Agronomic Traits of two Rapeseed Cultivars

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Rapeseed (*Brassica napus* L.) has potential to become an alternative oilseed crop in Karaj, Iran. Information on effective management of irrigation regime and nitrogen rate for rape seed is limited in this region. Therefore, a study was initiated to investigate the effects of irrigation regime and nitrogen rate on the yield and agronomic characteristics of two cultivars of winter rapeseed (Zarfam and Modena) in a semi-arid region, during 2007 and 2008. The four different irrigation regimes were 30 % (I1), 45 % (I2), 60 % (I3) and 75 % (I4) the maximum allowable depletion (MAD) of available soil water (ASW). Four N fertiliser rates were established: 0 (N1), 90 (N2), 180 (N3) and 270 (N4) kg N ha<sup>-1</sup>. In both years, there were effects on yield, yield components and water use efficiency due to irrigation regimes, nitrogen rates, and cultivars. Cultivars tended to respond similarly to irrigation regimes and nitrogen rate for seed yield in both years of the study. The results revealed that treatment combinations of I1\*N4, I1\*N3 and I2\*N4 maintained significantly greater leaf area index (LAI), above-ground dry matter (DM) and seed yield of the crop than other combinations. For all irrigation levels, the seed yield was highly responsive to N fertiliser rates from zero to about 147 kg N ha<sup>-1</sup> (N inflection), and thereafter, the rate of yield responses declined. The amount of N fertiliser required to achieve the maximum seed yield was 147 kg N ha<sup>-1</sup> for I4, 150 kg N ha<sup>-1</sup> for I3, 189 kg N ha<sup>-1</sup> for I2 and 166 kg N ha<sup>-1</sup> for I1. The present results highlight the practical importance of adequate N fertilisation in yield formation in winter oilseed rape and suggest that the rate of N inflection will be about adequate for the crop to meet its N requirements. Earlier flowering, longer flowering duration, and greater tolerance to drought stress for Zarfam cultivar were detected as determinant physiological traits for successful adaptation to water deficit.

**Keywords:** Cultivar, irrigation, maximum available depletion, nitrogen, rapeseed, seed yield

## Effects of Combined Application of Organic Manures and Biofertilisers on Soil Fertility and Grain Yield of Black Gram (*Vigna mungo* (L.) Hepper)

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India is the leading country in area, production (25 %) and growing wide variety of pulse crops but still the largest importer of pulses with 34 % of the global food use. The national average pulse productivity ( $597 \text{ kg ha}^{-1}$ ) is far below than the global average of  $857 \text{ kg ha}^{-1}$ . Consequently, per capita availability of pulses declined from 60.7 to 29.4 g day<sup>-1</sup> during 1951 to 2007. This is mainly due to the growing importance on cereal crops, decreasing soil nutrient status and emerging secondary and minor nutrient deficiencies. Therefore, a field experiment was conducted with black gram (*Vigna mungo* (L.) Hepper) in Tamil Nadu, India to investigate the influence of farm yard manure (FYM), neem cake (NEC) in combination with *Rhizobium leguminosarum* bv. *phaseoli* (RHL), *Pseudomonas fluorescence* (PSF). Parameters of assessment were soil fertility, grain yield, plant dry matter and protein content of black gram seeds. The highest grain yield ( $1122 \text{ kg ha}^{-1}$ ) was recorded with combined application of NEC+RHL+PSF, which is 194 % higher than control treatment. Combined application of RHL+PSF with either NEC or FYM increased the soil organic carbon by 30 %, over control. The addition of nitrogen in soil was ranged from 3.2 to  $43 \text{ kg N ha}^{-1}$  in treated plots. RHL inoculation with either NEC ( $15 \text{ kg N ha}^{-1}$ ) or FYM ( $26 \text{ kg N ha}^{-1}$ ) recorded higher nitrogen addition than PSF. On the other hand, PSF application recorded higher phosphorus availability than RHL treatments. Co-inoculation of RHL+PSF with NEC was the most potent combination with the addition of  $43 \text{ kg N ha}^{-1}$  and  $4.2 \text{ kg P ha}^{-1}$  than FYM. Contrastingly, negative balance was observed with potassium availability. Unlike nitrogen and phosphorus, combined inoculation of RHL+PSF with FYM increased the bacterial, fungal and actinomycetes population by 172, 333 and 268 %, respectively, over initial soil status. The NEC+RHL+PSF combination increased the average total plant dry matter and seed protein content by 158 and 30 %, respectively, over control. The results indicate that integrated supply of RHL and PSF along with NEC or FYM plays a significant role in improving soil fertility and pulse productivity.

**Keywords:** Co-inoculation, black gram, neem cake, per capita availability, productivity, pulses

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## Improving Zinc Nutrition of Wheat in Iran

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Zinc (Zn) is an important micronutrient for both plants and humans and Zn deficiency in crop plants and humans occurs in several countries around the world. Zinc deficiency in humans often develops from diets that are low in bioavailable Zn. It is particularly widespread in populations that depend on cereals such as wheat as their main staple food. In Iran, wheat is the most important agricultural crop and its average consumption is about 400 grams per head and day. Since wheat is a main source of food, Zn concentration in the grains is one of the main determinants of the food quality with respect to human Zn nutrition in this country.

Soil is the primary source of Zn for plants and factors such as Zn availability in soil, plant genotype, mineral nutrition and health, all affect the Zn uptake by plants. Currently, more than 40 percent of agricultural land in Iran is affected by low availability of Zn mainly due to high pH, low organic matter content and inadequate land use (e.g. monocropping). Mineral nutrition (including Zn nutrition) of plants can be improved by using mineral fertilisers, organic manure, plant residues and/or human waste. Alternatively, Zn nutrition of plants can also be improved, at least on a short-run, by promoting mycorrhizal symbiosis, which has the capacity to contribute substantially to plant Zn nutrition.

Recently started collaborative project between Iran and Switzerland aims at following: 1. Assessing the importance of mycorrhizal symbiosis and Zn fertilisation in wheat growth and Zn uptake from Zn-deficient soil; 2. Assessing Zn acquisition by wheat from plant residues under different fertilisation regimes, and 3. Evaluating different pre-crops for their potential to improve subsequent wheat crop growth and quality (with respect to their Zn content). This will be addressed in a series of experiments using Iranian soil and employing soil sterilisation, mycorrhizal inoculation, wheat cultivars with different Zn-efficiencies, and tracing movement of Zn in a soil-plant system by employing radioisotope <sup>65</sup>Zn.

**Keywords:** Acquisition from soil, arbuscular mycorrhizal fungi, organic matter, wheat, zinc



## **Decomposition and Nitrogen Release Rates of Buried Chickpea (*Cicer arietinum* L.) Residue in a Mollic Phaeozem of Njoro, Kenya**

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Synchronization of nutrient release from organic material and nutrient uptake requires a better understanding of plant residue decomposition kinetics. A field experiment was consequently conducted, at field 7 research station of Egerton University, to determine chickpea residue decomposition and N mineralization rates.

Fresh chickpea residue, weighing 50 g, was placed in each of the fifteen 7 mm-mesh litterbags measuring 25 × 25 cm. The litter bags were arranged in a randomized complete block design and buried horizontally in the plough layer with five bags per replicate. One bag was randomly retrieved from each replicate after 10, 20, 30, 60 and 90 days. Dry weight of the residue was recorded after oven drying at 70°C for 48 hours.

The decomposition (KD) and N release (KN) rate constants were estimated using a single exponential model  $Y_t = Y_0 \times e^{-kt}$ ; where:  $Y_0$  is the original amount of material applied and  $Y_t$  the proportion of the initial dry matter or N remaining after a period of time  $t$ , in years. The  $K$  value was the slope of the linear regression of  $\ln Y$  versus  $t$ . The chickpea residue initially decomposed rapidly with 67 % of the original weight being lost within the first 30 days and 80, 94 % by 50 and 90 days, respectively. On a logarithmic scale, the calculated KD was  $-11.05 \text{ year}^{-1}$  and 20 days were required for 50 % loss in dry weight.

Nitrogen released from the residue followed the same trend as dry weight loss. The calculated KN of the chickpea residue was  $-3.11 \text{ year}^{-1}$ . The cumulative N mineralized, in 30 days, was  $18.9 \text{ g kg}^{-1}$  (58%) out of the  $32.4 \text{ g kg}^{-1}$  contained in the residue before incorporation in soil.

To synchronize nutrient release and nutrient demand, the chickpea residue incorporation should therefore be done closer to planting to benefit the subsequent crop.

**Keywords:** Chickpea, decomposition, litter bags, nitrogen release, synchrony

## Fertilising Effects of Combined Application of Sugar Cane Ash with Mycorrhiza Fungi and Compost in Different Cuban Soils

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Due to the high prices of imported chemical fertilizers Cuban soils are often inadequately low fertilized. On the other hand, in Cuba sugar cane ash, a residue of the sugar industry, is generated in enormous quantities and stored in outdoor piles, constituting an environmental risk. Adequate use of cane ash as an amendment for soils poor in phosphorus (P) and potassium (K) could contribute to plant nutrition. However, little research is in progress to utilize this residue. The objective of this work was to determine the adequate fertilization dosage of sugar cane ash alone, or with mycorrhiza and compost additions. Therefore, field studies and pot experiments were carried out with common Cuban soils (Eutric Oxisols and Inceptisols, including calcareous and non-calcareous soils) and different crops (maize and sugar cane). Results indicated that adequate cane ash dosages vary from 2.5 to 10 t ha<sup>-1</sup>, depending on the soil characteristics. Ash had notable effects on soil P and K pools of both soil types. Positive fertilizing effects of the moderate ash supply were also found for calcareous soils with high pH values. However, higher dosages may lead to excessive soil pH increases and should be avoided. The application of mycorrhiza together with ashes enabled optimal P and K availability, even if the average ash dose was reduced from 10 t ha<sup>-1</sup> to 5 t ha<sup>-1</sup>. A combined application of ashes with compost resulted in higher plant yields than compost application alone. Results also showed positive effects of cane ash on physical soil properties (soil structure, aggregate stability) and on soil microbial activity. Therefore we conclude, that sugar cane ashes can be an adequate substitute for high soluble P and K fertilizers in Cuban soils.

**Keywords:** Cane ash, environmental protection, fertilisation, mycorrhiza, organic soil amendments, phosphorus

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## Effect of Green Manure and Integration of Zeoponix and Chemical Fertiliser on Soil Chemical and Biological Properties in Sunflower Cultivation

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An experiment was conducted to evaluate the effect of green manure and integration of zeoponix (mixture of zeolite and chicken manure) and chemical N fertiliser urea on soil chemical and biological properties in sunflower cultivation at Tarbiat Modares University research farm, Iran. Chikling vetch (*Lathrus sativus*) was sown as a green manure on 21 April, 2009 and was ploughed and mixed with the soil at full blooming stage. Some plots remained uncultivated as a fallow treatment. Sunflower was sown on all plots with 50 000 plant per hectare on 27 June, 2009. The main experimental treatments consisted of different crop sequences including green manure-sunflower and fallow-sunflower. The above treatments were assigned to the main plots. Different integrated fertilising treatments which are zeoponics+25 % chemical fertiliser, zeoponics+50 % chemical fertiliser, zeoponics+75 % chemical fertiliser and zeoponics considered as control, were assigned as subplots to each main treatment plot. The experimental data were analysed as split plots based on a randomised complete block design with three replications.

Soil analysis test showed that the organic C content in fallow treatments significantly increased in comparison to the green manure treatments. The total N content in soil was higher in fallow treatments. In contrast, the highest P and K contents were observed in green manure ones. The highest amount of total N was observed in Z100 treatment, while for organic C, P and K amounts, Z50F50 was the best. The highest amount of carbon of microbial biomass and microbial soil respiration were observed in Z50F50 and Z100, respectively. There were no significant differences for interactions of main plots and sub plots for all traits. It could be concluded that manures had a greater effect on increasing soil organic C and N levels and we can recommend Z50F50 as the best treatment for sunflower cultivation.

**Keywords:** Green manure-zeoponix-chemical fertiliser-soil chemical and biological properties

## Effect of Land Use on Phosphorus Fractions in Different Wetland Soils

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Demographic pressure and upland degradation rapidly enhance the conversion of previously unused wetlands into agricultural production areas in East Africa. The quality of wetland soils and their suitability for agricultural use is determined by many factors such as the pH, the texture, the content of soil organic carbon and the availability of water and nutrients. Preliminary studies could show that the amount and the availability of Phosphorus appear to be key determinants of the resilience of wetland soils to intensified land use. By changing the land use system and consequently the aeration status of the soil (*i.e.* by drainage or irrigation), the amount of total soil P appears unaffected, while the share of P in different fractions (labile, extractable, organic, total) is hypothesised to vary as a function of wetland type and land use system. We compared wetland soils from an inland valley in Kenya and a flood plain in Tanzania under a wide range of land use types (unused, fallow/grazing, cropping with or without drainage/irrigation) regarding standard soil chemical and physical attributes as well as the availability and pool size of different organic and inorganic P fractions (Hedley fractionation). Additionally the dry biomass accumulation and P uptake by 4-week-old rice plants (*Oryza glaberrima*) grown in potted soils from these wetlands under flooded and drained conditions were determined. Changes in pool sizes of different P fractions under the diverse aeration and land use systems are seen to provide indicators for the resilience or vulnerability of wetland soils to agricultural use.

**Keywords:** Hedley fractionation, Kenya, *Oryza glaberrima*, soil aeration status, Tanzania

## The Effects of Time of Manure Application and Different Biological Fertilisers on Quantitative and Qualitative Characteristics of *Cucurbita pepo* L.

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Understanding of relations and interactions between ecosystem's components and plants is one of the main conditions for sustainable production of medicinal plants. Natural systems agriculture is based on an understanding that natural systems are self-sustaining due to regulatory mechanisms and processes that help to ensure the long-term maintenance of the ecosystem. In recent years, biological fertilisers have received special attention by scientists in sustainable and low input agriculture. Schneider squash is one of the medicinal plants that cultivate around the world due to excellent effects of seeds in its fruits. The Seeds enriched of vitamin E and have been used for healing some diseases such as prostate hypertrophy in men. To study the response of summer squash as a medicinal plant, two manure application time and utilisation of different biofertilisers, split plot arrangement of factors based on randomised complete block design with three replications was used in 2008–09 growing season. Two manure application time (autumn and spring) were allocated to main plots and four biofertilisers including 1- Nitragin (containing *Azotobacter* sp., *Azospirillum* sp. and *Pseudomonas* sp.), 2- phosphate solubilising bacteria PSB (containing *Pseudomonas* sp. and *Bacillus* sp.), 3- Nitragin+PSB, 4-control, were assigned to sub plots. The results showed the significant effect of spring manure application on fruit and seed yield. Nitragin increased fruit and seed yield, significantly. The superiority of spring manure application was revealed on seed and fruit number. A positive correlation ( $R^2 = 0.92$ ) was found between fruit and seed yield with a linear trend in the range of 10 to 20 t ha<sup>-1</sup> and leveling off at the above 20 t ha<sup>-1</sup> fruit yields. The seed oil and protein content were not affected by treatments, however, the biofertilisers increased oil and protein yield compared to control. At a glance, the biofertilisers could be an appropriate alternative for chemical fertilisers high input conventional systems to achieve ecological production of summer squash.

**Keywords:** Biofertilisers, Schneider squash, seed oil, seed yield

## Estimation of Nitrogen Losses under Wheat Production in Gorgan, Northeast of Iran, using CropSyst Model

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Nitrogen is the most important nutrient in crop production, but it can be harmful for environment through leaching of  $\text{NO}_3$  to groundwater and gaseous loss of  $\text{N}_2\text{O}$ . Crop models are useful tools to simulate the plant growth, production, as well as to estimate the fate of nitrogen (N) in different production systems. This study was conducted in Gorgan, Northwest of Iran (1) to evaluate the CropSyst model to predict the fate and residual N of wheat production system and (2) to estimate N losses in different wheat management scenarios.

The updated CropSyst-wheat model was used to simulate the growth and production of wheat. Evaluation of CropSyst to predict N uptake and residual N in soil profile were performed using 16 local fields. Simulation of N losses in wheat production systems were conducted during 1967–2009 (40 years). Simulation scenarios were (1) irrigated cultivation (average input; AI), (2) irrigated cultivation (High input; HI) and rainfed cultivation (low input; LI).

Results indicated that CropSyst model could satisfactorily predict yield, N uptake, residual N of wheat production system. Wheat yield of scenarios were 4400, 4500 and 4000 ( $\text{kg ha}^{-1}$ ) for AI, HI and LI respectively. The LI yield was significantly lower than AI and HI. Total N losses in AI, HI and LI were 13.5, 18.1 and 9.8 ( $\text{kg N ha}^{-1}$ ) respectively. The highest losses of N occurred through gaseous loss (45 to 63 % of total N losses) in which volatilisation ( $\text{NH}_3(\text{g})$ ) contributed about 45 to 61 % of total N losses and scenarios showed significant differences. Nitrate leaching of scenarios were not significantly different and were about 3  $\text{kg N ha}^{-1}$ . It can be concluded that the application of urea as topdressing led to increased N losses ( $\text{NH}_3$  volatilisation) and changing of type of fertiliser and fertiliser management could reduce these N losses.

**Keywords:** Denitrification, N leaching, N losses,  $\text{NH}_3$  volatilisation, wheat

## **Response of *Clitoria ternatea* and *Vigna unguiculata* to Inoculation with *Rhizobium* and *Bradyrhizobium* Strains in Salt-affected Soils in the Cauto Valley, Cuba**

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In Cuba, about 1.000.000 ha of crop soils are affected by salinity. This also causes considerable losses in pasture yields and animal production. One of the alternatives to improve the fertility of these soils is the use of salt-tolerant legume species. Legumes may help to (1) improve the quality of salt-affected soils due to their capacity to fix atmospheric nitrogen (N) in symbiosis with *Rhizobium*; (2) increase soil organic matter; (3) serve as a protection against erosion; and (4) improve soil structure. The response of two tropical legume species, *i.e.* *Clitoria ternatea* and *Vigna unguiculata*, inoculated with native and commercial *Rhizobium* and *Bradyrhizobium* strains was studied under soil salt stress conditions. The study was carried out under field conditions. The effect of three *Rhizobium* strains (Jd19, 1031 and 1032) in *C. ternatea* and two *Bradyrhizobium* strains (VIBA-1 and VIBA-2) in *V. unguiculata* were compared to a control (without fertilisation and inoculation). using yield and nitrogen fixation parameters. In *C. ternatea*, Jd 19 had the highest effects on dry matter yield, ureide content and N accumulation. The inoculation effectiveness index was very close to the nitrogen response index for this species. In *V. unguiculata*, results show *Bradyrhizobium* strains to have a beneficial effect on different variables. Especially VIBA-1, improved nodule number, their dry mass and specific nitrogen fixation, as well as eventual crop yield. The highest effectiveness index value was also obtained when using VIBA-1. VIBA-2 showed better results than control. Positive linear and highly significant correlations were found between nodulation and nitrogen fixation, and total nitrogen content in plant tissue and plant yield.

**Keywords:** Legumes, nitrogen fixation, salt stress





# Plant systems

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# Agronomic practices

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## ***Dendrobium chrysotoxum* – Cultivation, Processing and Marketing of an Endangered Orchid Species**

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The prefecture of Xishuangbanna in Yunnan Province, occupying a mere 0.2 percent of China's total area, is the home to one fifth of its wild plants. The primary rainforests decreased from 70 percent in 1976 to below 30 percent in 2007. According to Xishuangbanna statistics bureau every year another 150,000 hectares of rainforest disappear, mainly replaced by rubber plantations.

Within the framework of the collaborative project Living Landscapes China (LILAC) and in cooperation with TianZi small-scale farmers should be enabled to get an additional or an alternative income to rubber or tea with the high priced Non Timber Forest Product (NTFP) *Dendrobium chrysotoxum*. A sustainable use whereas the agricultural added value remains in the villages encourages farmers to protect the hot spot of biodiversity and might slow down the loss of natural resources.

Since several years, field research of cultivation, harvesting and processing of *D. chrysotoxum* has been done in Xishuangbanna. To work out optimal market quality various ways of processing have been compared in both field and laboratory trials. A solar tunnel dryer, electrical laboratory dryers, on-floor solar drying and traditional ovens came into operation. Quality parameters were defined according to European marketing conditions, chemical and physical product analyses were made.

Despite of a very short flowering season of three weeks in April the preservation of flowers of *D. chrysotoxum* can afford a supplementary income to farmers. Harvested in the (dark) early morning the transport to the dryer should be short, dark and gentle. Best temperature for drying is about 50°C to avoid a loss of taste or colour. The price of *D. chrysotoxum* is very high: according to the Convention on International Trade in Endangered Species (CITES) the collection of wild flowers is not longer possible, the species is highly endangered due to the loss of intact primary rainforest areas and older trees. But it is possible to cultivate orchids in remained forest areas. Within 10 years a profitable orchid garden could be installed under older trees. So the marketing of this endangered species is not a contradictory to protection of rainforest.

**Keywords:** China, *Dendrobium chrysotoxum*, NTFP, post-harvest processing, Xishuangbanna

## **Model for Dermal and Inhalation Exposure Assessment of Pesticide Application on Agricultural Products in Colombia**

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This study presents a modeling approach to be included in a risk assessment framework for pesticide use in the agricultural production in developing countries. The model has two parts: the inhalation and the dermal exposure assessment. Firstly, the conceptual framework of the new proposed model is explained after a multi-criteria analysis of the existing methodologies. Then, the model itself is presented which consist of the estimation of dermal and inhalable exposure concentrations, studying the routes and pathways followed by the pesticides after they are sprayed. Four application techniques are studied in different environmental conditions: i) handed-pressurized (outdoors), ii) motor-pressurized (outdoors and greenhouses), iii) tractorized (outdoors), and iv) aerial (outdoors). The data for the model development is collected by doing surveys in three different regions in Colombia dedicated to potato, flowers and banana crops and by performing experiments quantifying the distribution of the pesticide in the human body. The experimental methodologies used to get this information are the whole body dosimetry and the button personal inhalable aerosol sampler. The tracer fluorescein is used as surrogate of pesticides. The final result is a mathematical tool that identifies the sensitive factors during the pesticide application which are suitable of being improved to mitigate the human exposure. This model is crucial for the risk assessment scheme in farming systems in Colombia and other developing countries as their current risk assessment framework is based on models from industrialized countries. This work is part of the project “Life Cycle Human Exposure and Risk Assessment of Pesticide Application on Agricultural Products in Colombia” financed by the Swiss National Foundation.

**Keywords:** Dermal exposure, inhalation exposure, pesticides, risk assessment, developing countries

## Energy Use Analyses in Iranian Wheat Project

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The study attempts to analyse the energy input-output relationship during Iranian Wheat Project from 1990 to 2005. Findings revealed that total energy inputs and output have increased from 26 503.5 and 20871.5 MJ ha<sup>-1</sup> in 1990 to 35 466.3 and 30 259.8 MJ ha<sup>-1</sup> in 2005, indicating a 25.27 and 31.03 % increase, respectively. Averagely diesel had the highest share, of 37.08 %, followed by electricity (21.23 %), chemical fertilisers (20.21 %), water (8.39 %), seed (7.94 %), machinery (2.33 %) and human labour (2.18 %), respectively. There was a significant increase in electricity usage (about 74 % increase), and an associated decrease in the diesel usage (about 34 % decrease) during 1990–2005 period because electric pumps replaced diesel pumps. Chemical fertilisers rose from 4 353.25 to 8 659.80 MJ ha<sup>-1</sup>, or by nearly 50 %. In the studied period, the share of nitrogen and potassium in the total fertiliser energy input increased from 72.00 to 84.79 % and from 0.00 to 0.65 %, respectively, while the share of phosphorus shrunk from 28.31 to 14.56 %. There were not significant changes regarding the human labour and machinery annually and seedbed preparation required the maximum energy, followed by harvesting. Pesticides increased extensively in the last year under study, particularly in case of herbicides, and of which 2,4-D/MCPA and Clodinafop-propargyl had the highest share. Values of energy use efficiency (0.70–1.00), specific energy (14.70–21.04 MJ kg<sup>-1</sup>) and energy productivity (0.05–0.07 kg MJ<sup>-1</sup>) showed an intensive use of inputs not accompanied by increase in output during Wheat Project. Most of the total energy inputs were supplied in the non-renewable and direct forms. Also, regression analysis indicated the impact of indirect and non-renewable energy on output was statistically significant.

**Keywords:** self-sufficiency, *Triticum aestivum*, wheat

## **Does Ethnicity Matter in Adoption of Organic Agriculture? Evidence from Small Holder Farmers in Mau, Kenya**

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Organic farming is becoming increasingly important in developing countries largely due adverse effects of conventional farming methods, lack of agricultural inputs, education and training and exegesis of climate change. Yet the pace of conversion to organic agriculture remains very low. Understanding the low rate of adoption of organic agriculture remains a major issue of academic and policy concern. In an area inhabited by people of diverse ethnic backgrounds, it would be interesting to understand whether the practice of organic farming is ethnically patterned. To establish whether ethnicity is a major factor in the adoption of organic farming in Kenya a total of 300 farmers were interviewed in three ethno-ecological zones in Mau East Escarpment. The area is disproportionately inhabited by the Agikuyu (traditionally agriculturalists), Kipsigis (traditionally pastoral community) and the Ogiek (traditionally hunters and gatherers). The results show that adoption of organic farming run along ethnic lines. It was found that Agikuyu tended to adopt organic farming. They mainly engaged in agricultural production and marketing which might be one strong argument to explain their attitude. The Kipsigis and Ogiek were least inclined to practice organic farming. Kipsigis and Ogiek are different dialects of the Kalenjin tribe from the Nilotic people. The Kipsigis are traditionally cattle keepers and their ancestors settled in plains to give their livestock space to graze. They are not keen on intensive cultivation nor on tree planting. Their main diet is diet is based on animal products. They are lately assimilated into cultivation and they are not market oriented. Ogiek traditionally hunt animals and eat honey and that is why they live in the forest. They are less interested in cultivation and that is why organic farming is low there. However their lifestyle is in certain senses close to the organic principles. In conclusion, this underlines the relevance of socialisation theory to understanding of the adoption processes. This finding suggests a need for ethnically focused interventions in the promotion of organic farming in the area so as to take into consideration relative affinity organic agriculture.

**Keywords:** Adoption, ethnicity, Kenya, Mau, organic farming

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## Factors Affecting Olive Production: The Case of Olive-growing Farms in Syrian Drylands

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In the last few decades, significant land use changes are taking place in the Syrian dry areas, as several crops such as cotton; wheat and barley are being replaced by the olive plantation due to less water requirements of the olive plants. Various factors are thought to be influencing the olive plantation and production in the regions and therefore, the study objectives are: 1) to analyse the factors that affect the production of olive across different zones in the study area and 2) to determine the constraints of olive production faced by farmers. Primary data were collected in a field survey using structured questionnaires administered to 140 randomly selected farmers from 19 villages in the Salamieh area in Syria in 2007/08 agricultural seasons. Data analysis procedures included descriptive statistics, factor analysis and logistic regression. The results showed that type of varieties (Sourani and Qaisi) planted by the farmers, application of chemical and organic fertilisers and irrigation water are the significant factors affecting olive production in the study area. The most important problems faced by olive farmers in the study areas are concerned with: Decrease in producer price of olive oil, high costs of olive production, lengthy keeping time of olive before it is milled, and pests and diseases infection. These four problems were rated considerably higher than other problems. To enhance farmers income through better olive growth, and production supplemental irrigation in addition the rainfall need to be ensured. As recommendations, development of extension leaflets on these varieties to create awareness about modern agriculture techniques and crop management practices. Facilitation of production inputs provision like (fertilisers, irrigation water infrastructure). In addition, better access to international markets with a particular focus the olive farming. To promote the sustainable cultivation and production of olive in the study area, these variables should be taken into account in any agriculture extension program.

**Keywords:** Dry Areas, extension, fertilisers, irrigation, olive production, Syria, varieties



## **Contribution of Improved Rain-fed Wheat Productivity towards Food Security in Pakistan**

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The population of Pakistan (170 million) has increased more than 3 times since 1960 and it is estimated to be doubled by the year 2025, which is posing a serious threat to the country's food security. Food supply increase is severely limited by an only modest expansion of the cultivated area and scarce water resources required to increase cropped area. In present scenario, it is inevitable to improve crop, land and water productivity and conserve precious natural resources. Less intensive and less resource degraded rain-fed agriculture presents a better option to narrow the gap in the agricultural food items demand and supply. Keeping in view the importance of crop productivity increase in rain-fed agriculture to meet the ever increasing demand of Pakistan population, the present study is designed for rain-fed Punjab study area. Wheat being the staple diet in Pakistan is selected as crop for productivity analysis. The study investigates the effect of operational land holding, cropping intensity, crop diversity, off-farm income, visit to agricultural research and extension institutes, market information, family labour force and farmers' age and education on wheat yield. Districts, Rawalpindi and Chakwal, were selected from rain-fed Punjab for primary data collection. Comprehensive farm level data were collected among 210 farmers during 2009–10 through personal interviewing, using a well-defined structured questionnaire. A Cobb Douglas production function is being applied to investigate the factors affecting wheat productivity and their respective strength. For that purpose the SPSS software package is used. First descriptive results of the survey reveal that the age, farming experience and education of the respondent farmers are 52.91, 30.03 and 7.5 years respectively. Land owned in the study area is 6.73 ha while operational holding is 5.16. Overall almost 90 percent area is rain-fed. The cropping intensity of the study area is 119.85 while crop diversity is 3.06. Overall wheat is cultivated on more than the half (52.5 %) of the cultivated area. The wheat yield of the study area is 1 704 kg per ha which is below national average.

**Keywords:** Food security, Pakistan, productivity, Punjab, rain-fed, wheat



## Biotic and abiotic stress (DPG session)

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## Host Parasitisation, Adult Emergence Rate and Female Ratio of the Egg Parasitoid *Trichogramma piceum* Dyurich (Hymenoptera, Trichogrammatidae) as affected by Holding Temperature

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*Trichogramma piceum* adults (Hymenoptera, Trichogrammatidae) are extremely tiny wasps. Their females seek out and parasitize host eggs of noxious lepidopterous insect pests such as *Helicoverpa armigera*. The recent study aimed at measuring the egg parasitism, emergence rate and female ratio at different periods and different holding temperatures, with the objective to evaluate the efficiency of using this beneficial to combat infestation of the boll worm both on edible and non-edible crops in Sudan and other countries with similar environmental conditions. The experiments were conducted in two separate temperatures (25°C and 30°C) at the same time, where *Helicoverpa armigera* egg-card was exposed to 24 hours old female of *T. piceum*. New egg cards were exchanged daily until tested females died. The results showed a strong exponential relationship ( $R^2 > 0.8$ ) at both temperatures tested between egg parasitism and age of the tested adult parasitoid. More than 50 % of the parasitoid eggs were laid in the first 4 days or 2 days after introducing the adult parasitoids with a parasitism rate of 4.1 or 4.6 black eggs /female parasitoid/day at 25°C or 30°C, respectively. The adults survived for ca. 10 days or 5 days depending on holding temperature. Regardless of the temperatures no difference was observed between the emergence rate and the period of parasitism (ranging 1.1 and 1.3) for the tested periods for both tested temperatures. A highly significant negative linear relationship ( $R^2$  was 0.92 or 0.80 for 25°C or 30°C respectively) was observed between period of parasitism and female ratio. The ratio was 78 % or 86 % at the first 4 days or 2 days for *T. piceum* egg-laying at 25°C or 30°C respectively. A drop in female ratio was observed afterwards.

**Keywords:** Emergence rate, parasitism, sex ratio, temperature, *Trichogramma piceum*

## **The Biotic (Longhorned Beetles: Cerambycidae) and Abiotic (Drought) Effect on the Production and Sustainability of *Acacia senegal* (L). Wild: Case Study of Northern Kordofan, Sudan**

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The *Acacia senegal* tree, producing gum Arabic provides an important source of cash income to the farmer population in the northern Kordofan State. Moreover, the tree serves economical as well as environmental functions. It provides fodder and fuel wood and perhaps increases crop yields through nitrogen fixation. In addition, it offers protection to the soils against desertification which is a perpetual soil productivity declining hazard arising from climate variation and human use of the land. Since the 1980s the decline of gum Arabic production has been reported by many investigators. Biotic factors such as insect pest attacks as well as drought affected the study area in different periods and were the major causes of this decline. Based on a questionnaire this paper evaluates the effects of the longhorned beetles (Cerambycidae) and drought on the production and sustainability of *A. senegal*. The results reveal that most of the respondents in the northern Kordofan State stated knowledge about the longhorned beetles. Moreover, 55.4 % of the respondents mentioned an effect of longhorned beetles by killing of the gum tree. 4.6 % mentioned a reduction in gum production whereas 38.5 % indicated both killing of the tree and a reduction of the gum production. On the other hand the study discovered the significant impacts of drought periods on the productivity and the sustainability of the gum tree, which lead to a 90 % reduction of gum and gum trees and consequently desertification. It could be recommended that forest extension service need to work closely with farmers of gum belt to diffuse knowledge of *A. senegal* insect pests. Efforts should be made by governmental and non governmental institutions to encourage farmers to regenerate and conserve gum trees and consequently improve the livelihood of the farmers.

**Keywords:** *Acacia senegal*, drought, gum Arabic farmers, longhorned beetles, northern Kordofan, Sudan

## **Host Finding Ability of *Lariophagus distinguendus* (Förster) (Hymenoptera: Pteromalidae) in Bagged Maize: A Potential Biocontrol Agent of the Maize Weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae)**

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The maize weevil, *Sitophilus zeamais* is a major pest of durable stored cereals pest of maize in sub-Saharan Africa, where it is causing considerable economic losses of the crop. The parasitic wasp, *Lariophagus distinguendus* is a synovigenic, solitary larval and pupal ectoparasitoid of several beetle species that infest stored goods. The parasitoid egg is laid into the infested grain beside the beetle larva. The host location ability seems to be highly developed and the female parasitoid is able to discriminate between healthy and infested grains. The potential of using *L. distinguendus* for the biological control of *S. zeamais* was assessed in maize stored in jute bags and bulk grain by investigating its host finding and its ability to penetrate the grain mass to parasitize its host. *L. distinguendus* penetrated and parasitized *S. zeamais* located in the jute bags, and the storage cylinders at various depths. Over 50 % adult *L. distinguendus* released into the chamber entered the jute bags to parasitize *S. zeamais*. Thus, *L. distinguendus* was able to find its host within the jute bags and storage cylinders containing *S. zeamais* infested maize kernels and produced F1 offsprings. The parasitic wasps also significantly reduced the emergence of *S. zeamais* in stored jute bag and in bulk maize. *L. distinguendus* searched and located its host in the jute bags and storage cylinders containing infested maize kernels placed in the wire mesh cages and produced F1 progeny. This suggests possible practical utilisation of *L. distinguendus* for the control of *S. zeamais* in bagged stored maize.

**Keywords:** Biological control, jute bag, *Lariophagus distinguendus*, *Sitophilus zeamais*

## Effects of *Phelipanche ramosa* Seed Bank on Parasitism and Growth of Tomato

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Branched broomrape (*Phelipanche ramosa* (L.) Pomel), an achlorophyllous root parasitic weed on several dicotyledonous crops, is a major constraint to tomato production across the world. The size of the parasite seed bank is a determinant factor with respect to crop yield losses and efficacy of control measures. A pot experiment was undertaken in a glasshouse at the University of Kassel Germany to investigate the effects of *P. ramosa* seed bank on tomato growth parameters. Different *Phelipanche* seed banks were established by mixing the parasite seeds (0–32 mg) with the potting medium in each pot. Tomato (var Strain B) seedlings were planted (3/pot) and thinned 15 days later to one per pot. Treatments were arranged in a completely randomised design (CRD) with four replicates. The results revealed that *P. ramosa* reduced all tomato growth parameters measured and that the reduction progressively increased with increasing amounts of *P. ramonsa* per pot. Significant differences between treatments in tomato growth parameters including number of leaflets, plant height, root weight, root/ stem ratio, total root length and total dry matter were displayed. Total dry matter accumulation and the specific root length per tomato plant were the most and least affected parameters, respectively. *P. ramosa* emergence, dry and fresh weight, number of branches, number of tubers and tubers fresh and dry weights also increased with increasing amounts of *P. ramonsa* per pot. It is evident that tomato damage by *P. ramosa* is influenced by the parasite seed bank and that dry matter accumulation in tomato is the most affected parameter. It is also evident that the size of the parasite seed bank should be taken into account in experimental evaluations and intervention measures.

**Keywords:** *Phelipanche ramosa*, seed bank, tomato plants

## Induction of Defense Related Enzymes and Gene Expression after Resistance Induction by Rhizobacteria and Silicon against *Ralstonia solanacearum* in Tomato (*Solanum lycopersicum*)

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Bacterial wilt caused by *Ralstonia solanacearum* is one of the most destructive diseases in tomato production. Silicon and rhizobacteria were tested in single and simultaneous application to elicit active defense responses in tomato against this pathogen. Individual application of silicon and rhizobacteria significantly reduced bacterial wilt incidence by 50.7 and 26.8 % in KK2 (moderately resistant) and in L390 (susceptible) genotypes with silicon amendment, and by 31.1, and 22.2 %, respectively, after rhizobacteria application, compared to the pathogen inoculated control. The elicitors also reduced bacterial populations in the mid-stem of tomato but the dual application of the two elicitors did not. In addition application of the individual elicitor increased the shoot dry weight in non-pathogen inoculated treatment in both genotypes. Up on inoculation the pathogen shoot dry weight was significantly reduced but showed a slight increment when each elicitor was amended in pathogen inoculated tomato plants (elicitor + pathogen). Silicon amendment significantly increased the silicon content in the root of both genotypes but not in the stem, which is typical for silicon non-accumulator plant. Non-significant increases of peroxidase (POD) and phenylalanine ammonia lyase (PAL) activity were observed in the individual treatments of silicon and rhizobacteria upon inoculation with *R. solanacearum*, while the activity of lipoxigenase (LOX) was significantly decreased in the pathogen inoculated silicon amended, but increased in the rhizobacteria treatment. In simultaneous application of silicon-rhizobacteria, the activity of the three enzymes significantly dropped. To elucidate the molecular mechanisms underlying silicon-rhizobacteria mediated induced resistance, first results of transcriptome analysis of up and down regulated genes will be presented.

**Keywords:** Lipoxigenase, peroxidase, phenylalanine ammonia lyase, rhizobacteria, transcriptome, tomato

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## Testing Environmental and Health Pesticide Use Risk Indicators: The Case of Potato Production in Boyacá, Colombia

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Environmental and health externalities of pesticide use are considered among the most relevant threats to agricultural sustainability, particularly in developing countries. Indicators are a useful tool to assess these drawbacks, and support developing and assessing risk-reducing policies. However, it is often the case that different indicators yield different risk assessment results. Furthermore, indicators are mainly developed for use under European and North American conditions, which are different from those commonly present in developing countries.

Therefore, it is of vital importance to investigate the applicability of the indicators in specific contexts and for selected environmental compartments in developing countries. This research aimed to contribute filling this gap by testing selected indicators in the case of smallholder potato producers in the Department of Boyacá, Colombia, to identify the most suitable ones with respect to compartments considered, ease of use, data requirements, and accuracy.

Firstly, five environmental (EIQ, PestScreen, POCER, EPRIP, PIRI) and four occupational health (EIQ, POCER, PRI-Farm, Dosemici) risk indicators and their methodologies were characterised. Secondly, the indicators were calculated using real application data and site specific information. Finally they were compared through correlation coefficients.

The analysis showed that the indicators differ substantially when the overall risk was considered, but with respect to the individual compartments a higher agreement was found. EIQ and PestScreen estimates were largely governed by the amount of pesticide applied, while the other environmental indicators depend more on pesticide fate and toxicity characteristics such as soil organic matter partition coefficient or toxicity to the respective end-point. In addition, site specific information such as plant's phenological phase, slope, distance to water body and the related pesticide drift model played an important role in indicator outcome.

A trade-off is present between the depth of the assessment and the easiness of the calculations. The analysis suggested that a combination of indicators should be used to better characterise pesticide risks, and identified the indicators which could be used as a first screening tool in the study area and similar contexts.

**Keywords:** Colombia, pesticide risk indicators, pesticide health risk indicators



# Genetic resources

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## Genetic Diversity and Adaptation of Date Palm (*Phoenix dactylifera* L.)

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Acquiring sufficient information on the genetic variation, genetic differentiation, and the ecological and genetic relationships among individuals and populations are essential for establishing guidelines on conservation and utilisation of the genetic resources of a species. The aim of this study was to assess the extent and pattern of genetic variation in date palm cultivars; the genetic diversity and structure in its populations occurring over geographical ranges; and the variation in its drought adaptive traits. Genetic diversity and relationships among selected cultivars and populations were assessed using microsatellite markers. Separately, fruits of selected cultivars, involved morphological and chemical characterisation, and morphological and DNA polymorphism of the mother trees were also investigated. Morphological and photosynthetic adjustments of selected cultivars to water stress were also studied. Results showed a significant ( $p < 0.001$ , t-test) differentiation between Sudan and Morocco groups of cultivars. However, the major feature of all tested cultivars was the complete lack of clustering and the absence of cultivars representing specific clones. The results indicated high genetic as well as compositional and morphological diversity among cultivars; while, compositional and morphological traits were found to be characteristic features that strongly differentiate phenotypes. Significant ( $p < 0.01$ , AMOVA) divergence was observed for soft and dry types; however, the genetic divergence among populations was relatively weak. The results showed a complex genetic relationships between some of the tested populations especially when isolation by distance was considered. Soft and dry phenotypes responded differently to different levels of water stress. Although a large amount of diversity exists among date palm germplasm, the findings suggest that the role of biological nature of the tree, isolation by distance and environmental effects on structuring date palm genome was highly influenced by human impacts. Identity of date palm cultivars as developed and manipulated by date palm growers, in the absence of scientific breeding programmes, may continue to mainly depend on tree morphology and fruit characters. The pattern of genetic differentiation may cover specific morphological and physiological traits that contribute to adaptive mechanisms in each phenotype. These traits can be considered for further studies related to drought adaptation in date palm.

**Keywords:** Genetic diversity, microsatellite markers, morphological traits

## Isolation of Root-specific Promoters and Generation of Abiotic Stress Resistance through Modulation of Antioxidant Expression in Cassava Storage Roots

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Cassava (*Manihot esculenta*) is a perennial root crop providing food for more than 800 million people worldwide. It is vegetatively propagated and its breeding to generate improved elite cultivars is reported to be difficult due to its high heterogeneity. Therefore, biotechnological approaches represent valuable tools to blur the edges of cassava improvement. In the last decade, several scientific teams have reported transgenic cassava lines with various improved traits to comply with the eclectic needs from small-scale farmers to commercial growers. Stacking traits will require precise and timely expression of the transgenes. Genetic elements with low homology are also necessary to reduce the probability of transgene silencing and enhance trait stability. Currently, promoters available for transgene expression in cassava are restricted to a few promoters for constitutive expression with the exception of the patatin promoter. Because many traits to be improved in cassava are connected to the root (the storage and harvested part of the cassava crop), the present project aims at providing additional root-specific promoters to the cassava biotechnology community. Fourteen *Arabidopsis* promoter candidates were selected for root-specific expression based on microarrays ([www.genevestigator.ethz.ch](http://www.genevestigator.ethz.ch)) and proteomics ([www.atproteome.ethz.ch](http://www.atproteome.ethz.ch)) data. Promoter sequences around 1.5 kb in size were cloned upstream of the uidA report gene to test its activity in cassava. Transgenic cassava lines were generated and analysed for each promoter-reporter gene system. Several promoters showed organ-specific expression pattern while others showed higher expression in roots compared to other organs. Promoters with interesting expression patterns were truncated into different size in order to determine the minimal promoter size retaining specific and determined expression activities. The most promising promoters will be shared with the cassava biotechnology network. At ETH Zürich, the new set of promoters generated in the present study will be included in strategies to engineer cassava roots with delayed post-harvest deterioration, improved level of protein and vitamins as well as transgenic cassava with enhanced drought tolerance.

**Keywords:** Biotechnology, cassava, promoter, root specific

## Classification of Wheat Genotypes Based on Yield and Grain Zinc and Iron Density using Cluster Analysis

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Cultivation of micronutrient-efficient genotypes may be the most sustainable and cost-effective solution for increasing the grain yield of food crops for the fast growing human population and in the same time improving human mineral nutrition. Breeding high-yielding micronutrient-dense genotypes is a great challenge. In this study cluster analysis was used to select Zn-efficient genotypes with high yield potential and high density in grain Zn and Fe. The Stress Tolerance Indicator (STI) as a criterion to explain the grain yield response of wheat genotypes to Zn fertilisation and grain Zn and Fe concentration were considered for the cluster analysis. Thirty spring wheat genotypes (Trial 1) and twenty winter wheat genotypes (Trial 2) were grown on two different sites during the 2006–2007 growing season with and without Zn fertilisation on each site. In the Zn fertiliser treatment 40 kg Zn ha<sup>-1</sup> were applied in the form of ZnSO<sub>4</sub>·7H<sub>2</sub>O. In addition to these variables, we determined the STI as a criterion to compare the response of the various genotypes to the treatments. All these variables varied significantly ( $p < 0.01$ ) among the spring and winter wheat genotypes. Zinc fertilisation significantly enhanced yield and grain Zn and Fe concentrations ( $p < 0.05$ ), with effects differing on the two sites. Also the STI significantly depended ( $p < 0.01$ ) on the sites. On the basis of the cluster analysis, wheat genotypes were divided into three groups, one group being micronutrient-dense, high grain yield genotypes. Although the clustering was different for the two sites, the classification proved to be useful to identify genotypes producing yields of high quantity and quality.

**Keywords:** Grain micronutrient concentration, grain yield, micronutrient-efficient, wheat genotype



## Varietal Susceptibility of Potato to the Black Cutworm, *Agrotis ipsilon* (HFN) (Lepidoptera: Noctuidae)

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The black cut worm (BCW) *Agrotis ipsilon* (HFN) (Lepidoptera: Noctuidae) is a highly polyphagous pest of several wintery crops and became a major potato pest on lighter soils in Karari, Khartoum state, Sudan. The black cut worm inflicts serious damage on the tubers, resulting in drastic yield losses. Despite its economic importance, little attention has been directed to this pest in Sudan.

Field experiments were conducted during two seasons in Karari, to evaluate 10 potato varieties (lines/accessions: Desiree, Spunta, Alpha, Draga, Mondial, Lesita, Ajax, Famosa) for resistance to BCW damage. The percentage of damaged tuber numbers (% DTN) and weight (% DTW) were used as parameters for evaluation. Differences in both parameters were very highly significant, between varieties and seasons ( $p < 0.001$  for both parameters). The interaction between the variety (lines/accessions) and seasons was also highly significant ( $p < 0.001$ ). Two parameters were found to correlate strongly and significantly ( $r = 0.83$ ).

The 10 potato varieties (lines/accessions) were also subject of a series of no-choice tests in the laboratory during two seasons. The tests included testing the larval and pupal developmental rates on potato tubers. Significant differences were noted in larval weight gains (LWG), due to differences in potato varieties across the various feeding tests. Alpha, Lesita, Bright varieties showed higher levels of resistance both in the field and in the laboratory, while Desiree and Spunta showed highest level of susceptibility. Factors governing the causes for resistance are discussed.

**Keywords:** *Agrotis*, black cut worm, potato, Sudan

## Water-use Efficiency of Sorghum (*Sorghum bicolor* L. Moench) Genotypes in Mali, West Africa, is Affected by Climate Variability

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Global climate change, in synergy with rapidly increasing population, reducing proportion of arable land and changing eating habits, poses serious challenges for the already skewed water resource allocation to agriculture. Technological options (genotypes and/or component technologies), for both tactical and strategic adaptation of agriculture, are required for sustainable and/or efficient use of water, especially in the arid and semi-arid regions of the world. One cost effective and feasible option is the introduction and/or development of ideotypes with general or specific adaptation traits that match phenology with water availability.

Diverse sorghum [*Sorghum bicolor* (L. Moench)] genotypes (10) from several races, with differences in morphology and sensitivity to photoperiod, were evaluated in 2008 and 2009 for efficiency with which they used available water for biomass and grain production under rain-fed conditions in Mali. Three sites (along a latitudinal gradient), staggered monthly (to create different climate scenarios) and a split plot arrangement fitted in a randomised complete block design with 3 replications were used in this study. Water use efficiency (WUE) of biomass production and grain yield was calculated from harvest data, seasonal rainfall amount and the change in soil water content monitored by TDR. Additionally, intrinsic water use efficiency (net CO<sub>2</sub> assimilation rate / stomatal conductance) was measured during the vegetative growth periods by infrared gas analyzer.

Mean WUE (pooling varieties, locations, sowing dates and years) in the production of biomass ranged from 0.176g L<sup>-1</sup> to 3.310 g L<sup>-1</sup> while it was lower for grain yield (0.001 g L<sup>-1</sup> to 0.5828 g L<sup>-1</sup>). Years did not significantly affect both measures of WUE while they were differentially influenced by date of sowing, genotype and location. Intrinsic WUE was not differentially affected by any of the treatment factors. The significant interaction between genotypes and locations and genotypes and sowing date for WUE of biomass production and grain yield indicate that genotypic variability can be exploited in order to adapt sorghum production systems to variable climate. The implications for both modelling and development of appropriate ideotypes (photoperiod sensitivity, maturity grouping) are highlighted and discussed.

**Keywords:** Climate change, grain yield, harvest index, leaf gas exchange

## Effects of Plant Density and Row Width on Canopy Architecture in Sorghum

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Plant architecture can be used to simulate resource acquisition, biomass production and plant stand levels thus enabling for resource capture efficiencies to be compared between architectures which differ for genetic or environmental reasons. Understanding effects of plant density is essential for a wide range of applications from breeding of cultivars adapted to high densities, to understanding the behaviour of associated crops or the competition with weeds.

Five biofuel sorghum genotypes and one maize hybrid were grown at two planting densities (20 plants/m<sup>2</sup> and 30 plants/m<sup>2</sup>) and two row distances (40 cm and 67 cm). The elevation angle, phyllotaxy and blade curvature orientation were monitored using 3 D Polhemus digitiser and the shoot organ characteristics (leaf area, leaf length, leaf area index, total biomass) were monitored by destructive measurements. Leaf area indices calculated from destructive measurements were compared with those of nondestructive measurements using the LAI-2000 device (Licor, Lincoln, USA).

Variation of plant density caused significant changes in architectural traits like leaf area index (LAI) and total biomass. From the early stages of crop growth, leaf elevation angle (L5-L7) and azimuthal orientation were markedly affected by treatments, with the measured leaf length showing a strong correlation ( $r^2 = 0.84$ ) to the digitised leaf length. An interaction between width and population density on total biomass of the crops was determined for one genotype (*S. bicolor* × *S. sudanense*) displaying the highest biomass and leaf area index (LAI) under all conditions. This might have been triggered due to the genotype having small and narrow leaves that led to low leaf area which are compensated by tillering and branching. The interactions between genotypic and environmental characteristics affecting plant behaviour were analysed and genotype specific characteristics for traits like tillering, leaf area formation and leaf orientation described.

**Keywords:** Leaf area index, plant density, plant architecture, sorghum genotypes

## Identifying Potassium-use-efficient Cotton Genotypes for Low Potassium Input Sustainable Agriculture

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The identification of cotton (*Gossypium hirsutum* L.) genotypes, efficient in potassium (K) uptake and utilisation, for low-K-input sustainable cotton production represents an important environmentally friendly approach in relation to genetic resource management. It would reduce the costly input of K-fertilisers and manage K resources in agro-ecosystems. K use efficiency of 25 cotton genotypes was evaluated under adequate and deficient K conditions in hydroponics. Although low K supply reduced the growth of all genotypes, a considerable genotypic variation was found among genotypes for their biomass production (dry weight of shoot and root, and leaf area). K-efficient and K-inefficient genotypes were identified on the basis of their growth responses at deficient K supply. Cotton genotypes that had higher growth at deficient K supply were K-efficient. The correlation analysis revealed that K-efficient genotypes had more capacity to uptake K under its deficient condition. However, ranking of genotypes by two different methods showed that the only most desirable, 'efficient-responsive' genotype was NIBGE-2 with excellent adaptation potential to both the K levels. The genotypes CIM-506 and Desi okra were 'non-efficient' and 'non-responsive' at deficient and adequate K conditions, respectively, with low shoot dry weight. For the first time, such a big number of cotton genotypes are screened and identified for their K-use efficiency, in order to exploit their potential for sustainable production under K deficiency stress. Also, for the first time, we are recommending the ranking of crop genotypes in screening experiments involving different methods to ensure the validity of results to be utilised in future studies focusing on developing nutrient-efficient crop genotypes for low-nutrient input sustainable agriculture.

**Keywords:** Genotypic variation, *Gossypium hirsutum*, K uptake, K use efficiency, K utilisation, sustainable agriculture

## Contribution to the Systematics of the Genus *Centrosema* (Leguminosae) through Molecular Analyses: An Ongoing Project in Venezuela

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*Centrosema* is an economically important Neotropical genus which, together with *Desmodium* and *Stylosanthes*, is regarded as a genus with particularly high potential as a forage legume in the tropics and sub-tropics. Several *Centrosema* species are currently being used not only as forage but also for soil cover and soil improvement. Some species are well adapted to prolonged drought and the acid, low-fertility soils that prevail in the tropics, thus making *Centrosema* species particularly important for low-input agricultural production systems.

There are some uncertainties regarding species delimitation and evolutionary relationships within the genus, due to the morphological plasticity of the species. Consequently, there is a number of differences between species which are not discernable using only morphological analysis. Therefore, the main objective of this research is to assess species delimitation and phylogenetic relationships among Venezuelan *Centrosema* species, using molecular data, as a complement of morphological studies. Molecular analyses are based on polymorphism of intergenic sequences of cpDNA *atpβ-rbcL* and *trnK/matK*, Internal Transcribed Spacer (ITS) of rDNA, Random Amplification of Polymorphic DNA (RAPD), and Simple Sequence Repeats (SSRs). Preliminary results of the intergenic sequences *trnK/matK* (*trnK*685F/*matK*1932) and *atpβ-rbcL* (R7/S11) show, on the one hand, that *Centrosema* has a monophyletic origin, *i.e.*, the species have a common ancestor. On the other hand, the grouping of species (clades) obtained by these molecular markers differs, in some cases, from the classification proposed by Williams and Clements (1990) where the *Centrosema* species were classified in 11 sub-generic groups based on morphological similarities. More conclusive results are expected when further data are obtained.

**Keywords:** *Centrosema*, introns, ITS, phylogenetics, RAPD, SSRs

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## Analysis of Cassava (*Manihot esculenta* Crantz) Stress-inducible Promoters and Modulation of Antioxidant Expression in Cassava Storage Roots

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Cassava (*Manihot esculenta* Crantz) is the 5<sup>th</sup> staple crop for over 800 million people in tropic and subtropics. The rising economic importance of cassava has led to increased efforts to stabilise yields by developing varieties with enhanced resistance to biotic and abiotic constraints. An important constraint that limits cassava's full potential is the short shelf life of harvested roots. The roots undergo rapid deterioration 24–48 hours after harvest, the so-called post harvest physiological deterioration (PPD) which renders the roots unpalatable and unmarketable. Use of genetic transformation, circumvents the limitations of traditional breeding for vegetatively propagated crops with high degree of heterozygosity such as cassava. Engineering cassava genotypes for reduced PPD, requires a reliable transgenic expression system in desired tissues at the desired level. Seven proteomic based PPD-inducible promoters were selected, isolated and fused to the uidA reporter gene in binary vectors for the production of transgenic cassava and *Arabidopsis*. Functional activities of each promoter segment by GUS staining and quantification of uidA gene proteins in various plant organs are being emphasised on a set of transgenic lines.

Additionally, strategies to reduce PPD in cassava roots have been tested using constitutive root-specific expression of candidate genes. PPD is caused when wounds are created as a result of harvesting cassava storage roots. The wounds initiate an oxidative “burst” with subsequent over-accumulation of reactive oxygen species (ROS). Inadequate wound healing and the “rare return to homeostasis from stress” cause prolonged and oxidative damage spreading from the site of injury. Up-regulation of defense-related genes occurs in cassava storage roots post-harvest; but this is insufficient in magnitude and timing to prevent deterioration. To examine the potential of ROS scavenging enzymes (*i.e.* glutathione peroxidase (GPX) and dehydroascorbate reductase (DHAR)) to reduce the oxidative stress, we have developed transgenic cassava plants constitutively over-expressing either GPX or DHAR under the control of the patatin promoter. Integration of the GPX and DHAR expression cassettes in the cassava genome has been confirmed by PCR and southern blots. The transgenic lines are currently being evaluated for their level of tolerance to PPD, salt and drought.

**Keywords:** Oxidative stress, post harvest physiological deterioration, promoters, tropical crop

## Adaptation of Sugar Beet (*Beta vulgaris* var. *saccharifera*) to Tropical Conditions of Sudan

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Sugar beet contributes significantly to world sugar industry (45 %). Although the leading sugar beet producing countries are in temperate regions, results of adaptation of sugar beet to tropics are encouraging. Accordingly, the current investigation aimed at testing of some sugar beet introductions for yield and quality under tropical conditions of Sudan. Four sugar beet varieties from Strube/Lineal Service, Germany viz., SUD-01-08, SUD-02-08, SUD-03-08 and SUD-04-08 were tested. The experiment was conducted at five locations representing north, east and central Sudan climates. Moreover, two sowing dates were used in central Sudan location. Results manifested no significant differences among tested varieties in root yield in all testing sites, except at Gezira 1 and Gezira 2. Moreover, the effect of variety  $\times$  environment interaction was not significant. However, the combined root yield means were significantly different as SUD-03-08 (97 ton ha<sup>-1</sup>) was leading followed by SUD-02-08 (90.9 ton ha<sup>-1</sup>), SUD-04-08 (88.1 ton ha<sup>-1</sup>) and SUD-01-08 (85.9 ton ha<sup>-1</sup>). Similarly, SUD-03-08 produced the highest combined mean sugar yield (16.1 ton ha<sup>-1</sup>) followed by SUD-02-08 (14.8 ton ha<sup>-1</sup>), SUD-04-08 (14.7 ton ha<sup>-1</sup>) and SUD-01-08 (13.7 ton ha<sup>-1</sup>). The effect of variety on sucrose content (Pol %) was not significant, except at Hudeiba location. The combined means were also not significantly different with overall sucrose content of 16.59 %. The effects of variety and variety  $\times$  environment interaction on total soluble solids (TSS=Brix %) were not significant and the overall average TSS was 19.15. Similar results were observed for fibre%, purity% and pH with overall averages of 3.2 %, 86.6 % and 8.3, respectively. The effect of environment on average root weight was significant with New Halfa produced the largest root weight (1.873 kg) while New Hamdab produced the smallest root weight (0.618 kg). The effect of variety on forage yield was significant at Gezira 1, but not at Gezira 2 and Dongola testing sites. The combined forage yield means were significantly different with SUD-03-08 produced the highest forage yield (10.8 ton ha<sup>-1</sup>) followed by SUD-02-08 (9.0 ton ha<sup>-1</sup>), SUD-04-08 (8.7 ton ha<sup>-1</sup>) and SUD-01-08 (6.4 ton ha<sup>-1</sup>). To close, our results clearly demonstrated the high potential for sugar beet production under tropical conditions of Sudan.

**Keywords:** Adaptation, sucrose, sugar beet, sugar yield

## Some Physiological and Biochemical Treatments in Relation to Sink and Source Strength in a Water Stress Resistant and a Sensitive Cultivars of Wheat under Post Anthesis Water Stress

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The grain development and filling stage is one of the main steps in the formation of the final economic yield of wheat. In Mediterranean regions (such as Iran) occurrence of water stress during the grain filling period is the main factor for a significant yield reduction. This research was performed in order to evaluation the effects of post anthesis water stress on some physiological characteristics in relation to sink and source strength of two wheat cultivars: Zagros cultivar (ZC) and Marvdasht cultivar (MC) that are resistant and sensitive to post anthesis water stress, respectively. This study was performed in the research greenhouse of the agricultural faculty of Tehran University, Iran in 2005 and 2006. A factorial experiment on base of a randomized completed block design with three replications was used.

Under no-stress conditions the grain yield, biomass yield, 1000 grains weight and no of grains in spike of MC was higher than ZC. Under stress situations all characteristics, but for the no of grains in spike, decreased more for the MC than for the ZC. Under control treatment, chlorophyll a and b and soluble protein concentration, photosynthesis rate and stomatal conductance of ZC flag leaves were greater than MC.

After post anthesis, the maximum concentration of IAA was found at the early grain growth stage (cell division and cell growth) and the maximum ABA concentration at the beginning of grain filling (17 days after anthesis). Water stress significantly decreased IAA and increased ABA concentration in the grains of both cultivars. In the control and the water stress treatments ABA concentration in the grains of MC was higher than ZC.

With respect to the results of this research, IAA may be involved in the regulation of cell division and cell growth and hence in the formation of sink size. A reduction in IAA and an increase in ABA concentration at the beginning of grain filling stage may be the most important factor that is involved in switching from cell division and enlargement phase to grain filling phase.

**Keywords:** Absciscic acid, Indole acetic acid, photosynthesis, soluble protein, stomatal conductance, water stress, wheat



## Water Use and Yield of Wheat Genotypes as Affected by Water and N-supply

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Water resources are a constraint in agriculture not only in semiarid, but also in subhumid climates. Hence, we investigated water use of 4 wheat genotypes from mediterranean (cvs. Golia & Gönen) and temperate climate (cvs. Monsun & Taifun) and their response to water deficit after heading and to late N-application.

All plants were raised in pots under a rain shelter from April to August 2007 receiving the same optimum-treatment apart from late N-application before heading (N: approx. 30 vs. 60 kg ha<sup>-1</sup>) and water supply during 3 weeks after heading (W: soil moisture was either maintained at field capacity or was lowered and kept at half of available FC by deficit irrigation).

VA3 of the 3-factorial experiment (cvs  $\times$  N  $\times$  W, n = 5) revealed many significant interactions, particularly of water supply with late N-application and genotypes. High compared to low N-doses increased biomass, grain yield, protein content of grains, water use efficiency (WUE) and evapotranspiration efficiency (ETE) at well-watered conditions, but failed to do so at deficit irrigation. Grain yield and WUE of well-watered plants declined from Monsun over Taifun and Golia to Gönen with significant differences between each of the genotypes; and deficit irrigation reduced yield in 3 genotypes, but not in Taifun. WUE was improved by deficit irrigation in Taifun, but lowered in Gönen and did not respond in the other 2 genotypes.

There were several interactions cvs  $\times$  N  $\times$  W; e.g.: high N-Dosis induced yield increases in well-watered plants and low ones under deficit irrigation in 3 genotypes, whereas Golia did not respond to high dosis, irrespective of water supply.

It is concluded that increasing the late N-application, which favours yield protein content and WUE under well-watered conditions, is less or not effective under deficit irrigation after heading. The 2 genotypes from mediterranean climate (Golia and Gönen) produced less biomass and yield than those from temperate climate (Monsun and Taifun) and displayed a similar or even higher yield reduction under deficit irrigation; since their WUE, ETE and HI was also lower, they appeared even less adapted to lack of water after heading.

**Keywords:** Drought adaptation, N-side-dressing, spring wheat genotypes, water use efficiency

## Screening and Selection of some Bread Wheat (*Triticum aestivum* L.) Genotypes Adapted to High-temperature Areas of Sudan

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Expanding wheat production into the warmer areas of Sudan becomes one of the major urgent strategic agricultural national policies. This goal, however, necessitates development of early maturing and heat tolerant cultivars. To meet this objective, twelve different selected bread wheat genotypes were field tested for performance under terminal heat stress. The genotypes were grown at two sowing dates, optimum (normal) and late (terminal heat stress) during winter season of 2008–09, at Shambat (Khartoum, Sudan). The experimental design used was split plot design with three replications. Different agronomical characters were measured and used for evaluation. These included grain yield/area, grain yield/plant, 100-grains weight, number of spikes/plant, number of grains/spike, days to booting, days to anthesis and days to maturity. The results revealed that the adverse effect of terminal heat (late sowing) was more significant and pronounced on yield and yield components. Significant effect due to the interaction between the sowing dates and genotypes was observed for grain yield/area, grain yield/plant, 100-grain weight, days to booting, days to anthesis and days to maturity. The screened genotypes exhibited differential response to the different environments, sowing dates (normal and terminal heat stress) for yield traits. Under optimum sowing date, the genotypes Teve and Hudiba2 gave the highest yield, followed by Henne, Hudiba1, and Kauz, respectively. While the genotype Samr-Pastor gave the highest yield under late sowing date (terminal heat stress) and therefore out-yielded all other genotypes including the check variety Imam. However, this genotype (Samr-Pastor) showed the similar yield performance across both sowing dates. Other genotypes that exhibited tolerance to terminal heat stress were Henne, Hudiba1 and kar, respectively. Therefore, among the twelve screened genotypes, the genotype Samr-Pastor could be selected as the most potential high yielding, heat-tolerant and stable one, which could be adapted to the non-traditional warmer areas of wheat production in Sudan.

**Keywords:** Bread wheat, cultivars, high temperature, screening, selection, Sudan

## Photosynthesis of *Jatropha curcas* and *J. mollissima* under Drought Stress

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*Jatropha curcas* recently is highly promoted to become an important source for bio-fuel production in tropical regions. The often mentioned advantage of the species is it's assumed adaptation to droughtstress and the possibility to cultivate plantations on marginal land under arid climate conditions. Little is known, however, on the productivity under these conditions and the mechanisms of drought tolerance.

To test the response of photosynthesis of different *Jatropha* species to water limitations as a measure of adaptation and productivity we combined a green house experiment with measurements under natural conditions. In all cases we estimated photosynthetic rates and stomatal conductance from light response curves in relation to soil moisture. The green house experiment was performed in Göttingen with *Jatropha curcas* and the field trials on a farm in the vicinity of Patos, Paraíba in the North-East of Brazil with *Jatropha mollissima* as a natural element of the regional dry forests. Some other woody species from this site were also included as a control.

Both *Jatropha* species showed very similar responses to light under wet conditions with a maximal photosynthesis rate ( $A$ ) of about  $25 \mu\text{mol m}^{-2} \text{s}^{-1}$  at a light intensity of  $600 \mu\text{mol m}^{-2} \text{s}^{-1}$ . Under dry conditions with  $0.05\text{--}0.10 \text{ m}^3 \text{m}^{-3}$  soil moisture  $A$  was reduced to maximum values between  $5$  and  $10 \mu\text{mol m}^{-2} \text{s}^{-1}$  at a light intensity of  $400 \mu\text{mol m}^{-2} \text{s}^{-1}$ . In comparison with control species at the field site, *Jatropha* shows a higher reduction of photosynthesis under stress conditions.

The results show that the measured physiological response of *Jatropha* species to water stress is a typical behaviour within the genus. Their tolerance to drought is not related to high productivity under dry conditions but an expression of adaptation to and survival during extended periods without sufficient soil moisture.

**Keywords:** Drought stress, *Jatropha*, photosynthesis, soil moisture

## **Evaluation of Different Strategies to Engineer Cassava Brown Streak Virus (Potyviridae) Resistance in Cassava (*Manihot esculenta*).**

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Cassava Brown Streak Virus (CBSV) has emerged as a factor causing important losses in cassava field in East Africa. Even though it was first identified in 1930's, molecular diversity and dissemination dynamics remain poorly studied. Classical symptoms are restricted to the storage roots and it renders early disease diagnostic complicated. CBSV is an RNA virus belonging to the Potyviridae family. The CBSV genome encodes for nine proteins, the coat protein (CP) being the most conserved sequence amongst the different CBSV isolates.

Degenerated primers were used to amplify the full CBSV CP sequence from CBSV-infected cassava collected in Tanzania. In order to evaluate the RNA interference mechanism in this system, different strategies were conducted: The characterised CBSV CP partial sequence was used to produce cassettes for expression of sense, antisense transcripts as well as their untranslatable versions. In addition, a cassette for exogenous expression of double-stranded hairpin homologous to CBSV CP sequence was produced to test the efficacy of conventional RNA interference against CBSV.

Transgenic cassava lines were produced for the complete set of binary vectors covering the above presented approaches. Transgenic cassava lines were selected based on transgene copy number and expression levels. Relative transcript quantification through qRT-PCR allowed the selection of transgenic lines containing high and low level of CP sense and antisense transcripts. The transgenic lines were also characterised for the load of short RNAs homologous to CBSV CP sequence through Northern blot procedures adapted for short RNAs detection. The selected transgenic cassava lines are being evaluated for CBSV resistance by grafting transgenic scions on wild-type cassava rootstock infected with a virulent CBSV species. Virus quantification methods were established for the CBSV - cassava host system and they are used to assess virus tolerance and/or resistance in the transgenic cassava lines.

**Keywords:** Cassava transformation, Plant resistance, RNAi

## Biofortification of Cassava and Rice

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The starchy roots of cassava (*Manihot esculenta* Crantz) and the grain of rice (*Oryza sativa*) are a vital source of carbohydrate for more than half of the human population in the world, especially in tropical and sub-tropical regions. However, consumption of cassava or rice does not provide all the required elements for human health due to low protein content, poor levels of several EAAs (essential amino acids), micronutrients and vitamins. It provokes major nutritional deficiencies in populations having a diet mostly relying on cassava or rice consumption.

In order to raise the protein and EAAs content in cassava, both push (metabolic pathways alteration) and pull (sink strength alteration) strategies are being assessed. Strategies 1) Manipulation of a nitrogen assimilation related transcription factor; and 2) Modulation of the aspartate family metabolic pathway; refer to the “push” concept while the strategies 3) Over-expression of heterologous storage proteins; and 4) Investigation of cassava storage proteins; represent an evaluation of the “pull” approach. Transgenic cassava lines for each approach have been produced to determine the most suitable strategy to elevate protein and EAAs contents in cassava roots.

Another important limitation in cassava roots is the low level of vitamins; in particular the vitamin B complex that is partially lost after processing. The metabolic pathways for the de novo biosynthesis of vitamins B1 and B6 have been recently characterised in *Arabidopsis* with the identification of key enzymes for vitamin B1 (THIC) and vitamin B6 (PDX1 and PDX2) synthesis. In order to improve the vitamin B content in cassava roots, transgenic cassava over-expressing the aforementioned enzymes have been produced. Elevation of vitamin B1 and B6 contents will be attempted for the whole cassava plant and for the cassava roots. In order to evaluate the possibility to raise vitamin B levels in seed crop, transgenic rice over-expressing vitamin B1 and B6 related enzymes in the complete plant and in the rice endosperm have also been generated.

The above-presented strategies are currently evaluated through protein, EAAs and vitamins B quantification in the transgenic lines. The most promising strategies could be combined to produce biofortified cassava and rice cultivars.

**Keywords:** Cassava, rice, vitamin B1, vitamin B6, biofortification, protein

## Selecting Rhodes and Napier Grass Genotypes for Dry Areas

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The aim of this research was to assess drought resistance in the collections of Rhodes (*Chloris gayana*) and Napier grass (*Pennisetum purpureum*) held in the genebank of the International Livestock Research Institute (ILRI) in Ethiopia. This would allow selection of better genotypes for use as livestock feeds in dairy or fattening systems in dry areas.

Separate trials were planted for each grass during the dry season at the ILRI Zwai research site in the Ethiopian Rift Valley, where both grasses are well adapted under irrigation. The area has an annual average precipitation of 600 mm. For each species, 60 accessions were planted in 3 replicates in a split-plot design with irrigated and non-irrigated treatments. The irrigated plots were watered weekly with flood irrigation and the non-irrigated plots received less than 20 mm of rainfall over the trial period. Gravimetric soil moisture content was determined weekly in the two treatments. Plants were established from cuttings during the wet season and cut back to 10 cm at the start of the experiment. Biomass yield was measured after 5 weeks of re-growth for Rhodes grass and after 8 weeks of re-growth for Napier grass. Drought resistance was measured as the ability of a genotype to be relatively more productive than others under water deficit conditions.

Although the trial was limited to one site and one season, split-plot ANOVA showed significant differences between irrigation treatments and among accessions for biomass yield ( $p < 0.01$ ) in both species indicating the possibility to select from the germplasm collection. Rhodes grass showed better adaptation to drought than Napier grass. Better adapted accessions of more productive grasses will support demand for feeds for dairy and fattening systems in dry areas and could provide solutions for smallholders to adapt to changing environments in sub-Saharan Africa.

**Keywords:** *Chloris gayana*, drought resistance, dry areas, forage, genotype, livestock feed, Napier grass, *Pennisetum purpureum*, rhodes grass, selection

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## The Effect of Water Deficit Stress on Germination Traits of Ten Perennial Ecotypes of Alfalfa (*Medicago sativa* L.)

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As a perennial forage crop, alfalfa can be cultivated in marginal lands and has a high yield and good quality high-protein content. In Iran alfalfa is the main forage crop and is grown on about 618,000 ha, where summer drought is relatively severe and sometimes alleviated by irrigation. In order to study the response of 10 different perennial ecotypes of alfalfa to water deficit at germination stage, an experiment was conducted in a controlled environment. The experiment was performed as a factorial, randomised complete block design with three replications. In this research the effect of six levels of osmotic potential (0, -4, -6, -8, -10 and -12 bar) resulting from polyethylene glycol 6000 were investigated on germination index of ten different perennial alfalfa ecotypes including six Iranian ecotypes (Gharah yonje, Hamedani, Farahane Arak, Synthetic Karaj, Mohajeran Karaj and Shorkat) and four foreigner ecotypes (Harp, Jolia, Deft and Dian). The following traits were measured: germination rate and percent, root and shoot lengths, seedling dry weight, and root to shoot dry weight ratio.

Analysis of variance showed that water deficit influenced all seed germination traits of alfalfa ( $p < 0.01$ ). Also, there were significant differences among ecotypes for above-mentioned traits. In general there were not significant differences among ecotypes for seed germination traits at water deficit up to -4 bar. Root and shoot length and root and shoot weight of alfalfa seedlings increased with increasing water deficit up to -4 bar which resulted in seedling dry weight increase. Root to shoot dry weight ratio also increased in water deficit up to -4 bar. In high water deficit (between -6 and -8 bar) all above-mentioned traits were severely decreased.

**Keywords:** Alfalfa, germination, *Medicago sativa*, seedling growth, water deficit

## Improvement in Protein Quality of Waxy Maize for South East Asia by Doubled Haploids and Marker Assisted Selection

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Starch of waxy maize basically is characterised by 100 % of amylopectin (absence of amylose). Like conventional maize its nutritional value is relatively low due to low content in lysine, tryptophan and threonine, which are essential amino acids regarding human nutrition. Thus, infant malnutrition is a major issue in margin regions of South East Asia (SEA), where waxy maize is the staple food. This study aimed to develop waxy maize of acceptable agronomic and organoleptic properties with higher protein quality by combining existing waxy cultivars with Quality Protein Maize (QPM) lines developed by CIMMYT. QPM is controlled by the recessive gene *opaque2*, responsible for higher lysine and tryptophan contents, and genetic modifier genes impacting physical kernel properties like hardness. *In vivo* gynogenesis by the mean of inducer lines, kindly provided by University Hohenheim (Germany), principally should permit to rapidly obtain doubled haploids (DH) originating from [*waxy*\*QPM] hybrids. Even though initial difficulties were encountered in adapting the DH-technique to subtropical maize genotypes (*e.g.* interference in anthocyanin pigmentation), finally the mean haploid induction rate (8.2 %) and the mean chromosome doubling rate (40 %) were relatively high. However, the fitness and fertility of DH were rather low, leading often to low seed set (19 % of the plants in average). Specific molecular markers developed for *waxy* (*wx*) and *opaque2* permitted to identify several double recessive *waxy*-QPM DH, which represent a valuable base for classical breeding of protein improved waxy maize for SEA. These doubled haploids had almost 100 % amylopectin starch and had a much increased lysine content as well. But the hardness and vitreous endosperm trait specific to QPM maize seemed to be lost possibly due to the *waxy* gene.

**Keywords:** Doubled haploids, maize, *opaque2*, QPM, waxy



## Characterisation of Staygreen Trait Associated with Drought Tolerance in Cassava (*Manihot esculenta* Crantz)

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Over 70 % of Kenya's population depends on agriculture and agriculture-related activities for their economic livelihood. More than 1/3 of these people live in the arid and semi-arid lands defined by low soil fertility and frequent droughts. However, these areas have agricultural potential if irrigation systems are established and drought tolerant crops bred. Cassava ranks as 5<sup>th</sup> most important staple food crop for over 800 million people in the tropics and sub-tropics. The crop is particularly resilient under sub-optimal conditions, with several cultivars reportedly performing well under prolonged drought conditions.

Recent advances in genomics have contributed to a better understanding of biological mechanisms and allowed the development of new or improved screening methods for more efficient breeding strategies. Understanding the molecular mechanisms of drought tolerance in selected cassava cultivars and subsequent development of molecular markers could facilitate the rapid introgression of the drought tolerance trait in farmer-preferred and locally adapted cultivars. Breeding cassava for drought tolerance is likely to enhance its sustainable production and contribute to food and income security.

This study intends to evaluate cassava's phenotypic and physiological response to drought as well as molecular characterisation of the crop response to drought stress. Analysis of the so-called stay-green cassava cultivars is being emphasised. The selected cultivars are being characterised under controlled (greenhouse) and field conditions (at two drought-prone locations in Kenya). Molecular analysis involves identification of differentially expressed drought responsive genes by using OMICS tools. The recent release of the cassava genome ([www.phytozome.net/cassava.php](http://www.phytozome.net/cassava.php)) allows the selection of drought-responsive genes by analogy to other studied plant species. Selected genes will be analysed by qRT-PCR after designing gene-specific primers. The drought-responsive genes will be functionally characterised using cassava transgenic systems.

Broadly, this research will generate and implement advanced molecular tools that uncover genetic pathways modulated upon drought to characterise cassava drought tolerance physiology. The transfer of technology (methods developed during the project), will enhance capacity building at IITA-Kenya and the evaluation of traditionally bred stay-green cultivars combined with development of molecular markers for rapid introgression of the stay-green trait will ensure a valuable output for plant breeders and partners in the South.

**Keywords:** Cassava, drought, molecular markers, stay-green trait

## Conservation, Characterisation, Regeneration and Safety Duplication of Wild *Vigna* Genetic Resources in Thailand

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This research is part of the conservation and utilisation of field crops genetic resources research project of the Thai DOA. The prime aims of the project were 1) to make an inventory of known locations where *Vigna* species can be found, 2) to undertake field visits to validate the findings from previous records and make recommendations to conserve the populations found in those locations for *in situ* conservation of *Vigna* species and 3) to regenerate and make a safety duplication of those species under threats. Nine surveys were carried out and covered 12 provinces of Thailand. Found locations were recorded by a GPS. Passport data of collected accessions were recorded. Sixty-five sites from previous records were searched. It was found that 41 sites had disappeared and only 24 sites were found. Seven *in situ* sites were newly found. Sixty-six samples, of plant for herbarium specimens and of seeds for *ex situ* regeneration were collected. Species were identified by seed characters and herbarium specimens. The most found species were *Vigna umbellata*, followed by *Vigna minima* and *Vigna trinervia*. Wild *Vigna* in several sites had disappeared due to threats imposed to the conservation sites, both abiotic or biotic. Abiotic threats were such as slash-and-burn, road expansion, urbanisation, or herbicide application. Biotic threats were such as disease, insect pests, nematode or alleopathy effect. Maps of wild *Vigna* species distribution as well as their *in situ* sites were also displayed. Attempt, when possible, was made to relieve threats in order to sustain these *in situ* conservation sites. After the surveys and collections, wild *Vigna* species were characterised and regenerated at Chai Nat Field Crops Research Centre for a safety duplication and sustainable use. Seeds of each species were then divided into 4 lots. The first lot is used as genetic materials in the *Vigna* breeding programme while the second lot is safely deposited at the national genebank in Bangkok. The third and fourth lots are for depositing in a regional genebank at AVRDC and the world newly established Svalbard genebank in Norway, respectively.

**Keywords:** Characterisation, conservation, genetic resources, regeneration, safety duplication, threats, *Vigna*

## Conservation of Potato Landraces in Three Microcentres of Diversity in Ecuador

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Ecuador is an important centre of diversity for potato. We identified 3 areas with a high potato diversity, also known as microcentres. These are the provinces of Carchi (North), Chimborazo (Center) and Loja (South). The objectives of this study were to describe the current state of *in situ* conservation of potato in Ecuador by analysing the genetic diversity present at these microcentres, conducting collection of germplasm, survey the germplasm donors, and a molecular characterisation of the collected materials using SSRs. A total of 159 potato landraces were collected at the microcentres. The surveys (150) identified the landraces that farmers consider as lost. Interestingly, according to the names provided by the farmers, a large number of landraces they considered lost are still in hands of other farmers in the same microcentres. This suggests a limited exchange of seed potatoes (and information) among farmers. To verify that similar/identical names also constitute identical genetic materials we conducted molecular analysis to the landraces. Eight simple sequences repeats (SSR) were used to characterise the 158 landraces. Using these markers, 78 alleles were identified. To analyse the relationships between the collected landraces, a dendrogram was constructed using NTSYS. In general a high degree of diversity was found among the Ecuadorian potatoes from the three microcentres. However, genetically identical materials were identified from the same microcentre (same or different names) as well as among microcentres (same or different names). One group of landraces was unique for Loja and another for Chimborazo, whereas some landraces from different microcentres also grouped together. These data indicate that farmers' seed exchange in the past was more dynamic than we previously thought because landraces moved from North to the South of Ecuador. Finally, these preliminary results also suggest that an important part of the genetic diversity of potatoes is still present *in situ*, maintained by farmers as a food security resource regardless the factors that could produce genetic erosion, such as the introduction of new high yielding potato varieties.

**Keywords:** Genetic diversity , *in situ* conservation, potato landraces

## Response of Tomato Introgression Lines to Low Root Zone Temperature and Drought

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Tomato (*Solanum lycopersicum* L.) is an economically important vegetable cultivated worldwide. It is a thermophilic crop and low root zone temperature (RZT) and drought can hamper plant growth, development and total biomass production. Sub-optimal temperature also limits the tomato growing season and area, e.g. in Tropical Highlands and may result in increasing production costs if greenhouses are needed. Developing a cold and drought tolerant tomato variety with sustainable field performance is a big challenge in tomato breeding. Breeding programs should include the detection of quantitative trait loci (QTL) and evaluation of allelic performance by cultivating introgression lines under sub-optimal conditions. Introgression lines (IL) carrying QTL alleles for cold tolerance have already been identified in a *S. lycopersicum* × *S. habrochaites* IL-library.

The main objective of this study is to reveal the physiological basis of drought and cold tolerance in tomato. Responses of introgression lines to low root zone temperature and drought were studied and measured in terms of stress tolerance index, stomatal conductance, leaf expansion rate, total green leaf area, percentage of wilted leaf area, water use efficiency, osmotic adjustment, biomass accumulation and partitioning.

Tube grafting was carried out seventeen days after seedling emergence. The grafted plants were grown under three different growing conditions including well watered low RZT (10°C) and optimum RZT (15–20°C) and drought stress conditions with optimum RZT. All plants were well watered before transplanting into the experimental units and the plants were subjected to stress by withholding irrigation repetitively for five to six days intervals. After seven weeks of treatment plants were harvested for destructive measurements. Results show that the graft combination comprised by the recurrent parent as scion and an introgression line, which is supposed to carry a QTL with positive effects on plant vigour under low temperature, as rootstock produced significantly higher leaf area and dry mass. The highest assimilate production in the recurrent parent-introgression line combination gives hint that a hormonal signal from the roots leads to improved performance of canopy growth under abiotic stress.

**Keywords:** Cold tolerance, drought, introgression lines, low root-zone temperature, QTL, *Solanum lycopersicum*, tomato

## Management, Characterisation and Evaluation of Wild *Vigna* Genetic Resources in Thailand

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The *Vigna* genus has 7 subgenus spread around the tropics and subtropics of Asia, Africa and America. Of those, only subgenus *Ceratotropis* is originated in Asia thus commonly known as Asian *Vigna*. The Thai Department of Agriculture has continuously conducted a survey and collection of wild *Vigna* genetic resources in Thailand as well as introduced from overseas. Lately, 66 samples of wild *Vigna* genetic resources under threats were collected countrywide for a safe keep. In 2009, a total of 102 accessions (accs.) of wild *Vigna* from 22 species were grown in order to regenerate, evaluate and safely duplicate at Chai Nat Field Crops Research Centre, Thailand. The most found species were *V. umbellata* (18 accs.), *V. minima* (13 accs.), *V. reflexo-pilosa* (11 accs.), *V. radiata* (11 accs.), *V. trinervia* (10 accs.), *V. mungo* (10 accs.). These were from a local collection together with accessions introduced from overseas. Being a viny and indeterminate type, they were grown in pots with sticks to support the stems. Each accession was characterised and evaluated for morphological characteristics and agronomic traits using the IPGRI descriptor for mungbean (*V. radiata*). The results showed that, given the differences in their own genetic, location, soil type, microclimate and imposed threats, the morphological characteristics and agronomic traits of wild *Vigna* varied dramatically. For example, terminal leaflet shapes varied from cuneate (42 accs.) to ovate-lanceolate (28 accs.), ovate, or deltoid. Petal colour, the typical characteristic of the subgenus *Ceratotropis*, varied from light to dark yellow. The number of days to harvest varied between 49 to 122 days (average  $75 \pm 18$  days). For agronomic traits, the number of pod per plant was from 12 to 688 pods (average  $190 \pm 140$  pods). The number of seed per pod varied between 5–14 seeds (average  $9 \pm 2$  seeds/pod). Seed size varied between 5–82 g (average  $26 \pm 17$  g/1000 seeds). Seed yield ranged between 1–68 g/plant (average  $26 \pm 19$  g/plant). The morphological characteristics and agronomic traits were then recorded in a database for a sustainable use in efficient breeding programmes. Some of these wild *Vigna* genetic resources were also deposited in the Thai genebank for a safety duplication.

**Keywords:** Agronomic traits, *Ceratotropis*, evaluate, genetic resources, morphological characteristics, regenerate, safety duplicate, wild *Vigna*



# Mixed cropping, agroforestry and biofuels

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## **Strategies to Use Biofuel Value Chain Potential in Sub-saharan Africa to Respond to Global Change / Enhancing Low-productivity Farming in Tanzania and Linking to SMEs**

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Better-iS aims at identifying the potential for linking low-productivity farming to small and medium enterprises (SME) to enhance livelihoods through biofuel value chains. Local biomass production and processing targeted to small-scale farmers in Tanzania (Morogoro) through linkages to SMEs is expected to be improved. Within the scope of increased energy demand, strategies on locally produced feedstock or biofuels may be used decentralised for producing electricity, cooking and heating; or the option to be exported to the international market will be developed. The following analytical assessment streams are undertaken to achieve the objective:

1. Model assessments to downscale global climate change scenarios to local case study regions in Tanzania and to assess biomass potentials for national energy demand simulations.
2. Participative assessments of the viability on potential pathways of linking low-productivity farming to SME on local, decentralised biomass concepts.

Beyond academic benefices, farmers, regional organisations and local authorities in sub-Saharan Africa will be collaboratively develop feasible strategies to benefit from biomass production potential and mitigate food insecurity.

After three years the project will have accomplished the following outputs:

- Top-down global modelling approaches applied to downscale implications for energy demand, excess supply or gaps in supplies.
- The evaluation of energy biomass production as well as consumption patterns focuses on competing biomass uses (food, material, energy) and resulting options for cascading systems.
- Energy and climate balances which link both, outputs from the top-down approach on global scenarios and the bottom-up approach of biomass value chains.
- Bottom-up biomass value chains in the Tanzanian case study region to assess the viability on potential pathways of linking low-productivity farming to SME on local, decentralised biomass concepts.
- Sustainability Impact Assessments in the case study region reflect trade offs between socio-economic and environmental indicators on the basis of identified biomass value chains.

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- A digital Information System of feasible value chain concepts is provided as advice packages and will be tailored for later activities for capacity building and dissemination strategies.

First project results will be presented. Lessons learnt for successful project implementation, benefits and risks can be evaluated and discussed.

**Keywords:** Biofuel value chains, impact modelling, indicator, sustainability impact assessments, Tanzania

## Model-based Approach to Quantify the Production Potential of Chinese Cabbage/Maize Strip Intercropping in the North China Plain

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Intercropping is a traditional and sustainable production system in the North China Plain (NCP). In recent years however, with labour moving out of agriculture the area under intercropping cultivation has steadily declined. The traditional row-intercropping systems are very hand labour intensive and can hardly be mechanised. To maintain intercropping and the associated advantages new row-intercropping systems that can be mechanised have to be developed. In that respect the management of a tolerable degree of competition for growth factors is a key issue. Intercropping of maize with Chinese cabbage is a popular system in the NCP. Due to the strongly different canopy heights it offers a great potential to intensively study availability, competition and use-efficiency of solar radiation, a major growth factor. Field experiments in Germany and China showed that the level of incident radiation strongly influences the yield potential in Chinese cabbage/maize strip systems. In Germany significant yield reduction in Chinese cabbage occurred, whereas in China with incoming radiation being twice as high, radiation was not a limiting growth factor. To optimise the production potential of the system strip widths of Chinese cabbage have to be adjusted to the local solar radiation conditions. For this purpose the CROPGRO model was employed to simulate growth and development of Chinese cabbage under reduced incident radiation. The regional variability in available radiation was considered by using up to 30 years of weather data from 14 meteorological stations across the NCP. Simulations were carried out for five different soil texture. Performance of different strip widths, which were adjusted to common machinery working widths were tested. The results were linked to a Geographic Information System. In systems with a small strip widths yield decline was significantly stronger in the northern part of the NCP. A strip width wider than 2.4 meters did not cause any significant yield reductions over the entire NCP. In a next step cultivars with different shading tolerance will be tested in the model and in the field to further optimise the system.

**Keywords:** Chinese cabbage, crop growth model, GIS, intercropping, North China Plain

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## Improving Banana Production in Coffee Agroforestry Systems in Central America

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Sixty smallholders intercropping coffee, banana (*Musa* spp.) and trees in Central Costa Rica and Northern Nicaragua were described, of which twenty farms were intensively investigated. The aim of this work was to describe and analyse the coffee agroforestry system with focus on banana production. This was based on the assumption that bananas have to face deep-shaded conditions, and that coffee, banana, and trees may influence each other.

There was a high variation of field size, transmitted light, density, basal area, and canopy area. In Costa Rica mean plant density is 4244 coffee ha<sup>-1</sup>, 341 trees ha<sup>-1</sup>, and 579 bananas ha<sup>-1</sup>. In Nicaragua mean plant density is 4852 coffee plants ha<sup>-1</sup>, 185 trees ha<sup>-1</sup>, and 358 bananas ha<sup>-1</sup>.

Thirteen different banana cultivars were identified, of which 91 % are from subgroup AAA Gros Michel and AAA Cavendish in Costa Rica, and 97 % are from AAA Gros Michel and AAA Red Subgroup in Nicaragua. Leaf Area Index of AAA Gros Michel 'Coco' (dwarf cultivar), and AAA Red Subgroup cultivars was significantly higher than AAA Cavendish 'Congo'. Dry weight of AAA Red Subgroup was significantly higher than AAA Gros Michel 'Coco'. Number of hands of AAA Red Subgroup was significantly lower than AAA Gros Michel or AAA Cavendish. There were also significantly different infection rates of Black Sigatoka (*Mycosphaerella fijiensis*) between cultivars.

Tree canopy area and tree crown surface are significantly negative linear, correlated to percent intercepted light of banana, plant or stem density. This probably indicates that the upper tree storey influences the banana crop. Intercepted light of banana is significantly positive linear correlated to dry matter of banana. This probably indicates that light is a limiting factor.

The interrelationships between coffee, banana and tree need further verification. Further research may focus on limiting factors of banana production in coffee agroforestry systems

**Keywords:** Dry weight, leaf area index, light interception, banana

## Is Multistrata Agroforestry a Viable Alternative for Small Farmers in Peruvian Amazon?

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One of the major causes of deforestation in the Peruvian Amazon is small-scale slash-and-burn farming. As a viable alternative, we have designed and evaluated the *multistrata* agroforestry system during the implementation of a development project around the fast-growing jungle town of Pucallpa (Ucayali). Our target group was chosen according to a study identifying factors that affected system acceptance. Based on the results, we are focusing on small and middle-sized farms, where the farmers already grow a larger variety of crops. The target group is low and middle-income families who do not focus on livestock ranching. From 2006 till 2009, a total of 65 plots (average size 0.5-1 ha) were established in eight villages around Pucallpa, most of them on deforested and severely degraded soil infested by weeds (*Imperata* sp.). As at the end of 2009, altogether 41 plots (adoption rate around 60%) were successfully maintained by the farmers. The system is based on the cultivation of fast-growing indigenous fruit tree species guaba (*Inga edulis*) combined with other native fruit and timber species. The key component acid-soil tolerant leguminous tree guaba, is traditionally used to shade perennial crops, provide firewood, control noxious weeds and produce a sweet pulp. During the early years of establishment, farmers intercrop the trees with their own staple crops such as cassava, maize and rice. In subsequent years, tree-growing prevents farmers from annual cropping, but there is room to grow shade-resistant crops such as pineapple. The preferred incentives were based on providing farmers with quality tree seedlings, organizing communal exchange work and continuous technical assistance. The system has proven to be a viable alternative for local conditions: it is able to restore and maintain fertility on degraded soil and provide farmers with useful marketable produce. In the initial years, they can harvest annual crops, later valuable fruits and (we estimate) ten years to harvest timber trees. The economic performance of the systems is also promising. In ten economically-evaluated plots the net present values and cost-benefit ratio has been much higher, compared to traditional slash-and-burn plots.

**Keywords:** *Inga edulis*, multistrata, native fruit, Peruvian Amazon, slash-and-burn, small farmers

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## **Research Design, Soil and Biodiversity Baseline for Long-term Farming Systems Comparison of Full Sun and Shaded Agroforestry Cocoa Production under Conventional and Organic Management in Alto Beni, Bolivia**

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Cocoa, mainly produced by 5 to 6 millions of smallholder farmers, is considered as one of the most sustainable production system in the humid tropics. Little is known about the sustainability of different cocoa production systems.

A long-term experiment is set up in Alto Beni at 400 m above sea level with a humid winter dry climate, 1'540 mm annual rainfall. The trial assesses the sustainability of five cocoa (*Theobroma cacao*) production systems with the parameters of yield and yield stability, input-output efficiency of nutrients and energy, soil fertility, biodiversity, economic result, climate change mitigation and adaptation. The two-factorial experiment is arranged in an completely randomised block design; the five cocoa treatments, based on local and international practices, are four times repeated. The production systems are differentiated by the diversity of shade canopy and by crops, from mono culture full sun cocoa to a agroforestry cocoa with leguminous species (*Inga edulis*, *Erythrina poeppigiana*) shade canopy, including fruits (e.g. *Euterpe precatoria*, *Theobroma grandiflorum*) and timber (e.g. *Centrolobium ochroxylum*, *Swietenia macrophylla*) species, and a higher diversified agroforestry system based on the natural successions of species. The management of the cocoa is conventional and organic. The five treatments are: mono culture full sun cocoa conventional, mono culture full sun organic, agroforestry conventional, agroforestry organic and successional agroforestry organic. Fallow plots and nearby forests plots are monitored for soil fertility and biodiversity. Field clearing started in 2007 followed by maize (*Zea mays*) crop and end of 2008 the cocoa plots (48 m × 48 m) were established.

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The results of the baseline studies concerning soil fertility show good nutrient level for cocoa production; the variance of soil parameters is documented in a soil map. According the FAO soil classification (2006) the soils are Lixisole and Luvisole with high base saturation.

The biodiversity of above ground fauna and flora highlights the new register of species: *Neopelma sulphureiventer* for the department of La Paz and the serpents *Chironius multiventris* for Bolivia and endemic species of amphibians *Oreobates choristolemma*. Indicator species for a monitoring are defined.

**Keywords:** Agroforestry, biodiversity indicators, cocoa, conventional, organic, soil fertility, system comparison



## Performance of *Jatropha curcas* under Different Soil and Climatic Conditions in Kenya

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As the world's petroleum fuel records and consumption figures indicate that the peak and depletion of fossil fuel reserves are within a breach of a few spans of years from now, countries around the world are hurriedly developing strategies for on-farm production of renewable sources of fuel from crops. In Kenya, campaigns for the production of renewable green energy has been doubled with the Government, Non-Governmental Organisations and Private Companies emphasising the importance of *Jatropha* (*Jatropha curcas*) as the preferred candidate for biodiesel production. Dry areas are particularly targeted as potential production sites with the argument that *Jatropha* could make use of marginal land not suitable for food production. While this is done, information on the climatic and edaphic suitability of this crop is lacking to smallholder farmers. The study hypothesis was that regions for biofuel production have not been properly identified in Kenya. Therefore the objective of this research was to study the performance of *Jatropha* (*Jatropha curcas*) under different soil and climatic conditions in smallholder farms in Kenya. A survey was conducted in 150 randomly selected farms at the Coast, Central, Eastern, Rift Valley and Nyanza provinces (30 per province) representing typical *Jatropha* regions in Kenya with existing *Jatropha* plantations. Questions on *Jatropha* agronomy, management practices and cropping challenges were asked. An in-depth study of 5 farms in each region chosen randomly was performed to verify the information obtained, taking data on the morphological and yield performance of *Jatropha*, diseases and pests incidences, soil analyses on pH, nitrogen, carbon and bulk density. Climatic data was obtained from meteorological stations in the regions. Results showed that the performance of *Jatropha* was positively linked to humid conditions, well distributed annual rainfall of 500–750 mm, moderately sandy to loam soils, pH close to neutral and good level of management. It was concluded that good management practices together with climatic and soil suitability are important for successful *Jatropha* production. Further, it was evident that not all regions where *Jatropha* is grown and promoted in Kenya could support the crop in terms of climatic and soil requirement without proper crop management practices.

**Keywords:** Climatic suitability, edaphic, *Jatropha curcas*, management practices

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## **Economic Development and Biofuel Production: Towards a Sustainable Regulation Model**

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The research, using an interdisciplinary approach to Law & Economics, analyses the different interests involved in the development of biofuel production and trade: on one hand, the economic interests of the open market and, on the other hand, the pressing needs for both social and environmental sustainability. The object of the study can be justified in three levels: philosophical, theoretical and pragmatic. On the first, philosophical, the research is based on the modern paradigms of science, *i.e.*, postpositivism or postempiricism, the metatheoretical stance following positivism. In applied sciences in general, this metatheory has had a profound impact on the way the acquisition of knowledge is understood. In Law, particularly, this paradigm – which is still under construction – has led to a true revolution in areas such as Constitutional Law, where theories have been emerging regarding a “new constitutionalism”, which places the Constitution in the centre of the legal system. Pragmatically, the study aims to explore the historical moment the international community has been undergoing: the rise of economies whose potential is truly titanic, especially when taken as a group, offers a unique opportunity to study the nuances in the equilibrium between economic growth – a necessity – and social and environmental sustainability – an urge. In this context, to study renewable energy is to touch the very core of this necessity – and of this urge. The scientific developments regarding biofuels focus primarily on productivity: which biomass offers the best cost/production relationship, for instance. However, a crucial aspect is, sometimes, overlooked: the social and environmental consequences of such developments and, even more neglected, the role of legal regulation in ensuring this sustainability is fully achieved. Thus, by situating in a position between the borders of Law and of Economics, this study aims to draft the principles and general aspects of legal regulation regarding biofuels, using, as a parameter, the Brazilian experience in bioethanol and biodiesel.

**Keywords:** Biofuel, regulation, sustainability

## ***Jatropha curcas* as a Potential Driver for Rural Development in Mesoamerica**

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As the costs and consequences of the world's dependence on fossil fuels grow, the prospect of cultivating bio-fuels is becoming a new paradigm in agriculture being considered in Latin America. One potential biodiesel feedstock crop, *Jatropha curcas* (JC), has generated much interest for its adaptation to dry land cropping and its potential to provide income to small farmers in tropical regions. Although considerable research on JC is being conducted in India, little is known about the crop's productive potential in Mesoamerica, considered to be its centre of origin. Zamorano University in Honduras is executing a long-term programme to understand and improve the cultivation of JC for biofuel production in the region, addressing a value chain approach for Biodiesel production out of JC, evaluating the economic feasibility of its cultivation in Mesoamerica at different scales, and accelerating the use of bio-fuels in developing countries. JC productivity is evaluated with a set of comprehensive agronomic trials installed on 8 hectares of Zamorano land using JC "Cabo Verde" variety. Additionally a collection of regional, Asian and African accessions is studied in a genetic programme to develop improved JC varieties for Mesoamerica. The outcomes of both agronomic research programs are transferred to small and medium scale farmers through a comprehensive extension programme which aims to improve income and to promote a biofuel producing culture among them. In order to support these efforts Zamorano will purchase JC seeds through local collection centres and convert them into biodiesel or PPO fuel in Zamorano's pilot plant. The resulting bio-fuels will then be used to reduce environmental impact of fossil fuel consumption on Zamorano Campus area and surrounding areas.

**Keywords:** Biodiesel, biofuel, *Jatropha curcas*, Mesoamerica

## **Biodiesel and Social Inclusion in Rural Areas: A Study Based on Principal Component Analysis in the North of Brazil**

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The north of Brazil is located in the so-called Brazilian Legal Amazon and is among the poorest regions of the country. So, aiming at alleviating the regional disparities and promoting the social inclusion, the Brazilian government launched in the year of 2004 the national programme of biodiesel use and production (PNPB). However, after 5 years of the PNPB implementation it is not clear whether the social inclusion is taking place, *i.e.* whether the poorest farmers are being included in the Brazilian biodiesel chain. In this context, a cross sectional study was conducted with small-scale farmers in the north of Brazil, in two sub-study regions situated in a transition area between Cerrado and Amazon rain forest. A range of socio-economic indicators were collected among smallholders who cultivate *Jatropha curcas* and *Ricinus communis*. The explicit factors, relevant to assess living standard in the present study are: (i) family income, (ii) durable goods, (iii) transport mean, (iv) toilet facilities, (v) dwelling facilities, (vi) educational level, (vii) social capital, (viii) crowding factor, (ix) health condition, (x) food security, (xi) resource dependence, and (xii) water shortage. Based on this, the Principal Component Analysis (PCA) and a non-linear logit model were utilised to assess the relationship between farmer's living standard and the adoption of oil seed activity. The results point towards an ambiguity regarding the social inclusion target of the Brazilian programme of biodiesel use and production (PNPB). In one sub-study region poor families are adopting the oil seed activity and therefore are being included in the Brazilian biodiesel chain (*Ricinus communis* region) but in the other sub-study region the poor families continue to be marginalised without access to this new economic alternative and therefore the social inclusion is not taking place (*Jatropha curcas* region). This study is unprecedented in the region and the results are extremely important in obtaining an appropriate method of regional and national government subsidy for an alternative clean energy activity with social inclusion of poor families.

**Keywords:** Biodiesel, brazil, Logit, principal component analysis, social inclusion

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## Development of Sustainability Criteria in the Context of Bioenergy Production in Rural Tanzania: The Case Study of the Tandai/Morogoro

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The production of modern and traditional sources of bioenergy such as liquid biofuels and biogas but also woodfuel and charcoal became an increasingly controversial discussed topic in recent years. This development was initiated by a whole set of distinct triggers such as global warming, “peak oil” and increase in fossil fuel prices as well as increasing prices for agricultural commodities. Due to the fossil fuels demand of the transport sector, the substitution via biofuels was mostly on the spot of this dispute. A lack of area and a supply gap evoked through changed exquisiteness of cash crops in Europe respectively prospected area or production potentials in developing countries. In Tanzania in October a moratorium on biofuels stepped back to small farmers and processors and fulfilment of sustainability criteria. These criteria are to be developed and still don’t appear in the present draft of Tanzania guidelines on biofuels.

The contribution of the Leibniz Institute for Agricultural Landscape Research (ZALF) aims at a sound, comprehensive and locally grounded analysis of sustainability effects of woodfuel and *Jatropha curcas* production in the village of Tandai in the foothills of the Uluguru Mountains in Morogoro District/Tanzania. The recently completed field survey (expected accomplishment mid June 2010) followed, among others, also one distinctive research topic: The consensual based development of sustainability criteria as well as the related sustainability assessment for the local level. In the mid-term, the benefits and risks of the implementation of new energy crop value chains, or its compartments, should be assessed.

An outline and overview of an adequate set of sustainability criteria was developed and discussed at a local kick-off workshop in March 2010. Stakeholder with such different backgrounds as ministry officials, researchers and local farmers agreed consensually upon the hereby derived set, consisting out of social, economic and ecologic criteria. The next step, a village workshop in Tandai, adjusted the perspectives of the experts to the realities on the ground. Additionally, quantifiable criteria and qualifiable criteria were elaborated and their data requests summarised into a data collection questionnaire.

**Keywords:** Indicators, sustainability, sustainability impact assessment, Tanzania

## Response of Leaf Area and Biomass Partitioning of Physic Nut to Variable Water Supply

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*Jatropha curcas* L. (physic nut), a perennial plant belonging to the *Euphorbiaceae* is considered as an important source of biodiesel production. However, basic agronomic properties of *Jatropha* have not thoroughly investigated. The aim of this study was to characterise crops growth rates, biomass partitioning parameters and leaf area development under rainfed and irrigated conditions.

The study was carried out in Fenoarivo, South-West Madagascar on a site with yellow / red or reddish lateritic soil with a planting density of 1250 plants/ha in a randomised design from December 2009 till May 2010. The experiment was done on 3 years old *Jatropha* plants that were pruned at the beginning of the winter season. Plants were rainfed or daily supplied with 10 mm of irrigation. Crown diameter, plant height and biomass were measured at 5 harvest dates and bushes were separated into trunk, branches, twigs and leaves. Length of branches and leaf dry mass per branch were determined. Non-destructive measurements of leaf area index (LAI) were done at four positions around the tree at two lateral distances (30 and 50 cm) each with a Hemi-View system and compared with destructive samplings of leaf area and dry mass.

First findings indicate that neither crop growth rate nor LAI were increased by irrigation but effects are expected during later sampling dates. Dry mass of newly formed twigs and leaves were correlated with pre-existing branch dry matter and volume indicating the significance of reserves from pre-season growth phases for actual growth potential. Leaf dry mass per branch appears to be a rather stable parameter of biomass allocation illustrating a conservative way of spatial exploitation of light. Non-destructive measurements of LAI with Hemi-View images are correlated with data from destructive sampling. Estimates of LAI from images at 30 cm distance correlated better with total LAI compared to that taken at 50 cm distance. Based on additional information from nutrient concentration it is concluded that *Jatropha* must be considered as a high-input crop if profitable oil production is the target.

**Keywords:** Biomass, growth, *Jatropha curcas*, leaf area

## Energy and Carbon Footprints of Biofuel Systems using Banana and Plantain Waste

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Waste that accumulates in *Musa* production systems (up to 40 % of total fruit biomass) has a great potential to be processed into bioethanol due to high sugar contents of fruits, and can open new energy sources and markets for small-scale banana and plantain producers. However, the economical and ecological sustainability of biofuel systems strongly depends on how they are produced.

The present study aimed to analyse energy and carbon footprints of *Musa* bioethanol production systems using a life cycle approach. The study compares three case studies differing in management practices, which are (1) a coffee producer's cooperative in Costa Rica using *Musa* as shade trees, (2) organic banana producers from Ecuador, and (3) conventional banana producers from Ecuador.

The best net-energy balance ( $19.3 \text{ MJ L}^{-1}$ ) was obtained for the case study from Costa Rica, closely followed by the organic producers from Ecuador ( $17.1 \text{ MJ L}^{-1}$ ), which are *Musa* production systems operating with low external inputs. The net-energy balance for the conventional banana farms in Ecuador was significantly lower ( $7.2 \text{ MJ L}^{-1}$ ), mainly due to the high amount of energy required for producing external inputs such as mineral fertilisers and pesticides. All three case studies yielded avoided carbon emissions (C emissions that are avoided when biofuels are used instead of petroleum based fuel), with the best value obtained for the Costa Rican case study ( $0.48 \text{ kg C L}^{-1}$ ), followed by the organic ( $0.44 \text{ kg C L}^{-1}$ ) and the conventional ( $0.34 \text{ kg C L}^{-1}$ ) banana producers from Ecuador. 40-100 % of gasoline consumption of farm households could be replaced by bioethanol, thereby saving C emissions in the range of  $226\text{--}1038 \text{ kg yr}^{-1}$ .

The study clearly showed the need to conduct feasibility studies that consider economic as well as ecological aspects. Biofuel systems should aim at having more favourable energy and carbon balances than fossil fuels, which will open opportunities for carbon credits and new markets.

**Keywords:** Biofuel, carbon, Costa Rica, Ecuador, energy, life cycle analysis, markets, *Musa* spp

## ***Pueraria phaseoloides* Fallows Improve Labour Efficiency and Productivity of Cassava Systems in the Forest Zone of Cameroon**

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Southern Cameroonian farming systems on inherently infertile Ultisols comprise fallow phases to maintain crop productivity. Cassava, the main staple food, is gaining importance as a food cash crop commercialised. However, yields are low and fields are small (0.15–0.25 ha), due to high labour demand, inefficient manual field operations, and seasonal labour scarcity. A factorial fallow type  $\times$  tillage system  $\times$  intercrop on-farm trial aimed to identify technologies that minimise labour demand in small holder cassava systems, while maintaining or improving cassava productivity.

Cassava yielded 20.1 t ha<sup>-1</sup> fresh roots after *Pueraria phaseoloides* dominated fallow (improved fallow), compared to 17.0 t ha<sup>-1</sup> after fallow dominated by *Chromolaena odorata* (natural fallow). Ridge tillage attained 21.7 t ha<sup>-1</sup>, compared to 16.5 t ha<sup>-1</sup> after no-till treatment. Intercropping with maize had no effect on cassava performance compared to sole cassava. Maize yield was not affected by fallow type, yet ridging doubled grain yield from 0.51 to 1.0 t ha<sup>-1</sup>. To cultivate the *P. phaseoloides* plots, 129 labourdays ha<sup>-1</sup> were required, 22 % less than after natural fallow. To cultivate the no-till plots, 132 labourdays ha<sup>-1</sup> were required, 12 % less than for ridge tilled plots. Intercropping with maize did not significantly increase total labour requirements, but additional maize revenue increased labour productivity from 14\$ labourday<sup>-1</sup> in sole cassava to 23\$ labourday<sup>-1</sup> in cassava-maize intercrop. Cassava planted after *P. phaseoloides* fallow, intercropped with maize and ridge tillage was with 34\$ labourday<sup>-1</sup> and 2600 \$ ha<sup>-1</sup> most labour efficient ( $p < 0.01$ ) and most profitable ( $p < 0.01$ ) compared to all other treatments. *Pueraria phaseoloides* fallow alone significantly increased labour productivity and profitability by 64 and 63 % respectively compared to natural fallow. Largest labour-savings were achieved during the peak labour demand period of planting season.

To increase adoption rates of the *P. phaseoloides* improved fallow rotation technology in forested areas and derived savannahs like in south-central Cameroon, farmers should be made aware of the immediate labour-saving effects and the increased profitability rather than the long-term soil fertility improvement. Higher profitability of cassava crop will subsequently improve commercial orientation of cassava growers and improve and diversify revenues.

**Keywords:** Agronomy, cassava, improved fallow, labour, pueraria

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## Agroforestry Species in Peruvian Amazon: Farmers' Preference Survey

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The involvement of farmers into the process of improvement of multistrata agroforestry systems (AFS) has been receiving increased research attention during last decades. Proper species composition, reflecting both farmers' needs and ecological sustainability, is the crucial feature of AFS. According to our knowledge native tree species preference survey has been carried out in the Peruvian Amazon, however, the preferences for the species regarding different floristic strata were not reported from this region. The objective of this study was to identify the most preferred species from particular floristic strata suitable for AFS in the surrounding of Pucallpa in Peruvian Amazon. The data was gathered in two-rounded survey using participatory methodology modified according to Franzel *et al.* among local farmers. The list of 13 preferred species includes well-known commercial species (*e.g. Cocos nucifera* or *Manihot esculenta*), fruit bearing species (including native fruit trees like as *Myrciaria dubia*), medicinal plants (*Morinda citrifolia*), legume (*Cajanus cajan*), spices (*Piper nigrum*) and traditional indigenous species so far lacking exploration (*Plukenetia volubilis*). The respondents selected on average 65 species, so the demand for useful plans reflect the high biodiversity of the region; the farmers do not stand the marketability above the household consumption and the farmers go on searching for alternatives to traditional cash crops. The balance between the need for biodiversity conservation and satisfaction of needs of small-scale farmers in the Peruvian Amazon can contribute for sustainable development of the rural areas in the region. Considering the current knowledge of preferred species among farmers in given area, it is imperative to carry out research exploring their potential in evolving production systems and to quantify the opportunities of adoption and improvement of AFS.

**Keywords:** Amazonia, floristic strata, multistrata systems, Peru, priority setting

## Different Farming Systems and Resilience Building in a Changing Climate – On-farm Comparisons of Organic and Conventional Cocoa Cultivation in Alto Beni, Bolivia

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Resilience research has been applied to socioeconomic as well as for agroecological studies in the last 20 years. It provides a conceptual and methodological approach for a better understanding of interrelations between the performance of ecological and social systems. In the research area Alto Beni, Bolivia, the production of cocoa (*Theobroma cacao* L.), is one of the main sources of income. Farmers in the region have formed producers' associations to enhance organic cocoa cultivation and obtain fair prices since the 1980s. In cooperation with the long-term system comparisons by the Research Institute of Organic Agriculture (FiBL) in Alto Beni, aspects of the field trial are applied for the use in on-farm research: a comparison of soil fertility, biomass and crop diversity is combined with qualitative interviews and participatory observation methods. Fieldwork is carried out together with Bolivian students through the Swiss KFPE-programme Echanges Universitaires. For the system comparisons, four different land-use types were classified according to their ecological complexity during a preliminary study in 2009: successional agroforestry systems, simple agroforestry systems (both organically managed and certified), traditional systems and conventional monocultures. The study focuses on interrelations between different ways of cocoa cultivation, livelihoods and the related socio-cultural rationales behind them. In particular this second aspect is innovative as it allows to broaden the biophysical perspective to a more comprehensive evaluation with socio-ecological aspects thereby increasing the relevance of the agronomic field studies for development policy and practice. Moreover, such a socio-ecological baseline allows to assess the potential of organic agriculture regarding resilience-building face to socio-environmental stress factors. Among others, the results of the pre-study illustrate local farmers' perceptions of climate change and the consequences for the different crop-systems: all interviewees mentioned rising temperatures and/or an extended dry season as negative impacts more with regard to their own working conditions than to their crops. This was the case in particular for conventional monocultures and in plots where slash-and-burn cultivation was practised whereas for organic agroforestry systems the advantage of working in the shade was stressed indicating that their relevance rises in the context of climate change.

**Keywords:** Agroforestry, Bolivia, cacao cultivation, organic agriculture, resilience, system comparisons

## Growth, Yield and Performance of Teak in Silvopastoral System in the Lowland Western Region, Ecuador

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Dual-purpose cattle production systems, comprising milk and meat production, are traditionally utilised by family farms on open pastures in the lowlands of the Western Region of Ecuador (IWRE). However, Zebu-European crossbred cattle suffer from heat stress and therefore would benefit from shading. A tree that provides shade and has adapted to management conditions of pastures with seasonal burning is Teak (*Tectona grandis*). It is planted as live fence, by this forming a silvopastoral system. The net incomes of silvopastoral farmers are higher than compared to the incomes of traditional farmers, taking into account the initial investments of planting trees. The objective of this study was to determine the optimal number of trees and time of harvesting, thus defining a yield model for *Tectona grandis* for silvopastoral systems in IWRE. The data base comprises 40 permanent sample plots and 479 interval plots on 600 ha. The oldest stand is currently 50 year old. Height curves for three site indices (21, 19 and 17 m with a reference age of 10 years) were constructed, yield tables for the three site indices were defined and mean annual volume increment (MAI) curves presented with range of site index values. The maximum MAI was  $20 \text{ m}^3 \text{ ha}^{-1}$  at the age of 13 for a site index of 21 m and  $133 \text{ trees ha}^{-1}$ . Future volume can be easily estimated through growth simulation models or yield tables, none of these tools have yet been developed in the lowlands of the western region of Ecuador for teak in silvopastoral management.

**Keywords:** Site index, teak annual increment, volume equation, yield tables

## Evaluation of Insect Biodiversity in Various Agroforestry Systems in Peruvian Amazon

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Agroforestry systems are nowadays more and more applied in tropical degraded lands for reforestation, soil improvement, production and also for biodiversity conservation. According to Schrot (2004) agroforestry systems are able to conserve biological diversity. Our research was focused on biodiversity evaluation and its comparison among several types of agroforestry plantations established during last seven years in the zone of Campo Verde (region Ucayali) in Peruvian Amazon. For the evaluation was chosen class Insecta for its important role in the ecosystem, easy and standard collection and good manipulation. Data collection was realised in 2007, 2009 and last collections are in realisation till July 2010. Our hypothesis was that multistrata agroforestry systems have higher potential of biodiversity conservation than other types. There were used malaise traps, emergent traps, sweeping nets and direct collection methods. Treatments were realised in multistrata systems with *Inga edulis*, piper plantation with bolaina trees (*Guazuma crinita*), till July 2010 continues data collection in agroforestry systems with cacao (*Theobroma cacao*). During the years the highest average values of biodiversity shows multistrata systems: the Simpson's diversity index was higher in systems with *Inga edulis* (38,2) and also higher species richness (243). Data from agroforestry system with piper plantation shows lower biodiversity index (21,4) and also species richness is lower (189). Observations had confirmed that biodiversity values are very affected by changing rainy and dry season during the year, when the abundance declines rapidly in the dry season. The multistrata agroforestry systems shows relatively high biodiversity indexes after six years of existence because the many of the plots are composed by fast growing and developing trees planned for wood logging after some 15 or more years. We supposed that multistrata systems with cacao plantation can reach higher diversity because its production period is up to 30 years without logging disturbance. Our vision to the future is to evaluate biodiversity of various agroforestry systems and to investigate the positive impact of these systems on the pest species natural reduction and its application in local agriculture of Ucayali region.

**Keywords:** Agroforestry, insect biodiversity, multistrata systems, species richness

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## **We Do Want to Plant a Baobab Tree: The Story of Malawi**

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Considering the baobab tree multiple uses, its nutritional and medicinal properties, and its economic value, it seems that this species should be widely cultivated. However, this is not the case: several factors stop local people from planting it. The situation in Malawi might be different than elsewhere due to the local economic importance of this tree: it is commonly used by commercial fruit processors and it is exported to Europe.

In order to determine if the baobab could be cultivated in Malawi, semi-structured interviews and group discussions were carried out in five villages along the southern Lake Shore. Moreover, two methods of seed pre-treatment and five methods of vegetative propagation were attempted with local farmers.

Few respondents had tried to plant a baobab tree, but only one obtained successful germination. All respondents were interested in planting baobabs and once told that fruiting period can be reduced through grafting, they were also keen on learning grafting techniques. Manual scarification was found to be better than soaking in water (seed pre-treatment). Grafting and budding success was high, while survival of stem cuttings was low. Although the success of the grafting carried out by a professional was higher than that of a farmer, farmer grafting success was high: about 85 %.

Results from this study indicate that if the economic importance of an under-utilised fruit tree is high, and the density of these trees low, despite traditional beliefs, local farmers are willing to plant it. And they can plant it, once taught, they have the skills to successfully pre-treat the seeds and graft the trees. Baobab economic importance could be used to motivate farmers to plant and better manage not only the baobab tree but also under-utilised fruit trees in general.

**Keywords:** *Adansonia digitata*, interviews, Malawi, propagation trials

## Survival and Growth of Selected Agroforestry Tree Species under Farm Conditions in Western Kenya

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Many projects seek to use agroforestry and other reforestation practices to rehabilitate degraded and abandoned sites. Yet recommendations are often based on species screening trials that are conducted in optimal conditions by researchers. There is good reason to expect that the performance of recommended trees would be inferior under field conditions, leading to project failure. At the same time, projects often dogmatically promote the use of indigenous species, asserting that they will perform better because they are adapted to local conditions, without verifying their assumptions. There is good reason to doubt the appropriateness of this recommendation, particularly when rehabilitating degraded lands.

This study aimed at assessing the survival and growth of tree seedlings under a range of management conditions which are realistic to occur in Western Kenya. Emphasis was on capturing a representative range of realistic farm conditions and the seedlings' responses rather than using controlled 'greenhouse' conditions for predicting their true performance in the field. The choice of tree species and the degree of care and management intensity applied to the seedlings was left to the farmers to decide. 144 trees of two different species were planted at each of 227 eligible farms using *Albizia coriaria*, *Grevillea robusta*, *Markhamia lutea* and *Senna siamea*. The survival and growth of the seedlings was monitored after 3, 6, 12 and 18 months.

Soil parameters explained the growth only very poorly while their impact on initial survival was higher. Generally, the species differed significantly in their response to management practices while a trade-off between survival and growth rate was also observed irrespective of the variability of external influences. The data provide evidence for result-oriented recommendations of suitable tree species as well as realistic scenarios for farm-based reforestation/afforestation projects.

**Keywords:** Agroforestry, Kenya, land rehabilitation, reforestation, tree survival

## Diversity Determinants of Indigenous Fruit Trees in Homegardens of the Nuba Mountains, Central Sudan

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Indigenous fruit trees (IFTs) play an important role for nutrition and cash income of rural communities in East Africa, particularly for children and women. While the occurrence of IFTs in the natural vegetation is threatened by over-use, agroforestry homegardens offer an opportunity for cultivating these trees, thus contributing to their *in situ* conservation. Quantitative data on IFT diversity in homegardens is lacking for most of East Africa. The present study aims to inventory IFTs in homegardens (locally called ‘jubraka’) in the Nuba Mountains, Central Sudan, and to assess socioeconomic and ecological factors determining IFT diversity.

In 36 randomly selected homegardens of two villages in the southwest (Sama) and southeast (Kalogi) of the Nuba Mountains, richness and abundance of IFTs were recorded and diversity indices calculated. Garden sizes were measured and socioeconomic household data gathered. A total of 13 IFT species were cultivated in 36 gardens. Mean IFT species richness per garden was not significantly higher in Sama than in Kalogi (2.5 versus 1.3,  $p = 0.107$ ), while other IFT diversity indices did so (Shannon index 0.82 versus 0.31,  $p > 0.001$ ; Shannon evenness 0.74 versus 0.35,  $p = 0.017$ ). Multivariate regression analysis indicated that IFT species richness was determined by the location Sama ( $p = 0.007$ ,  $\beta = 0.387$ ), number of household members older than 67 years ( $p = 0.014$ ,  $\beta = 0.389$ ) and size of homegarden ( $p = 0.036$ ,  $\beta = 0.329$ ). The Shannon index was also correlated with the location ( $p = 0.001$ ,  $\beta = 0.460$ ), number of old household members ( $p < 0.001$ ,  $\beta = 0.537$ ) and the level of commercialisation ( $p = 0.002$ ,  $\beta = 0.451$ ). The Shannon evenness depended on location ( $p = 0.001$ ,  $\beta = 0.536$ ), ratio of children to adults ( $p = 0.002$ ,  $\beta = 0.498$ ), number of old household members ( $p = 0.005$ ,  $\beta = 0.469$ ) and garden size ( $p = 0.025$ ,  $\beta = -0.366$ ). The variables gender and education of the gardener, poverty level and average age of adults of the household, possession status of the garden and garden management techniques such as use of pesticides and organic fertiliser did not seem to affect IFT richness and diversity.

The data indicate that large commercial gardens of households with old members and many children are most suitable for *in situ* conservation of IFT species in the study area.

**Keywords:** Agroforestry, homegardens, *in situ* conservation, Shannon index





# Rice research

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## The Adoption of Organic Farming in Thailand: A Case of Organic Rice

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Organic agriculture is one of several approaches to sustainable agriculture, and its importance in the agriculture sector is growing. At the same time, organic agriculture is frequently promoted as an exit strategy from poverty for small-scale marginal producers in developing countries. While the economics literature suggests that a lack of profitability and credit constraints are the main problems facing their adoption, several other important factors could also impact the adoption of organic farming, including economic conditions, management skills, agro-climatic conditions and social considerations. Contract and non-contract organic rice farms in Surin and Yasothon provinces versus their neighbouring conventional farms were used for their study. Descriptive statistics were used to investigate both organic and conventional rice farms. Binary logistic regression and Duration analysis were applied to investigate the factors affecting the adoption and diffusion of organic farming. The empirical results reveal that the important reasons for non-adoption of organic farming are more concerned with lack of incentive instruments to promote organic farming. Also attitude on specialised market and premium price for organic foods, and special credit are strongly affect organic farming. Many of organic farms emerged from conventional problems faced by farmers, while premium price with market access by contract farming, and extension agents are important incentives. Important factors on decision of adoption of organic farming show that water accessibility, farm-gate price and attitude on conventional problem are positively significant. Besides, off-farm work and farm size have negative influence adoption of organic farming. The constraints are mostly concerned with practice and management due to lack of technical know-how, as well as marketing constraint with an information gap between producers and consumers. Meanwhile, extension focuses more on improvement of soil fertility techniques in order to reduce production cost and convincing organic farming.

**Keywords:** Adoption, duration analysis, organic farming, organic rice

## Transforming Global Rice Research to Meet Future Needs

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Rice farming has an annual value of over \$150 billion, and directly or indirectly affects over 2 billion people who either depend on rice as their food staple or are involved in the production or processing of it. Rice provides 20 % of the worlds food calories. Some 400 million chronically hungry people depend on rice for their livelihood. Rice is also rapidly rising in its importance as a food staple in Africa and Latin America.

The Green Revolution in Asia had its origins in major scientific advances, which primarily benefited small holders that produce the bulk of rice consumed in Asia, but also raised questions about the sustainability of such intensive agriculture. Research in the past three decades has greatly expanded to also address critical needs in crop and natural resources management, environmental issues, and human health and nutrition through a combination of crop improvement and good agronomic practices. Documented annual economic benefits from past rice productivity-enhancing research exceed \$19.5 billion.

Changing environmental, economic, demographic and social landscapes will change the way rice will be grown in the future, towards eco-efficient production systems, including diversified cropping systems and value chains. This will require innovations derived from strategic, increased R&D investments. It will also require a transformation of the agricultural research and extension systems to ensure that these innovations are what farmers and others in the value chain need, and to get them to these users faster.

This paper will review trends in world rice production and priorities for rice research. We will present a strategic vision and plan for a Gobar Rice Science Partnership (GRiSP) through which we propose to re-focus and align research for development activities. We will provide innovative examples of how agricultural R&D in such a context could change to become more effective, thus serve the needs of rice producers and consumer better, and also make major contributions to the world's pressing environmental and social issues. We will also provide examples of innovative public-private sector partnerships and end with a set of recommendations for policy makers and for the rice research and development community in Europe.

**Keywords:** Drivers of change, food security, R&D strategy, rice

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## **The Impact of Rice and Maize Price Volatility on Farm Households' Income and Consumption in Northern Viet Nam**

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World food prices were characterized by massive fluctuations during the past three years. Rapidly increasing food crop price levels in 2007 and in the beginning of 2008 were followed by a sharp decline later on in the same year. Rural households in low income countries are affected by price volatility of agricultural commodities both through its impact on consumption expenditures and income. Food price hikes in 2008 also caused major public concern about food security in low income countries, but also created hopes of higher agricultural incomes for rural households. Therefore, the objective of this study is to investigate both the extent of net income shocks related to volatile food crop prices as well as households' response to income and consumption risk through a household level study covering the period from 2006 to 2008.

The research was conducted in the mountainous Yen Chau district in northwestern Viet Nam, which is among the poorest districts in the country. Agricultural production is dominated by two major crops, paddy cultivation for subsistence needs in the lowlands and intensive production of maize as the primary cash crop in the uplands, which constitute, on the average, approximately 8.5 % of total consumption expenditures and 65% of total household cash income, respectively.

In a first step the static impact of rising rice and maize prices on household net income was analyzed using the Net Benefit Ratio, a method widely applied in literature. Rising rice prices had a moderate impact on net income, but the effect was widespread since 45 % of the households are rice net buyers. Households' maize income fluctuated significantly between 2006 and 2008, whereby the massive decline in maize income in 2008 of 25 % relative to 2007 was mainly attributable to considerably higher input costs rather than to the decrease of output prices.

In a second step households' resilience to the maize income decline in 2008 was analyzed using an OLS regression model which employs an asset based approach linking households' capital endowment with the stability of their consumption expenditures. The regression results show that the maize income decline of 2008 did not translate into decreased consumption expenditures compared to the year before. Only few households applied specific measures to cope with the income depression, the most widespread one being the postponement of the purchase of valuable consumption durables. Nevertheless, farmers did respond to differences in maize prices by adjusting the timing of maize sales.

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Although households were found to be resilient to the maize income depression in this instance, the high degree of specialization on maize production has to be viewed as a relatively risky strategy, given the high levels of input requirements and severe soil erosion observed, coupled with fluctuating input and output prices. Therefore, policies should focus on improving the economic and ecological sustainability of maize cultivation in the short run, but also foster income diversification in the longer run.

**Keywords:** Consumption risk, coping and adaptation strategies, income volatility

## **Adaptive On-farm Evaluation of Resource Conserving Rice Cultivation Practices in the Middle Senegal River Valley**

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Sahelian rice production is often critiqued as sub-optimally yielding, highly input intensive, and resource and cost inefficient. Now practiced in six Sahelian countries, the System of Rice Intensification (SRI) has been proposed as a potentially viable alternative to conventional rice cultivation. Principles include the use of single, young transplants at wide spacing, compost, mechanical + manual weed control, and intermittent irrigation. We report on three seasons of on-farm experiments in three locations in the Senegal River Valley. During the 2008 Dry Season, farmers' (FP) and recommended management practices (RMP) were compared with a locally adapted version of SRI (ASRI), which employed all principles, but substituted compost with mineral fertilizer. Across sites, we found significant yield increases for RMP (+20 %) and ASRI (+31 %) relative to FP. But while farmers appreciated the yield and water saving benefits of ASRI, they also found it labor demanding, especially for weeding activities that coincided with horticultural crop labor requirements. Farmers subsequently designed and implemented a fourth system that hybridized RMP and ASRI (hereafter "Hybrid"), by maintaining intermittent irrigation, increasing crop density and following a single round of mechanical weeding with localized herbicide applications. RMP, ASRI and Hybrid yields were 25 %, 25 % and 19 % greater than FP in the 2008 Wet Season. The Hybrid system was generally successful in reducing weed biomass; it also reduced labor and input requirements, and gave the highest net profits in 2 of 3 sites. In the 2009 Dry Season, the Senegalese State halted subsidies for herbicides. RMP, ASRI and Hybrid yields were 36 %, 37 % and 34 % greater than FP. The Hybrid approach reduced herbicide use by 38 % and 57 % compared to FP and RMP, and was most profitable at all sites. Modeling the economic impact of water savings reinforces these results, although analysis of data on farmers' perceptions of the systems highlighted key constraints associated with scaling-up to the whole-irrigation system level. We underscore that rather than rigidly comparing pre-defined cropping systems, far greater research emphasis should be placed on experimentally integrating farmers' ideas and efforts to learn from and modify farming practices to local socioeconomic and agronomic circumstances.

**Keywords:** Adaptive management, bioeconomic analysis, rice, Sahel, SRI, System of Rice Intensification, water savings, weed management

## Response of Transpiration of Lowland Rice Varieties to Water-saving Irrigation

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A growing world population decreases water availability for agriculture while the demand for rice, the major staple crop for a large part of the world's population, increases at the same time. Growing rice with less water while maintaining its high yields is one of the major objectives in rice research to date.

Through adapting the system of irrigation, unproductive water losses such as evaporation, percolation and seepage can be reduced and the level of productive water use then depends mainly on transpiration. Little is known on how such water saving techniques affect transpiration of rice as it is more difficult to observe in the field and it is influenced by varietal characteristics as well. A field experiment was conducted at the Sahel station of AfricaRice in the northern part of Senegal with the aim to assess the transpirational responses of two contrasting lowland rice genotypes to irrigation management. The irrigation treatments were (1) flooded – a constant ponded water layer of about 10 cm throughout the season and (2) Saturated Soil Conditions – frequent irrigation to saturate the top soil without stagnant water to reduce unproductive water losses. Leaf gas exchange was measured (1) twice a week at noon on all active leaves of the main culm and (2) weekly diurnals each with three replications. Changes in transpiration were observed for leaf development and age as well as for diurnal kinetics. These measurements will be used to calculate transpiration over the cropping period in order to estimate water losses through transpiration on field level. Differences between treatments and varieties will be determined and compared with lysimeter results for evapotranspiration and evaporation obtained from the same plots. The results will be discussed in view of the effects of water-saving irrigation on transpiration of the two varieties as dependent on leaf senescence levels and diurnal microclimatic effects.

**Keywords:** Field water balance, genotypic variation, irrigated rice, unproductive water losses



## Iron Biofortification of Rice Endosperm by Tissue Specific and Synergistic Action of Genes Responsible for Iron Uptake, Transport and Storage

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Nearly one-third of the world population, mostly women and children, suffer from iron malnutrition and its consequences, such as anemia or impaired mental development. Iron fortification of food is difficult, because soluble iron is either unstable or unpalatable, and non-soluble iron is not bioavailable. Biofortification programs based on conventional breeding have met with only marginal success because of negative correlations between yield and nutritional quality. Genetic engineering of crop plants to increase iron content has therefore emerged as an alternative for iron biofortification. To date, strategies to increase iron content have relied on single genes, with limited success. Our work focuses on rice as a model plant because it feeds half of the world population, including most of the iron-malnourished people. Recently, we developed rice lines (NFP lines) with more than six fold increase in the endosperm iron content compared to conventional mega rice varieties. Our transgenic rice lines have an iron content of up to  $7 \text{ mg kg}^{-1}$  in polished grains. This has been achieved through targeted expression of nicotianamine synthase and ferritin genes that exhibited a synergistic effect on iron uptake and storage. Agronomic evaluation of these high-iron rice lines did not reveal a yield penalty or significant changes in trait characters. This demonstrated that rice can be engineered with a small number of genes to achieve iron biofortification at a dietary significant level. We are further performing gene expression profiling in the flag leaves of NFP lines in order to study the effect of transgenes on endogenous gene expression, focusing on genes involved in metal homeostasis. This would also help to identify candidate genes responsible for micro-nutrient composition in the rice grains. In addition, we aim at further increasing the iron content in rice endosperm by root specific expression of iron-regulated metal transporter in the NFP lines. The long term goals of the project include combining the traits like improved pro-vitA content and high iron content into a single rice line.

**Keywords:** Iron biofortification, rice

## **Evaluation of the Potential of *Aprostocetus procerae* Risbec (Hymenoptera: Eulophidae) as a Bio-control Agent of African Rice Gall Midge, *Orseolia oryzivora* Harris and Gagné in Nigeria**

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African rice gall midge (AfRGM) is one of the major insect pests of rice in Nigeria. Its attacks could result in total crop failure. The dominant pest control strategy in the tropical rice over the past 30 yrs has been in the use of synthetic insecticide, host plant resistance and cultural control. These however have not given the desired results in the control of this insect pest. In order to alleviate growing public concern regarding the effects of synthetic pesticides on human health and environmental impact much attention has been given to biological control recently. Consequently, this study was conducted to determine the efficiency of *Aprostocetus procerae* in the management of AfRGM. Field evaluations of the potential of *A. procerae* were conducted at two locations identified as AfRGM endemic areas in Nigeria; ogidiga in southeast and Edozhigi in northcentral during 2006 and 2007 farming seasons. Sampling for *O. oryzivora* infestation/parasitism was conducted at monthly intervals at both locations from June through November of 2006 and 2007 using farmers' fields. For each field sampling, 50 plants were randomly selected to assess the intensity of damage due to *O. oryzivora* (percent tiller infestation) and dissected for percent parasitism. All screen house/laboratory evaluations of level of parasitism was conducted at IITA/AfricaRice Ibadan. The results indicated that *A. procerae* has very high potential for the control of AfRGM. However, the percentage parasitism of the host was low at the beginning of the season and increased significantly later in the season with a peak in October of each season. The linear functional/numerical responses to host densities exhibited by the parasitoid makes it an important factor in suppressing AfRGM population. This result suggests that the use of *A. procerae* is an important part of IPM programme for the management of AfRGM.

**Keywords:** *Aprostocetus procerae*, bio-control, *Orseolia oryzivora*

## Characterizing Effects and Potential Mechanisms of the Major QTL “Pup1” in Rice (*Oryza sativa* L.)

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Phosphorus deficiency is an important factor limiting rice (*O. sativa*, L.) yields under upland or rainfed lowland conditions. But especially in developing countries farmers are facing financial difficulties with increasing costs of fertilizers.

A major QTL improving P uptake rates on P20deficient soils was identified in backcross populations between the indica/aus landrace Kasalath (high P uptake), and the japonica cultivar Nipponbare (low P uptake). Nipponbare near isogenic lines (NILs), carrying the Pup1 (P uptake 1) donor allele from Kasalath, were shown to have higher tolerance of phosphorus deficiency.

Consequently, the objectives of this study were to 1) characterize the effects of the major QTL Pup1 in Pup120NILs under a range of P and water supplies, and 2) to identify possible mechanisms.

A greenhouse experiment with 3 replications was conducted at the International Rice Research Institute (IRRI) in the Philippines. The NILs [14-4 (+Pup1) and 14-6 (-Pup1)] were grown on two different soils (Siniloan and Pangil) with two water treatments (fully irrigated and drought stressed), and 2 nutrient treatments (+P and -P). The observations showed that +Pup1 NILs showed higher tiller number and plant height under P deficient conditions. At the end of the experiment a higher leaf area index was found for the +Pup1 NILs. Both NILs in Pangil soils under -P conditions showed a higher plant height in the drought treatment than under fully irrigated conditions. Furthermore, NILs containing the +Pup1 QTL showed less leaf symptoms of Fe-toxicity which occurred after some time in the fully irrigated -P treatment in the Siniloan soils.

To additionally characterize Pup1 we conducted a second pot experiment with Pup1 NILs and the varieties IR64 and Vandana with the objective to determine the ability of the roots to penetrate hardpans (wax layers) and deeper rooting. NILs containing the +Pup1 QTL had more roots penetrating the wax layer than -Pup1 NILs, but IR64 and Vandana performed better than both NILs.

It can be summarized that the Pup1 QTL did in most cases improve plant performance. However, the selected water, fertilizer, and soil treatments caused some unexpected interaction effects modifying the plant response and the effect of the Pup1 QTL.

**Keywords:** Drought, phosphorus deficiency, QTL, rice

## Exploiting the Diversity of Adaptation Mechanisms for Site-specific Management of Iron Toxicity Stress in Lowland Rice

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Iron toxicity is an abiotic stress affecting lowland rice on an estimated 18 Mio hectares. Crop damage and yield losses imply the occurrence of excessive amounts of Fe(II) in the soil solution, its uptake and acropetal translocation in the xylem and its movement into the leaf symplast. There, Fe(II) catalyzes reactive oxygen species, which can damage cell membranes and structural components. The amount and the time of occurrence of toxic Fe(II) in the soil solution differs between environments and soil types. The intensity of iron stress in the plant varies seasonally and further depends on the phenological stage of rice. The severity of symptom expression and yield loss is additionally determined by genotype characteristics and prevailing stress tolerance mechanisms. Such mechanisms may involve the exclusion of potentially toxic Fe(II) from the root or the leaf symplast, or the detoxification of included Fe(II) in plant tissues.

Consequently, different types of iron toxicity (intensity, duration, time of occurrence) occur depending on environmental factors (climate, season, soil, landscape structure). These Fe toxicities differentially affect rice plants, depending on the level of stress tolerance and the type of adaptation mechanism. There is a need to match iron stress types with effective mechanisms to effectively counteract conditions of iron toxicity. This paper synthesizes the current state of knowledge on the occurrence of Fe toxicity in different environments, presents recent research findings on plant physiological mechanisms of stress adaptation, and proposes ongoing and future research involving molecular marker studies and the environment-specific targeting and extrapolation of promising genotypes.

**Keywords:** Fe(II)/Fe(III), *Oryza sativa*, oxidative stress, QTL

## N Diagnosis in Rice Leaves by Photochemical Reflectance Index and SPAD

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Plants are often subjected to abiotic stresses. Of these stressors, nitrogen deficiency is important in many natural vegetations and agricultural production systems. In order to apply the appropriate amount of N fertiliser, the Chlorophyll Meter (SPAD) is widely used as an N diagnosis tool in crops. An alternative approach of non-destructive measurements is the photochemical reflectance index (PRI), a normalised difference index using two narrow reflectance bands at wavelength of 531 nm and 570 nm. This study focused on the comparison of measurements with the PlantPen PRI-200 handheld PRI device, the Minolta SPAD-502 chlorophyll meter, and chlorophyll fluorescence and gas exchange parameters using the GFS-3000 (Heinz Walz GmbH, Germany).

Cold-tolerant rice cultivar Chhomrong was grown in a hydroponic systems using Yoshida nutrient solution of pH 5.5 with different N levels (0.18, 0.36, 0.71, 1.43, 2.86, 4.28, 5.71 mM N) in a greenhouse at the University of Hohenheim, Germany from August 2009 to October 2009. After 41 and 57 days in Yoshida solution, fully developed youngest leaves were measured and harvested. SPAD and PRI values reflected the leaf N status, with SPAD and PRI values ranging between 29 and 46 and 0.08 and 1.14, respectively. Both diagnosis tools proved to be reliable indicators of severe nitrogen deficiency. Gas exchange measurements indicated that non-photochemical quenching parameters were significantly affected by N levels and PRI values were negatively correlated with NPQ. Light-saturated CO<sub>2</sub> assimilation rates and maximal carboxylation rates were positively correlates with N-supply. It is concluded that PRI and SPAD can be used to predict the leaf N status, however SPAD readings failed to indicate early symptoms of N deficiency. The PRI may be better suited in this regard.

**Keywords:** Chlorophyll, non-photochemical quenching, photochemical reflectance index, rice

## Intra-annual Genotypic Patterns of Growth and Water Use of Irrigated Rice in the Sahel

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With an increasing world population, the demand for rice as one of the most important staple crops is growing. Rice production can be increased either by intensification of existing or by exploitation of new and less favourable land resources. At the same time, rice production is confronted with climate change and increases in temperatures as well as more frequently occurring weather extremes are expected. In order to overcome the challenge of climate change as well as an increasing demand for rice, locally adapted varieties are needed, which are able to meet the given climatic conditions.

Rice production in the Senegal River Valley strongly depends on intra-annual climatic variation with a hot and dry period from March to July, a short wet season from August to October, and a cold and dry period from November to February. During the hot season, heat sterility as well as high water losses due to extreme vapour pressure deficits are common. The cold season is characterised by low development rates and high yield losses due to cold sterility. These variable conditions are ideal for studying genotype-by-environment interactions in order to assess genotypic traits with regard to their suitability to specific environments.

For the ongoing study, 10 contrasting genotypes were selected representing the large variation in the global gene pool in terms of duration, water use, and heat and cold tolerance. In bi-monthly planting dates, irrigation water input, evapotranspiration, plant development and yield were observed at 2 climatically different sites under flooded and non-flooded conditions in order to identify genotypic traits supporting water limited rice production as well as stable high yields under rather unfavourable thermal conditions. Varietal responses in terms of water use and yield will be presented and the related traits and their beneficial characteristics for specifically targeted environments discussed.

**Keywords:** Climate change, irrigated rice, temperature stress, water use efficiency

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## Reversing Urban Bias in End-markets: Competitiveness of Senegal River Valley Rice

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Urban bias constitutes an important institutional impediment to economic development in poor countries. The neglect of rural areas resulted in severe market failure the past decades. Some African governments now recognise that they should invest in agriculture in order to reverse urban bias but mainly focus on the increase of production. However the equally important objective of investing in quality tailored to consumers so as to reverse urban bias' footprint on end-markets is often forgotten. Senegalese policy makers are now implementing an ambitious food self-sufficiency programme which focuses almost exclusively on production. Recently, farmers in the Senegal River Valley (SRV) have started marketing enhanced-quality SRV rice branded as Rival.

Rice imports into Senegal consist almost entirely of broken rice. In international markets, broken rice is considered an inferior product and is therefore much cheaper than whole-grain rice. We conduct Vickrey second price auctions in two major Senegalese end-markets and show that, while the conventional SRV rice is seen as an inferior product to imported rice, urban consumers are willing to pay price premiums averaging 45 FCFA/kg (US\$0.09/kg) for quality SRV rice, relative to imported rice. They are further willing to add 17 FCFA/kg (US\$0.03/kg) for Rival-labeled rice. These findings suggest that SRV rice is able to compete against imported rice if post-harvest quality is tailored to consumer preferences. Our data further identifies product familiarity as a significant decision-making factor in purchasing quality SRV rice, while there is still an 18–47 % awareness gap in Senegalese cities. This provides useful information for generic promotion programs that need to accompany food self-sufficiency programs, which aim to reverse urban bias.

**Keywords:** Agricultural policy, experimental auction, grain quality, value chain, West Africa

## Role of Antioxidants in Developing Rice Varieties Tolerant to Iron Toxicity

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Iron toxicity is among the most prevalent mineral disorders in highly reduced paddy soils and leads to substantial yield losses in lowland rice production in Africa and Asia. Elevated concentrations of reduced  $\text{Fe}^{2+}$  in the soil solution result in the excessive uptake of  $\text{Fe}^{2+}$  ions that are transported to the leaves via the transpiration stream. In the leaf symplast  $\text{Fe}^{2+}$  catalyzes the excessive formation of reactive oxygen species (ROS). This oxidative stress becomes visible as bronzing symptoms and can cause the death of entire leaves or plants. Based on previous experiments three different adaptation strategies of tolerant genotypes had been distinguished: (i) exclusion of  $\text{Fe}^{2+}$  by oxidation at the root surface, (ii) immobilisation in the stem tissues or retention in the apoplast to prevent  $\text{Fe}^{2+}$  from entering the symplast, and (iii) detoxification of ROS to prevent the formation of stress symptoms despite high tissue  $\text{Fe}^{2+}$  concentrations (= tissue tolerance). In this study factors conferring tissue tolerance were determined by biochemical analyses of a range of contrasting genotypes including landraces, high yielding varieties, parents of a QTL mapping population and a gene knockout mutant that was deficient in tissue ascorbic acid concentration. Plants were stressed with 1000 ppm  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  in hydroponic culture for five days. Biochemical analyses included substrates and enzymes involved in the ascorbate-glutathione cycle, and further enzymatic and non-enzymatic antioxidants such as superoxide dismutase, catalase, peroxidase and phenolics. These results will be discussed with an emphasis on their possible application in the breeding of tolerant rice varieties, and compared with factors of oxidative stress tolerance under different environmental stresses such as zinc deficiency or high ozone concentration.

**Keywords:** Antioxidants, iron toxicity, *Oryza sativa* L., QTL, reactive oxygen species, tissue tolerance



## Effect of Water Saving Irrigation, Tillage and Residue on Yield and Water Productivity of Rice in the Khorezm Region of Uzbekistan

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Water management is the most important issue constraining and threatening the productivity and sustainability of rice production in irrigated drylands of Uzbekistan. In conventional system, farmers in Uzbekistan used to maintain 15–20 cm standing water throughout the rice growing season which involves application of more than 60,000 m<sup>3</sup> water per hectare. Water efficient conservation agriculture technologies like aerobic rice with optimum residue management and reduced tillage can increase water productivity and use efficiency. Thus, an experiment was conducted in Khorezm region of Uzbekistan during 2008–2009 for improved understanding of rice yield, water productivity and water saving potentiality of direct seeded aerobic rice. In this experiment, three tillage systems (permanent bed planting, zero tillage flat and conventional methods) with three levels (25, 50 and 100 %) of standing residue retention of previous wheat crop and two methods of irrigation (intermittent irrigation and continuous flood irrigation as farmers practice) were evaluated. In 2008, the beds were freshly prepared while after that it was kept permanently untilled. Rice variety (Nukus-2) released and adopted for conventional flood irrigated system was used for this study. In the years, leaf area index, aboveground biomass, harvest index and grain yield was significantly higher in conventional method of irrigation and cultivation than under permanent beds and zero tilled flats in all levels of residues. There was yield penalty of 28 and 33 % in 2008 and 45 and 43 % in 2009 under permanent beds and zero tilled flats, respectively. But conventional rice utilised significantly higher *i.e.* 66 909 and 59 058 m<sup>3</sup> ha<sup>-1</sup> water, respectively in 2008 and 2009. While beds and zero tilled flats utilised less than one third of this amount. In both the years, water productivity was significantly higher in aerobic rice than under conventional. Higher height of standing residue provided shading effect to rice crop during the early growth stage resulting into less partitioning and less harvest index. Under the diminishing water supply, aerobic rice can be promising alternatives for this region provided the suitable machinery for the proper planting, nitrogen fertiliser application and residue management, and suitable aerobic rice variety.

**Keywords:** Aerobic rice, bed planting, conservation agriculture, direct seeded rice, water productivity

## Model Comparison for Simulating Upland Rice Production in Small-holder Farming Systems in Benin

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Many issues are currently raised up concerning the uncertainty and validity of crop models to be used for the evaluation of adaptation strategies to climate change. The test of the performance of the field scale crop model under different agro-ecological conditions is a prerequisite for the evaluation of the impact of management strategies and climate change on the crop yield and production at larger spatial scales. The aim of this study is to determine an appropriate model in the presence of controlled technique data, given the range of data available in rainfed agriculture. Attention will be given to two methods that will be tested: EPIC (Erosion Productivity Impact Calculator / Environmental Policy Integrated Climate) and Oryza2000. Specifically, this study has to describe the potential of two models to simulate growth and yield performance of rice crops under several conditions of management in the context of West African small holder farms. The focus will be put on the new rice varieties for Africa named NERICA (New Rice for Africa) which are low-input rice germplasm developed for resource-limited and smallholder production systems. Their introduction is a driving force of the rice intensification cropping systems on both upland and lowland conditions in Africa. Then, some on-farm trials in different environmental zones in the Republic of Benin have been selected: (1) coastal zone, (2) Guinean Savannah and (3) Sudanian zone, showing high soil heterogeneity and the use of different crop cultivars. In order to evaluate the performance of the two crop models, the collection of agronomical, climate and soil data will be done. Then some management scenarios will be defined and simulated in cooperation with the involved stakeholder of rice production in Benin Republic.

**Keywords:** Crop model, modelling, onfarm simulation, rice

## Characterisation of the Pathogenic Population of Bacterial Blight of Rice in West Africa

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Bacterial leaf blight (BB), caused by *Xanthomonas oryzae* pv. *oryzae* (Xoo), one of the most important diseases of rice under irrigated cultivation, was reported for the first time in the end 70<sup>th</sup>, in Mali. Although it had been described in many West African countries, no significant research on this key disease had been conducted at that time in Africa. The use of resistant varieties is recommended as the most effective approach to control BB. In Asia 30 resistant genes have been identified but their reaction against African isolates is not known. Therefore, using near isogenic lines developed by IRRI, the virulence of Xoo populations was evaluated both in natural infected fields and in standard pathotyping condition in order to provide information that can be used in breeding programs to introduce effective resistance in cultivars to be released in specific regions. In Niger, Xa1, X4, Xa7, xa13 and Xa21 were found efficient against a large part of the bacterial population meaning that the corresponding non functional avirulence genes are absent or rare in Xoo population in Niger. In Mali, xa5, Xa7, Xa14 and Xa21 were efficient in four experimental sites. The susceptibility of the Gigante is a matter of concern as this variety is used as donor for resistance to Rice Yellow Mottle Virus (RYMV), another important rice disease in Africa. The resistance of IR24 used as susceptible recurrent parent to build the NILs appeared surprisingly resistant indicating probably a difference between Asian strains and African strains at pathological level. The information generated should be used by breeder not only to develop resistant varieties to Xoo but also to avoid an eventual susceptibility to Xoo of RYMV resistant progenies involving Gigante as parent.

**Keywords:** Bacterial blight, *Oryza sativa*, resistance, rice, virulence, *Xanthomonas oryzae* pv *oryzae*



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## **Understanding Cassava Storage Root Development and Engineering Cassava for Improved Performance as an Industrial, Food & Energy Crop**

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Cassava or manioc (*Manihot esculenta* Crantz), is grown for its starchy tuberous roots which provide food for over 800 million people - mostly small-scale and subsistence farmers in developing countries. High yield of starch, drought and heat tolerance, together with low requirements on soil makes cassava a valuable plant. Beside its role as food crop, cassava starch finds application in different industries such as coating agent thickener and emulsifier. In recent years, cassava has increasingly been grown for bioethanol production in Asian countries such as China, Viet Nam and Thailand. Cassava is an interesting choice because of its yield (superior to most energy crops including corn and sugarcane) and the high conversion rate of biomass to ethanol.

The project aims at understanding storage root formation and starch accumulation and at developing improved root for bioethanol production. To this end, systems to visualise and characterise the different stages of root formation are being developed (*i.e.* hydroponics, time course harvesting, *in vitro* system). Several gene candidates involved in storage root formation in other plant species have been selected and their cassava orthologs have been identified. Their transcript modulation over storage root formation is being analysed through qPCR. In parallel, carbon flux and translocation to storage roots are also being analyzed. Cassava root has high carbohydrate content, with 80 % dry weight of the stored carbohydrates being starch.

The ability to modify starch composition and structure offers important opportunities for creating new products and increasing the value of cassava as a crop. Several key enzymes shown to be involved in starch metabolism in other plants will be modulated in transgenic cassava. Starch quantity and quality in the transgenic lines will be evaluated. The successful generation of cassava cultivars with higher starch yields or higher value starches would secure cassava production and increase farmers' income.

**Keywords:** Cassava, starch, storage root

## Evaluation Yield of Chickpea and its Stability in Dormant Seeding

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Sowing outside of normal temperature range is called dormant seeding. In dormant seeding of cool season crops, soil temperature in planting time should be lower than base temperature of crop germination till seed can't germinate. Chickpea is one of the most rainfed products in Maragheh region in eastern Azerbaijan province (Iran). In this study growth and yield characteristics of dormant, early spring and common seeding were investigated by use of 20-year simulation (1975 – 1995). In this simulation the yield of seed in common seeding was lower than dormant seeding owing to the low vegetative dry weight in the beginning flowering and low seed filling rate. There wasn't any significant difference between early spring seeding and the other seeding dates. Also, there was significant difference between transpiration efficiency in seeding dates. Low transpiration efficiency in common seeding was related to low rainfall rate and high air vapour pressure deficiency in growth season. Water use efficiency in dormant seeding exhibited a significant difference to the two other seedings. Low water use efficiency in common seeding wasn't due to the increase in yield but it was related to sever decrease in evatranspiration in growth season. The comparison of water use efficiency in dormant and early spring seeding showed that low water use efficiency in dormant seeding was due to the high evaporation to transpiration ratio. Consequently, by use of simulation it is suggested that the farmers do their seeding in dormant form because stability and yield rate in this seeding are higher than two other seedings.

**Keywords:** Chickpea, dormant seeding, simulation



## Effects of Hydrophilic Coating on the Mobilisation of Endosperm Reserves in Seedlings of Summer Barley (*Hordeum vulgare* L. cv. maltasia)

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Seed coatings containing hydro-absorbers increase the amount of water available for germination and support seedling establishment particularly when unreliable rainfall early in the season leads to drought spells threatening the survival of the crop. Efficient mobilisation of seed reserves, onset of photoautotrophy, and the partitioning of biomass between roots and shoots are critical parameters for early crop establishment. Barley seeds coated with (1) absorber alone, (2) humic acid alone, and (3) a combination of humic acid, absorber, and a plant fortifier were assessed for mobilisation of seed reserves and onset of photo autotrophy as compared to uncoated seed. Coats containing humic acid were included in this study since humic acid is known to promote water penetration into seeds and germination. Coated seeds were categorised into 2 classes related to the original uncoated seed weight as (1) small coats (coats comprise less than 50 % of total grain weight) and (2) large coats (coats comprise more than 75 % of total grain weight). Grains were grown in growth chambers on moist filter paper for 16 days at 25°C and biomass of roots, shoots and remaining grain were assessed for 24 seedlings every 2 days. Initially total biomass of germinating seeds decreases due to respiratory losses for mobilisation of grain reserves and growth of roots and shoots until respiration is compensated by the onset of photosynthesis. Independent of the coat composition, germination patterns followed those of uncoated seeds in grains with a small coat. Respirational losses were increased for small coats and thus root and shoot growth delayed in comparison to uncoated seeds. Seeds with large coats showed a slower mobilisation of endosperm reserves compared to uncoated seeds, however, independent of the coat composition respiration losses during germination were minimal, root and shoot growth optimal, and total biomass losses during early germination marginal. This indicates a strong influence of seed coats on the energy balance of the germinating seed which may be either related to water uptake properties of the seed or to oxygen diffusion into the growing embryo. Implications for the use of hydroabsorbers and other substances in seed coats will be discussed.

**Keywords:** Germination, hydroabsorbers, respiration, seed coats, seedling growth

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## Soilless Culture of Pak Choi and Tomato in Iquitos, Peru

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In the tropics, unfavourable soil properties, extreme climate conditions and periodical floodings of cultivable land cause complications in the conventional horticultural production. Such a situation is found in the area of Iquitos in the Peruvian Amazon rainforest. There, techniques of soilless culture represent an opportunity to cultivate high-value crops year-round. By the use of simplified methods, soilless cultivation offers underprivileged populations to provide themselves with healthy vegetables. This way they have the ability to take care of their own needs and are economically independent. In Iquitos a study was conducted to the usefulness of soilless cultures to produce healthy vegetables, *e.g.* the leafy vegetable pak choi and different tomato cultivars under the special focus of different available substrates. In these trials the plants were cultivated in open systems with substrate and a standardised nutrient solution. Pak choi was cultivated in different substrates and plant container systems. After harvesting, health promoting glucosinolate contents of pak choi leaves were determined. Tests on tomatoes were conducted with different cultivars using the same type of substrate and plant container. After harvest the tomato fruits were analysed for their physicochemical characteristics as well as carotinoids and amount of total phenolic substances. In all cases the collected data of the soilless culture were compared with data derived from conventional produced market crops, respectively with data of reference and conclusions were drawn about the value of soilless cultivation. Comparing data from of soilless cultures with conventional cultures did not show any significant difference in the amounts of glucosinolate in pak choi or of total phenol content and lycopene content in the different tomato cultivars. In contrast, hydroponically grown tomato showed a lower value of  $\beta$ -caroten and ash as well as a higher amount of fat, protein and carbohydrate. These parameters mainly depend on plant nutrition which could not be compared. Yield in hydroponically grown tomato have been high enough to produce economically tomato and pak choi even during off-season. Overall, soilless culture in Iquitos proved to be an acceptable cultivation method, especially for self-supply of underprivileged people.

**Keywords:** Secondary metabolites, self-supply, simplified hydroponics, soilless culture, tropics

## Aeroponics as Potential System for Fully Controlled Staple Food Production

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Staple food crops such as rice or wheat constitute the most land intensive production systems. Urban food supply could profit from fully controlled vertical farming systems as the required space and the competition for fertile soils would be considerably reduced. Aeroponic systems will be required to reduce the weight of the vertically stacked production units. Aeroponics are soil-less production systems in which plant roots are supplied permanently or periodically with a fine mist of nutrient solution. These systems have been successfully established for commercial production of horticultural plants (*i.e. Brassica oleracea* var. *italica*, *Lactuca sativa*), medicinal and herbal plants (*i.e. Zingiber officinale*, *Scutellaria minor*) and for several scientific approaches (*i.e. plant nutrition, plant physiology*) showing that higher and less variable yields per unit area can be achieved. Little is known on aeroponic cultivation of staple food crops such as rice and the related genotypic, plant nutritional and technical challenges for future intensive food production.

An aeroponic system was developed for cultivating rice seedlings in a greenhouse. High end ultrasonic nebulizers with glass membranes combined with newly developed water proof ventilators were used to nebulize and distribute the nutrient solution. With the aim to find optimal irrigation frequencies, different duty-cycles of nebulizers and ventilators were adjusted and the effects on root and shoot growth rates of two different lowland rice varieties were determined.

As the maximum root length of the plants determines the outer dimensions of the aeroponic cultivation system and thus the economic efficiency the effects of different pH-levels of the nutrient solution on root-length, biomass accumulation, and leaf gas exchange were measured and compared to plants simultaneously cultivated in a classic hydroponic system comprising the same treatments. The effects of different nebulizing frequencies (irrigation intensity) and pH-levels on growth rates, root length and leaf gas exchange of the two genotypes as well as the differences between aeroponic and hydroponic systems will be illustrated and conclusions on design and implementation of the aeroponic system will be discussed.

**Keywords:** Multi-storey food production, *Oryza sativa*, urban farming, rice

## **Silicon Foliar Application on Yield and Yield Components of Rapeseed (*Brassica napus* L.) under Different Plant Densities in Iran**

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In order to study the effect of silicon foliar application and plant densities on rapeseed (Hyola-42 cul.) some yield characters, this experiment was conducted in Varamin zone at Iran during 2007-2008. In this study, the experimental unit had designed by achieved treatments in factorial on the basis completely randomized block design with three replications. Certain factors including three levels of plant density (500, 650 and 800 plants m<sup>-2</sup>) and silicon foliar application (0, 0.3 % and 0.6 %) were studied. The results showed that plant density and silicon foliar application significantly affected grain yield, biological yield, thousand grain weight, silique number per plant, grain number per silique, hieght plant and branches number. The highest grain yield, biological yield, silique number per plant and hieght plant were achieved under the 800 plants m<sup>-2</sup> and the highest thousand grain weight, grain number per silique and branches number were obtained under 500 plants m<sup>-2</sup>. Also, all plant features were increased under silicon foliar application and highest upon characterstics were achieved by sprying of 0.6 %. Our findings may give applicable advice to commercial farmers and agricultural researchers for management and concern on planting density strategy and estimate of silicon foliar application carefully for increase of quantity and quality yields in rapeseed cultivars.

**Keywords:** *Brassica napus*, grain yield, plant densitiy, silic foliar application

## **Improvement of two Winter Wheat (*Triticum aestivum* L.) Cultivars Establishment by using Seed Priming Technique**

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Low seed zone water potential and soil crushing caused by rain before seedling emergence frequently impede winter wheat stands. A split plot experimental in completely randomised design in three replications, involving petri dish and greenhouse was conducted to determine seed priming effects on winter wheat germination and emergence. Two native cultivars (Sardari and Sabalan) were used and assigned to main plot, and five priming treatments (check, water, KCl 2 %,  $\text{KH}_2\text{PO}_4$  0.5 %, and PEG 10 %) were allocated to the subplots.

The result revealed no significant differences between the germination of the KCl,  $\text{KH}_2\text{PO}_4$ , and PEG treatments. However there was a significant difference between the control and the water-based treatment with any of the primed seed treatments. The real difference was exhibited by the PEG treatment which germinated faster than the others treatments. The seed priming main effects for seedling number (emergence), tiller, E10, E20 and E50 % were significant different in the greenhouse experiment. KCl,  $\text{KH}_2\text{PO}_4$ , and PEG treatments emergence were noticeably higher than the control. All the priming treatments produced a higher emergence count than the control at both 10 and 20 DAP. This advantage ranged from 54.7 % to 42.2 % respectively. Seed primed by  $\text{KH}_2\text{PO}_4$  emerged 0.6 days faster than seeds that were primed with water only.

In conclusion, some priming media enhanced germination and emergence under petri dish and greenhouse conditions. Breeding efforts to develop standard height and tall winter wheat cultivars with long coleoptiles continues to offer the best hope for farmers in dry summer fallow regions where emergence is a major concern.

**Keywords:** Emergence, germination, plant establishment, seed priming, winter wheat

## Factors Involved in *in vitro* Shoot-tip Grafting of Apple (*Malus domestica* Borkh.) and Pear (*Pyrus* sp. L.)

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The aim of the study was to investigate the influence of different factors involved in *in vitro* shoot-tip grafting of apple (*Malus domestica* Borkh.) and pear (*Pyrus* sp. L.). The results revealed that autografting (homografting) was superior to the heterografting. The highest percentage of successful grafts (80 %) was obtained when shoot tips of Anna apple and Aly-Sur pear were obtained from tissue culture grown plantlets as compared with those obtained from flushes in trees grown under field conditions (30 and 40 %, respectively). A significant difference was noticed in apple micrografting success while using *in vitro* micropropagated shoots as rootstocks (60 %) as compared with the use of *in vitro* germinated seedlings (48 %). The same micrografting success (60 %) was achieved for pear micrografting with both kinds of rootstocks. Micrografting success could be raised from 30 to 90 % by adding BA ( $2 \text{ mg l}^{-1}$ ) to the nutrient medium but soaking scions and rootstocks in BA solution was unprofitable. Adding sucrose with 30 g/l to the nutrient medium was significantly effective on raising grafting success in both apple and pear to 60 % and 70 % from only 50 % and 40 % at 15 g/l sucrose level, respectively. Using liquid medium significantly raised successful grafts percent to 60 and 70 % from only 10 % in case of solidified media with agar for both apple and pear micrografts, respectively. Adding an agar drop to the grafted area was highly profitable which raised micrografting success to 70 and 60 % as compared with grafting without an agar drop (10 %) for both apple and pear micrografts, respectively. No significant differences were recorded in micrografting success percentages as a result of using both supporting agents (M-shaped perforated filter paper or a piece of cotton). By inverted-T incision, there were 80 and 90 % successful micrografts in Anna on MM106 apples and Aly-Sur on *P. calleryana* pears, respectively. Lower success of 70 % in both apple and pear was observed when scion was grafted by surface placement using cleft grafting. A high mortality rate was found with grafted plants transferred to soil which reached to 85 and 90 %, respectively.

**Keywords:** Apple, micrografting, pear, shoot-tip grafting

## Field Establishment of Cashew (*Anacardium occidentale* L.) Transplants as Affected by Nursery Periods

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Field establishment of cashew has been seriously hampered by long delay nursery periods which had led to transplanting of overgrown cashew seedlings with the attendant transplant mortality especially during the first dry season on the field. The experiment was thus set up to study field establishment of cashew transplants as affected by different nursery periods.

Four nursery periods were tried. These were cashew transplants at 3, 4, 8 and 12 weeks after sowing (WAS). The experiment was laid out in randomised complete block with 3 replicates. Records were taken on morphological plant parameters (plant height, stem circumference and number of leaves) of the transplants till flowering.

Cashew seedlings transplanted 12 WAS in the nursery had better morphological plant parameters compared to other transplants. At 3 months after transplanting (MAT) Cashew transplants of 12 WAS were 172.6 %, 93.7 % and 38.5 % taller than transplants of 3, 4 and 8 WAS respectively and the differences were significant ( $p < 0.05$ ). At 36 MAT, the magnitude of the differences fell to 27.7 %, 10.6 % and 20.1 % in that order. Similarly, seedlings transplanted at 12 WAS had 245.4 %, 151.9 % and 99.4 % more leaves than those of 3, 4 and 8 WAS at 3 MAT respectively. The percentage difference reduced to 53.6 %, 69.5 % and 31.7 % at 24 MAT, in that order. The stem circumference of 12 WAS cashew transplants were 46.5 %, 31.1 % and 8.3 % higher than the stem circumferences of cashew seedlings transplanted at 3, 4 and 8 WAS at 3 MAT respectively. However, the survival percentage of cashew seedlings transplanted at 12 WAS was least with 66.7 % while that of 3 WAS was 75.0 % within 12 MAT. No transplant mortality was incurred in seedlings transplanted into the field at 4 and 8 WAS. These two treatments recorded 100.0 % seedling's survival within 12 MAT. Cashew seedlings are best transplanted between 4 and 8 weeks after sowing in the nursery. This has to do with the encouraging survival rates of the transplants, thereby drastically reducing supply of the missing stands at the following planting season.

**Keywords:** Field performance, cashew, nursery period, survival rate

## Effect of Magnetic Field on the Mycelia Growth and Spawn of *Agaricus bisporus*

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Several factors have been historically applied by human for improving food production systems. Electric as well as magnetic fields have been recently experimented as a seed treatment. These fields are usually environmental- friendly and affect physiological and biological processes, thereby apply as non chemical manner in agricultural production. The white button mushroom is one the most important commercial mushrooms in the world. The effect of weak, extremely low frequency magnetic field on the mycelia growth of *Agaricus bisporus* was studied by exposing them to pure continuous sine-wave magnetic field of 12.5, 25 and 50 gauss at 50 HZ. Magnetic field was applied by a coil on PVC tube (radius 10 cm, copper wire 1.2 mm, 4000 rounds, about 36 kg wire) connected to three roasts with an ampere-meter and daily exposure (24 h/day). The petri dishes were then centred between the coils. Results of the study showed that the growth of mycelia at early stages of development increased at 12.5 and 25 gauss, while the mycelia growth was retarded at 50 gauss, 50 HZ. In the second part of the experiment, plates which had the *Agaricus bisporus* spawns exposed to wave magnetic field of 12.5, 25 and 100 gauss and their growth was evaluated by putting spawns in the solid culture at the 25°C in the incubator and their growth rate was compared with control after 3 days. The results revealed that growth rate of spawns in 12.5 and 25 gauss were more than control, while the growth rate of spawns in 100 gauss decreased drastically. There was no observable effect of magnetic field on the growth of mycelia. The exact mechanism, however, is unknown yet.

**Keywords:** Magnetic field, mycelia, white button mushroom



## **Determination of Optimum Tapping Date for Gum Arabic Yield in the Nuba Mountain Area**

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For more than two decades, the Nuba mountains area in South Kordofan State was under strife and civil war. During this period only few research efforts dealt with production of technologies in the area. Now due to the prevailing security situation in this State, proposing change and setting priorities is very important, and the fragile stability should strengthening the farmers. The objective of this study is to offer semi-sustainable income to the land user by determination of the optimum tapping date for gum arabic production in the area.

A randomised complete block design experiment with three replications was conducted at (Meari) in Nuba mountain area for two seasons 2008/2009 – 2009/2010. The treatments comprise 6 tapping dates for gum production of the “Hashab” tree, *Acacia senegal* (L.) Willd. This is from 1<sup>st</sup> October till 15<sup>th</sup> December with 15 days interval between each date and the other.

The results of this analysis show highly significant differences between the tapping dates on gum yield in almost all pickings and for the total gum yield. It is evident that mid of October or 1<sup>st</sup> November is the best and optimum tapping date for the “Hashab” tree in Nuba Mountains. By doing so farmer can originate about 8 pickings from the “Hashab” tree for gum arabic production in sequence of 15 days intervals in South Kordofan. This result can increase gum production in the area by 83 % and tight the farmers to his land for a long time.

**Keywords:** Gum Arabic, Sudan!South Kordofan, *Acacia* spp.



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**Comparison of the Nutritional Value of Organic vs. Con-  
ventional Foxtail Millet for Poultry Nutrition**

## Determination of the Phytase Activity and Phytate P of Quinoa (*Chenopodium quinoa* Willd.) using Spectrophotometric and Isotachophoretic Methods

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The quinoa (*Chenopodium quinoa* Willd.), is a pseudocereal that has been cultivated in the Andean region in Nariño, Colombia and have great opportunity in the improving food and feed mainly on its use as feedstuff. The aims of this work was to analyse the P contents, phytate phosphorus contents and phytase activity of Quinoa Nariño (QC); Quinoa Anapqui's (QBA); Quinoa -IICA 020 Oruro (QB); Quinoa Huancavelica (QP) and wheat (control) were also analysed at physiological temperature (39°C) and 37°C adopted for additives regulations. Phytic acid was determined by capillary isotachophoretic method and the phytase activity was estimated by a spectrophotometric method. Phosphorus in this study found in major level in QP-Huancavelica variety (508 mg g<sup>-1</sup>). The phytic acid P proportion in the total P was significantly ( $P < 0.05$ ) low in QC (19.64 %), QBA (26.95 %), QB (33.6 %) and QP (32.17 %) varieties analysed in comparison with wheat (60.22 %) evaluated.

The phytic acid P proportion in the total P was low in QC (19.64 %), QBA (26.95 %), QB (33.6 %) and QP (32.17 %) varieties analysed in comparison with the other cereals evaluated. The phytase activity was evaluated at physiological (39°C) temperature and at standard (37°C), the phytase activity was effected by the temperature in QC (1153 FTU kg<sup>-1</sup>, 1152 FTU kg<sup>-1</sup>), QBA (847 and 593 FTU kg<sup>-1</sup>), QB (896 and 613 FTU kg<sup>-1</sup>), QP (909 and 561 FTU kg<sup>-1</sup>) and wheat control (1137 and 1046 FTU kg<sup>-1</sup>) under 39 and 37°C, respectively. The Bolivian varieties did not present any significant differences. Presented negative correlation (-0.89 at 37°C and -0.79 at 39°C) was established between the phytase activity and the amount of phytic acid P among the four samples. To conclude, the results showed a great potential of the quinoa grains due to the low level of phytic acid P and high phytase activity.

**Keywords:** Antinutritional factors, endogenous enzyme activity, phytic acid, quinoa

## Factors Influencing the Quantitative and Qualitative Oil Content of Corn (*Zea mays* L.) Grain

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A field study was conducted in 2005 and 2006 at the agriculture experiment station of the college of agriculture, Tarbiat Modares University. The type of design was randomised complete block with factorial arrangement and three replications. The treatments were four levels of nitrogen fertiliser (0, 92, 184 and 276 kg N ha<sup>-1</sup>), three levels of integrated nitrogen fertiliser and manure application (46 kg N ha<sup>-1</sup> + 2.5 ton ha<sup>-1</sup> farm yard manure (FYM), 92 kg N ha<sup>-1</sup> + 5 ton FYM ha<sup>-1</sup> and 138 kg N ha<sup>-1</sup> + 7.5 ton FYM ha<sup>-1</sup>) and three levels of organic fertilisation (5, 10 and 15 ton FYM ha<sup>-1</sup>) along with three levels of irrigation (optimum irrigation (control), 75 % crop water requirement and 50 %). The results showed a maximum grain yield with the application of 138 kg N ha<sup>-1</sup> + 7.5 ton FYM ha<sup>-1</sup> under optimum irrigation. Maximum oil content of grain was found under optimum irrigation and the minimum oil content under 50 % of crop water requirement with 138 kg urea ha<sup>-1</sup> + 7.5 ton FYM ha<sup>-1</sup>. The greatest oil yield at first and second year was produced with 138 kg N ha<sup>-1</sup> + 7.5 ton FYM ha<sup>-1</sup> and least was produced with control. The results showed the greatest and least amount palmitic, stearic and oleic acids were produced when 50 % crop water requirement and optimum irrigation, also maximum and minimum amount linoleic and linolenic acid were produced when optimum irrigation and 50 % crop water requirement respectively. The best percentage oleic acid obtained in integrated and organic farming. From three fatty acid composition may offer several health benefits (oleic, linoleic and linolenic acid) with increased nitrogen levels increased. Also in between fatty acid composition oleic and linolenic acid were produced maximum amount in organic farming. Corn oil with higher levels of monounsaturated reduces blood cholesterol levels, thereby reducing the incidence of cardiovascular diseases. Such corn oil is also more chemically stable than conventional corn oil because it is less susceptible to oxidation. The use of corn with a greater content of monounsaturated may improve

**Keywords:** Corn, oil, quality, quantity

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## Effects of two Different Nutrition Systems (Organic and Chemical) on Yield and Yield Components of German Chamomile (*Matricaria chamomilla* L.)

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Among several alternative agricultural systems have been developed, organic agriculture has deserved increasing interest from. In order to study the effects of different nutrition systems (Organic and Chemical) on yield and yield component German Chamomile (*Matricaria chamomilla* L.) an experiment was be conduct in 2008 at the research farm of faculty of agriculture in Tarbiat Modares University in Peykan shahr, Tehran, Iran. The treatments were arranged as factorial in a randomised complete blocks design with twelve treatments and three replications. The factors were PGPR inoculation (inoculated and no inoculated), zeolite (0 and 9 ton ha<sup>-1</sup>) and vermicompost (0, 5, ton ha<sup>-1</sup>) in organic nutrition system. These treatments together with a chemical fertiliser control treatment (N: 60 kg ha<sup>-1</sup>) were also evaluated using a randomised complete blocks design with thirteen treatments and three replications. Studied characteristics were plant height, number of flower in plant, biomass, dry flower yield, essential oil content and yield essential oil. All data were analysed from analysis of variance (ANOVA) using the GLM procedure in SAS and means were compared using LSD at level of 0.05.

The results showed that different nutrition systems significantly affected all of measured traits, as plants treated by a mixture of compost, microorganisms and zeolite (organic nutrition system) showed a significant increase in vegetative growth, biomass, flower yield and essential oil content and yield. The significant difference between organic with chemical nutrition system on flower dry yield was not observed. Also, the essential oil content and essential oil yield in organic nutrition system was greater than chemichal nutrition system but significant difference between them was not observed. Consequently, the experimental results showed that organic nutrition system could be substantiated for the N inorganic fertiliser (conventional system) to an extent of 60 kg ha<sup>-1</sup> while the agronomic characteristic, flower yield and essential oil content of German chamomile were comparable to the chemical cropping system.

**Keywords:** Different nutrition systems, essential oil, flower yield, german chamomile, *Matricaria chamomilla*

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## Essential Oils and Heavy Metal Accumulation in *Salvia officinalis* Cultivated at Different Inter-row Spaces in Ash-Shoubak, Jordan

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Essential oil yields and heavy metal contents were determined in the sage medicinal plant, *Salvia officinalis* L., cultivated at 15, 30 and 45 cm inter-row spacing in Ash-Shoubak in the South of Jordan. Samples were harvested during vegetation (VEG), beginning of blooming (BB), full-blooming (FB) and fruit maturation (FM) stages. Essential oil yield and the content of heavy metals in the plant were determined by using hydrodistillation and atomic absorption spectrometry methods, respectively. The yields of essential oil and heavy metal contents were affected by inter-row spacing and phenological stage. The maximum oil yield  $2.00 \pm 0.115$  % was obtained in plants cultivated with 15 cm inter-row spacing and harvested at VEG stage, while the minimum (0.87 %) was obtained in plants cultivated with the same inter-row spacing but harvested at FM stage. Heavy metal contents were variable depending upon both inter-row spacing and phenological stage. Co, Cd, and Pb were not detectable. The content of Ni, Zn, Fe, and Cu were increased during the vegetative life cycle of the plant but still below their toxic level. *Salvia officinalis*, cultivated in Ash-Shoubak region is found to be rich in oil extract and free from hazard heavy metals.

**Keywords:** Essential oil, heavy metals, Jordan, sage, *Salvia*



## Azadirachtin and Oil Contents of Neem (*Azadirachta indica* A. Juss) Seed Kernels Growing in Different Agro-ecological Zone in Sudan

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Neem trees (*Azadirachta indica* A. juss.) growing in different habitats in the Sudan showed variations in azadirachtin (Az) content depending on the climate, rainfall, soil type, latitude and altitude. The Az-content ranged from 1.08 to 2.3 mg g<sup>-1</sup> of the seed kernel in the first season and from 0.48 to 3.09 mg g<sup>-1</sup> in the second season. The average content of the neem oil (N.O.) was 44.6 % in the neem seed kernel (NSK); no variation was found between these regions in the oil- content. Trees growing in regions with moderate climate, average rainfall of 400 mm, and altitude of more 470 m asl, proved to be rich in Az-content. However, trees growing in lower altitudes, alluvial or sandy soil, with hot climate reflected very low Az-contents. Rainfall was found to be the major factor affecting the level of Az in NSK, and the optimal rainfall is found to be 717 mm. Temperature and relative humidity were found to have no direct effect on the Az-content. However, the combination of temperature and the rainfall showed a positive correlation with the Az level in NSKs. Latitude and altitude have direct effect on Az level. Seasonal variations were clear over the two seasons, and no relationship was found between the two seasons.

Using the chemical data, metrological data, GIS and remote sensing methods maps were conducted to predict the production of these limonoids from different agro-ecological zones in Sudan. This method is applicable to other regions after the metrological data studied. This will improve the production of safe soft biopesticides from Neem trees.

**Keywords:** *Azadirachta indica*, Azadirachtin, ecological variations, neem seed, Sudan

## Determination of Crop Coefficient (Kc) for Wheat in the Gezira

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Proper management of irrigation water is essential in order to obtain maximum yield of wheat. Amount of water added to a field per irrigation depends upon climate, crop, soil and management options. Significant climatic elements are temperature, radiation, relative humidity and wind speed. The objective of this study is to update the Crop coefficient (Kc) for the newly released type of wheat (Emam) using newly developed methods of calculation of the reference evapotranspiration (ET<sub>0</sub>). A field experiment was conducted at the Gezira Research Station farm in Wad-Medani, Sudan. The plots were irrigated normally at 10 days interval. Results showed that the mean monthly ET<sub>0</sub> values during the growing season ranged between 5.5 and 7.3 mm day<sup>-1</sup>. The trend of the mean monthly air temperature and the mean ET<sub>0</sub> values were similar. This indicated that temperature is the one of the most important factor that affect ET<sub>0</sub>. The results showed a polynomial trend of both ET<sub>c</sub> and Kc. As observed the peak of ET<sub>c</sub> equal 8.3 mm day<sup>-1</sup> at 55 days after sowing coinciding with the maximum Kc of 1.42. A significant relationship was observed between Kc and days after sowing since the P-value was less than 0.1 at 90 % confidence level. The calculated Kc values were found to be 0.55, 1.02, 1.13 and 0.73 for initial, developmental, mid-season and late-season stage, respectively. The two growth parameters measured showed that the height of the plant increased linearly during the growing season and the mean measured height at harvesting was about 62 cm, whereas the mean measured root depth didn't exceed 20 cm.

**Keywords:** Crop coefficient, Gezira, irrigation, Sudan, wheat

## **Economic Contribution of Draft Power and Manure to Crop Farming System in Bhutan**

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The integration of livestock is an important part in the crop farming system in Bhutan. The livestock provides draft and manure to the crops and they in turn utilise the crop residues and unwanted biomass to convert to important food protein for human consumption. About 80 % of the population in Bhutan is concentrated in the rural areas and the majority of them practice crop livestock farming as a means to sustain their livelihood system. The farmers practice dry land agriculture with two cropping seasons per year. The farmers practice subsistence agriculture due to the absence of markets for their products. Marketing the products to distant markets involve high transaction costs.

The primary data was collected from 292 households in 2009 from the three regions viz. Western, Central and Eastern regions of Bhutan within the altitude range of above 500 — 2800 meters above sea level. The households were segregated into three categories depending upon their land ownership. The production elasticity of the major summer and winter crops of the three regions of Bhutan was estimated by a Cobb Douglas type yield function. The econometric regression analysis was run to explain the effect of explanatory variables like draft, Manure, Labor, fertilisers on the yield function of each crop. Both T-test and F-test was carried out to determine the level of significance of the elasticity.

The study suggests that the contribution of draft power and manure is crucial in the small holder mixed farming system in Bhutan. The use of such inputs at the household level helps to reduce the production costs and increase yield. The results of the study helped in understanding the importance of draft and manure to the crop productivity and the necessary interventions to improve upon it.

**Keywords:** Crop-livestock system, draft, manure, subsistence agriculture

## Study for Domestication of *Teucrium polium* L. under Cropping Conditions, Based on Ecological Agriculture

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In order to evaluate the agroecological criteria for the possible domestication of *Teucrium polium*, a preliminary survey was made in natural habitat of Tandureh national park in North Khorasan. In this case, biological criteria of plants including plant density, height, biomass and crown diameter was measured. Also in 2 separate field trials, agronomic criteria of this species were studied for two years (2006 and 2007) on an experimental field of the Institute of Plant Sciences of Ferdowsi University of Mashhad.

In the first experiment, two planting methods including direct seeding and transplanting were compared and in a second experiment plant density and date of transplanting was evaluated. In this experiment plant density was 25, 17 or 13 plants per m<sup>2</sup> on dates of transplanting (17 October and 5 May). Transplants were transferred in rows with 20 cm apart and the proper densities were arranged on the rows with 20, 30 and 40 cm between plants. In another trial in 2007, the effect of different levels of manure (10, 20 and 30 ton per hectare) and irrigation intervals (14, 21 and 28 days) on agronomic criteria of this species was investigated. In the natural habitat, this plant grows on an altitude of 1000–1100 m, on poor loamy soils with an average density of 4 plants per m<sup>2</sup>, height of 47 cm, crown diameter of 50 cm and dry matter yield of 11 g m<sup>-2</sup>.

Field experiments indicated that direct seeding is not successful and autumn transplanting was superior to spring transplanting. Furthermore the plants performed better in the second year as compared to the first year. Also performance of species in terms of yield, height and crown diameter was better under field condition compared to natural habitat. However essential oil content in the first year was 50 percent lower under field condition compared with nature. Different levels of manure and irrigation intervals did not affect agronomic criteria of *Teucrium polium*.

**Keywords:** Biomass, density, domestication, natural habitat, Tandureh national park, *Teucrium polium* L., transplanting

## Key Success Factors of the Organic Vegetable Production System in Thailand

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Vegetable production is essentially a small-farm venture that benefits thousands of families in urban, peri-urban and rural communities. In recent years however, production costs have increased. Often, there is an overuse of harmful chemicals, which endanger the health of consumers and pollute the environment. Whereas, Thai agriculture suffers from problems linked to the high external input system. As the awareness of problems linked to high-input agriculture is increasing, politicians, NGOs and farmers are searching for alternatives. As the result, the emerging popularity of organic agriculture in Thailand has resulted from a combination of three major trends. The first is an increasing public aspiration for healthy living. The second trend is the development of sustainable agriculture in response to the crisis faced in the farm sector. The third trend is the rise of environmental awareness, and pollution caused by use and misuse of agro-chemicals.

The objectives of the research were to understand the existing situation and key success factors on the organic vegetable system in Thailand. Data were collected from the best practice farmers, and processors/handlers such as Rai Thon Nuey (Dare to sweat farm), Rai Plook Ruk (Thai Organic Farm), Suwannabhumi Organic Co. Ltd., and Swift Co. Ltd. Semi-structured interview and observation were used collecting data. Empirical and documentary analyses were applied.

Findings revealed that organic vegetables are mainly leafy vegetables, especially the salad type, Chinese vegetables and premium crops such as asparagus and baby corn. The empirical study showed that three types of organic vegetable producers are commercial family farms, farmer groups with contract farming and large-scale corporate farms. Key success factors and important techniques of organic farming are practised with implicit knowledge which starting from the preparation of ecosystem and soil nutrient, during planting, crop maintenance with the system of food chain, and harvesting only edible pieces. These practices need the ability of thinking out of the box. While market access with simple post harvest at farm level conduct to longer shelves life and good quality produces are necessary.

**Keywords:** Key success factors, organic agriculture, organic vegetables, Thailand, urban agriculture

## Comparison of the Nutritional Value of Organic vs. Conventional Foxtail Millet for Poultry Nutrition

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Millet species are considered as high-value seeds being used in poultry diet as an alternative for corn. The present study evaluated the nutritional value and some characteristics of various organically vs. conventionally grown foxtail millets. To fulfil the objective, a field study was conducted with a completely randomised block design with three replications.

Foxtail millet (*Setaria italica*) was grown under conventional (applying chemical fertilisers and synthetic pesticides) and organic management in Isfahan, Iran. Then this millets use for TME assay. TME assays conducted with single comb white leghorn adult males.

Chemical analysis was carried out on samples obtained at the end of the field experiment. The CP and ME of conventional millet was higher than organic millet (11.01 vs. 10.38 %) and (3 161 vs. 3 075 kcal) respectively. The percentage of amino acids was not significantly different in conventional and organic foxtail millet (9.49 vs. 9.39 %). However total amino acid content in crude protein of organic and conventional millet was respectively 92.06/91.68 % indicating a higher amino acid and lower NPN content in crude protein of organic millets ( $P>0.05$ ). Percentage of MET, CYS, LYS, THR and ARG in crude protein of organic and ecologic millet were respectively 3.24/3.20, 1.81/1.78, 2.33/2.23, 3.73/3.72, 3.77/3.62.

In conclusion, using organic millet instead of conventional millets does not result in a decrease in quality and nutritional value of millets used for poultry production, therefore shifting toward organic poultry production would be possible through application of organic inputs.

**Keywords:** Amino acid, foxtail millet, Iran, ME, poultry

# Biotic and abiotic stress (DPG session) - Poster session I

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## Effect of Wind and Radiation on the Crop Water Stress Index Derived by Infrared Thermography

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For optimising irrigation scheduling, information about plant water status is required. Water stress detection with infrared thermography is a non-contact method and thus very fast and practical. It is capable to estimate large leaf populations simultaneously and provides an overview on stomata conductance to water vapour variation and dynamics. However, the application has a drawback as the leaf temperature depends not only on stomata conductance to water vapour but also on other environmental factors like air temperature, radiation, humidity and wind speed, which may lead to inaccuracies in thermography-based water status detection.

A greenhouse experiment was conducted on potted maize plants, which were dried out by stopping irrigation and compared to the well watered plants. Drought stress reactions were monitored in terms of stomatal conductance to water vapour and soil water content. Infrared pictures were taken daily during the time interval 12:30–14:30 with an Infrared -camera (Infratec Vario CAM). Wet-bulb temperature (maximum adiabatic cooling of the leaves) was measured by spraying water on a reference leaf just before taking the picture. The maximum leaf heating was measured by inhibiting transpiration of a reference leaf by covering the surface with a petroleum jelly. The crop water stress index (CWSI) was calculated from the measured mean canopy temperature and wet and dry reference temperature. After the establishment of drought stress, wind was applied and later plants were illuminated with 400W sodium lamps and the changes in canopy temperature were measured in a 10min interval. Associated meteorological data (relative humidity, temperature) were measured at an interval of 5 minute. In addition to the infrared pictures, visible images were taken concurrently to identify the area of the leaves accurately.

The results showed that the CWSI of plants under water stress changed quickly under the influence of wind and radiation. CWSI underestimate the level of water stress. And after a certain time interval it was difficult to distinguish between plants under stress and non-stress conditions.

**Keywords:** Crop water stress index, leaf water potential, maize

## **Evaluation of the Efficacy of Seed Treatment using Maxim XL 035 FS and Cruiser 350 FS Tank Mixture to Control Flea Beetle *Podagrica* spp.**

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Flea beetle is a serious early season insect pest in cotton and some vegetables that might cause total damage where it is not controlled. Field experiments were conducted during seasons 2006/2007 and 2007/2008 at the Gezira Research Farm to evaluate the flea beetle infestation in cotton cultivated with pre-treated seed. The observations made were field visual counts of infestation and damage caused by adult flea beetle. In addition no-choice laboratory and semi-field laboratory tests were executed.

The results showed that the damage of the flea beetle at 4 weeks after sowing was significantly reduced as compared to the no-insecticide control (*i.e.* only fungicide applied) when the insecticide Cruiser was applied at the rate of 3 cc kg<sup>-1</sup> seed (variety Acala Nour) alone or in combination with different doses of the fungicide Maxim. However, the reduction of flea beetle damage was best in the standard treatment (the insecticide Gaucho at 7 g kg<sup>-1</sup> seed + the fungicide Raxil at 2 g kg<sup>-1</sup> seed). In case of the cotton var. Barakat no significant differences were observed till 4 weeks after sowing between all treatments. The standard treatment (Gaucho + Raxil) was the best in reducing the damage of the flea beetles till 6 weeks after sowing, but it was not significantly different when Maxim was added to Cruiser treatments.

In the no-choice semi-field tests with the var. Acala and Barakat, no significant differences were observed between the three Maxim rates tested (0.75, 1.00 and 1.25 cc kg<sup>-1</sup> seed) when Cruiser was added and the standard treatment (Gaucho + Raxil) in reducing the damage of the flea beetles at 4 weeks after sowing in the field. No-choice laboratory test indicated also no significant difference between the three mixtures of Cruiser (3 cc kg<sup>-1</sup> seed) with Maxim and the standard treatment (Gaucho + Raxil). However, the three mixtures were significantly better in reducing the damage relative to the control after 24 hour of exposure in the laboratory. On the other hand the mortality of adult flea beetles was higher in the standard treatment (Gaucho + Raxil) followed by treatments containing Cruiser. No mortality was observed for untreated seed and the lowest rate of Maxim used singly to dress the seeds.

**Keywords:** Cotton, early season pests, flea beetle, seed dressing, Sudan

## **The Multiple Effects of Salinity and Drought Stresses on Physiological Parameters and Transpiration Rate of Quinoa**

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Lack of precipitation, high rate of evapotranspiration and un-sustainable use of water resources cause drought and salinity problems in agriculture in semi-arid and arid regions. Therefore, introducing crops, which could cope with such environmental situations, is essential. Quinoa is a facultative halophyte, which is known to tolerate abiotic stresses (such as drought and salinity). Greenhouse experiment was conducted to study the response of physiological parameters of quinoa (cv. Titicaca or Q 52) under the combination of full irrigation (FI) and progressive drought (PD) coupled with five irrigation salinity levels (0, 10, 20, 30 and 40 dS m<sup>-1</sup>). Stomatal conductance (gs), photosynthesis (An), leaf water potential (LWP), and soil water potential (ΨT) were measured during the drought period. The result showed that the gs and An decreased by increasing the salt levels in FI0–5 plants and under the combined effect of drought and salinity (PD0–5). The minimum gs value was found in the droughted plants under lowest (PD0) and highest (PD40) salinity levels. However, the lowest values of An and LWP were observed in FI40. Total soil water potential decreased due to reduction in both soil water osmotic and matric potential. Reduction in total soil water potential caused the transpiration rate to decrease. The study indicated that salt accumulation at the root surfaces and lack of contact between root and soil solution due to reduction in soil water content in drought treatments contributed to the observed increase in the apparent resistance of the soil-root pathway for water transport and thereby decreased the leaf water potential, shoot ABA and transpiration.

**Keywords:** Drought stress, photosynthesis rate, Quinoa, salinity stress, stomatal conductance, transpiration rate

## Possibility and Constrains of 1-mcp Application for Optimising Food Chain Management of Papaya Fruit (*Carica papaya* L.)

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Papaya (*Carica papaya* L.) is considered one of the most important crops throughout the tropical and subtropical countries with a high consumer demand worldwide. Papaya fruit –consumed fresh, cooked, dried or fresh-cut as convenient product- is known for its rich source of health-promoting phytochemicals, e.g. glucsinolates, carotenoids, dietary fibres. However, papaya fruit has a climacteric ripening behaviour deteriorating rapidly during transport, storage and marketing. Postharvest losses of up to 75 % occur during shipping and distribution showing a range of disorders associated with mechanical injury, chilling injury, undesired ripening by acceleration of ethylene evolution and diseases. Reaching 40 % skin yellow stage, papaya fruit become more susceptible to these disorders. Physiological ageing and softening is influenced by the maturity stage of fruits at harvest, postharvest treatment and storage conditions. The ethylene inhibitor 1-methylcyclopropene (1-MCP) is known to control ethylene-dependent processes and prolong storability and shelf life of various fruits and vegetables. However currently, there is almost no information available on the effect of 1-MCP treatment on papaya fruit.

In the present study two different 1-MCP concentrations (312 and 624 nL L<sup>-1</sup>) were applied to harvested papaya fruits at two different ripening stages, i.e. colour break and ripe. Thereafter, fruits were analysed for ethylene production and respiration rates as well as for TSS, acidity, dietary fiber, glucosinolates, carotenoids and phenol pattern subsequently during 6 days of storage at simulated commercial conditions. Results presented here revealed an inhibiting effect of 1-MCP at both concentrations on undesired changes of TSS, acidity and carotenoids in colour break fruits only. Ripening pattern of ripe fruits were negatively affected by 1-MCP. Furthermore, results will be discussed in detail with special emphasis on optimising food supply chain.

**Keywords:** 1-MCP, *Carica papaya*, health promoting compounds, papaya, shelf-life

## Sweet Potato Weevil and its Management in Ethiopia

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Sweet potato is one of the major crops grown in southern and eastern Ethiopia on which millions and millions of people depend for food and as a means of cash generation. The crops are left for long period of time beyond its physiological maturity in the field on which it grows as a means of storage. Though sweet potato weevil infest the crop starting from the vegetative stage, its ill effect very much increases when harvesting is delayed beyond its physiological maturity. The losses by sweet potato weevil to sweet potato can reach over 50 % within two months of extra storage. Two species of sweet potato weevil attack sweet potato in Ethiopia. These are *Cylas puncticollis* and *Cylas formicarius*. *C. puncticollis* is very common in southern Ethiopia, while *C. formicarius* is problematic in eastern Ethiopia. Attempts made to develop an integrated management of the pests succeeded in identifying some cultural practices and resistant varieties. Three times earthing up, regular cultivation when the soil is black soil, crop rotation, prompt harvesting and the use of deep rooted sweet potato varieties significantly suppress the population of sweet potato weevil in Ethiopia. Hence, these packages can be used as integrated management of sweet potato weevil in the country.

**Keywords:** Integrated pest management, sweet potato, sweet potato weevil

## Mitigation Strategies for Blossom-end Rot and Fruit Cracking of Tomato under Protected Cultivation in the Tropics

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Blossom-end rot (BER) and fruit cracking (FC) are prevalent disorders in tomato. It is widely accepted that a local Ca deficiency in the distal half of the fruits during the initial stage of fruit development is the main cause for BER. High fruit extension-growth particularly through excessive water uptake appears to be a main reason for FC. High light intensities, temperatures and humidity levels – typical attributes of tropical climates – have been suspected to aggravate BER as well as FC. Since most cultural practices leading to a reduction of FC might induce or aggravate BER and vice versa it is difficult to control both disorders at the same time. We attempted to develop mitigation strategies for BER and FC for greenhouse tomato production under the tropical climate conditions of Central Thailand. Cultivars differing in their susceptibility to BER and FC, foliar application of combined aqueous calcium (Ca) and boron (B) solutions and nighttime fertigation with nutrient solutions of either high or low electrical conductivity (EC) were tested. The Ca and B sprays decreased the incidence of BER but increased FC at the same time. Similarly, a decrease in BER by additional nighttime fertigation with nutrient solutions of low EC and in FC by high EC at night was counteracted by enhanced FC in the low EC and BER in the high EC treatment. It is concluded that under the tropical climate conditions of Central Thailand leading to high losses of marketable fruit yield through BER and FC an integrated approach is required combining an optimised management of the fertigation system, foliar Ca sprays when climate conditions are favouring BER and particularly the selection of genotypes highly tolerant of BER and FC.

**Keywords:** Blossom-end rot, Ca deficiency, Ca sprays, fertigation, fruit cracking, tomato

## ***Brassica italica* Grown under Water Stress — Plant Response Affected by Phloem Feeding Aphids**

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Water stress alters the chemical composition of plants, which can influence the plant tolerance to insect herbivory. Glucosinolates (GS) are the main secondary metabolites in brassicaceous plants that play an important role in plant defense and plant-insect communication. GS biosynthesis in plants and their accumulation is influenced by biotic and abiotic stressors of the environment. In the present study, the GS levels in broccoli plants, *Brassica italica*, grown under different water status conditions of soil, well-watered, drought and water-logged, was determined. Also GS content of plants was determined after 7 days feeding of two aphid species, the specialist *Brevicoryne brassicae* (L.) and the generalist *Myzus persicae* (Sulzer). HPLC analysis revealed that GS levels were significantly induced after feeding of *B. brassicae* on *B. italica* plants grown for two weeks under the various water status conditions. No significant differences could be found between GS induction in the three treatments. On the other hand, the induction of GS after *M. persicae* feeding greatly depended on water stress levels. GS content in well-watered plants increased more than in plants grown under drought conditions. *M. persicae* feeding did not increase GS levels when plants were grown under water-logged conditions. The aliphatic GS was increased to some extent in *B. italica* due to the feeding of both *M. persicae* and *B. brassicae* under different water status conditions of soil but the induced level was not statistically significant. Variation in GS levels was observed mainly due to the induction of indolyl GS due to aphid herbivory.

**Keywords:** *Brevicoryne brassicae*, drought, glucosinolates, *Myzus persicae*, water logged

## Genetic Exploration of Quantitative Fungal Resistance in Wheat: Broad Spectrum vs. Specific Approaches

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Fungal diseases are by far the most important threat for wheat yield and quality. In principle plants use two strategies for defense against fungal infections. One strategy involves specific resistance genes according to Flor (1946) leading to hypersensitive reaction and another one quantitative resistance genes, which provide only partial resistance. Research in the Wheat Consortium of the National Research Program 59 (NFP59) in Zurich has the unique advantage, to have genetically modified wheat lines available that contain different transgenes from the above-mentioned categories for defense against fungal diseases. Race-specific transgenes of alleles of *Pm3b* from wheat (B. Keller, UniZh) provide resistance against certain powdery mildew strains. On the other hand, chitinase and glucanase double gene expression cassette in Frisal A13 line and glucanase only in Frisal A9 line (J. Fütterer, ETHZ) might provide resistance against a broad spectrum of pathogens containing chitin in their cell walls. As an alternative or supplementary approach, an interstrain inhibition system of so-called “killer proteins” (KP) from *Ustilago maydis* viruses has been explored as a mechanism to increase specific quantitative resistance against smut fungi in wheat. Moreover, KP-genes do not have any endogenous homologous genes, therefore, their expression and activity should be independent of any homeostasis or endogenous signaling. The project analyzes the expression profile of endogenous pathogen-related genes in wheat and compares the profiles between the different types of resistance. We expect from the results new insights into the plant pathogen defense mechanisms, and how it can be enhanced by ectopic transgenes. Particularly, we expect information about putative pleiotropic effects on the expression of endogenous resistance genes.

**Keywords:** Expression profile, pathogen defense, wheat



## Effect of Water Deficit Stress during Seed Maturity on Germination Parameters of Three Soybean (*Glycine max* L.) Cultivars

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In order to study the effect of water stress during soybean seeds maturity on their germination parameters, a field and phytotron investigation was conducted at Seed and Plant Improvement Institute (SPII) and Tarbiat Modares University in 2008 and 2009, respectively. Treatments were arranged in a factorial experiment on the basis of randomised complete blocks with four replications. Factors consisted of: three soybean cultivars (DPX, BP and 032) and water deficit stress on mother plants including irrigation after 50, 100 and 150 mm evaporation from an evaporation pan class A, representing the control, a mild stress and a severe stress, respectively. All germination tests were carried out in a phytotron (model STC1300) with 16/8 h (day/night) and by 30/20°C. Several traits including 1000 seed weight, rotten seeds, normal and abnormal seedlings, mean time to germination, coefficient of velocity of germination, mean daily germination and the final germination percentage were measured during the field and laboratory investigations.

Results indicated that increased water deficit stress on mother plants significantly decreased 1000 seed weight, number of normal seedlings, mean daily germination and the final germination percentage. All cultivars produced more number of rotten seeds due to water deficit stress during seed maturity. Mean comparison of control and severe stress treatment showed that final seed germination percentage decreased as much as 7, 15 and 28 % in BP, DPX and 032 cultivars respectively. Therefore 032 cultivar had the lowest germination percentage (59.33 %) which reflects the negative effect of severe water deficit stress in maturity period. So this cultivar has been more susceptible to stress than others.

Furthermore it has minimum rate of normal seedlings number as much as 42 and 20 percent for mild and severe stress condition and the lowest mean daily germination (7.41 seed d<sup>-1</sup>) at severe stress treatment. Altogether it could be stated that low mean daily germination influenced by water deficit stress on mother plant significantly decreased the uniformity of germination.

**Keywords:** Germination, seed quality, soybean, water deficit stress

## Management Options to Control Weeds in Smallholder Maize Farms in Western Kenya

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Field studies were conducted in Kakamega, western Kenya, during short rains of 2008 and long rains of 2009 to investigate weeds in maize smallholdings on a Nitisol, Alfisol and Ultisol soil types. Major taxonomic groups, life history and leaf morphology were described and species field coverage determined. Similarity between species of the three soil types was tested using Jaccard's index. Rapid appraisal surveys were conducted with farmers to assess economically important weeds (species that reduce yields and are difficult to control by farmers). An associate field experiment was set up at Kenya Agricultural Research Institute (KARI) Kakamega with five management options (Farmer practice, clean weeding, zero-tillage, zero-tillage+cover crop and green manure) to assess the efficacy of these options to control weeds in maize. Across the three soil types, 55 weed species (in 51 genera and 21 families) were identified. About 84 % of these species were broadleaved, 12 % grasses and 4 % were sedges. *Cynodon nlemfuensis* had highest field coverage in the Alfisol while *Galinsoga parviflora* and *Bidens pilosa* both occupied much of the fields in the Nitisol and Ultisol. Soil attributes influenced species diversity, which was confirmed by Jaccard's similarity index of 0.50, 0.58 and 0.62 for Nitisol vs Alfisol, Alfisol vs Ultisol and Nitisol vs Ultisol, respectively. The most economically important species were *Cynodon nlemfuensis*, *Commelina benghalensis*, *Oxalis anthelmintica*, *Kyllinga bulbosa* and *Leonotis nepetifolia* largely because of their abundance, aggressiveness and persistence in the fields beyond seasonality. A negative and highly significant relationship ( $p < 0.0002$ ,  $r^2=0.54$ ,  $y=13.65-0.006x$ ) was observed between weed and maize biomass production. Zero-tillage+cover crop was more effective in reducing weed biomass by 920 to 1200 kg ha<sup>-1</sup> and thus could be an alternative management option for weed control in maize smallholdings in western Kenya.

**Keywords:** Alfisol, economically important weeds, Jaccard's index, Nitisol, rapid appraisal survey, Ultisol, weeds

## Controlling *Oryzaephilus surinamensis* in Wheat with the Use of Microwave Energy

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This research was conducted to contribute to the development of pest control by using microwave (MW) energy. A MW applicator at a frequency of 2.45 GHz was used to treat 240 g of wheat. The power input was fixed at 300 Watt. The wheat was evaluated at moisture content of 10 %, 14 %, and 18 %. The temperatures of sample surface were investigated at 45, 50, and 55°C for a 5 minute time exposure. Each treatment was run for 3 replications and about 20 adult *Oryzaephilus surinamensis* were infested in the sample.

As the insects possess small size (3 mm) and high mobility, the insects were packed in a wrapping plastic with 6 to 7 g of wheat. This procedure was applied since there was no significant difference on the surface temperature between the packed and unpacked wheat. The number of insect mortality was counted twice, thus immediately as well as 24 h after treatment.

It was found that the temperatures and moisture contents significantly influence insect mortality ( $p < 0.001$ ). At 45°C, the mortality increased significantly from 6.7 to 93 % when the moisture content was increased from 10 to 14 %. Nevertheless there was no significant difference in mortality at a moisture content of 14 and 18 %. When the temperature treatment was 50°C the mortality increased as the moisture content increased, but there was no significant difference of mortality among all moisture contents evaluated. At 55°C, a mortality of 100 % was found at all moisture contents. When the initial moisture content of wheat was 14 % and 18 %, the loss of moisture content was found within the range of 1.2 % to 3.6 %, so the treatment under these conditions could be used for the drying process.

MW energy can be used to control *Oryzaephilus surinamensis*, but a further experiment at a different time exposure is needed in order to increase the effectiveness of the method. It is also recommended to determine the effect of MW treatment on wheat quality.

**Keywords:** Microwaves energy, mortality, *Oryzaephilus surinamensis*, sawtoothed grain beetle

## Optical Sensor System for Fuel Saving during Thermal Weed Control

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Agriculture is one of the most important sectors within the Colombian economy, however, thermal weed control applications in agriculture are extremely simple and there is not a widespread use in the country. In order to promote studies in this field we propose an applied optical sensor system.

Regardless the amount of weed that covers the field in question, its surface distribution is usually irregular (*i.e.* nest forms) and consequently burning takes place across the entire surface.

In Colombia, weed removal techniques are limited to the use of herbicides or open burning. The result is a system with a high gas consumption that burns not only the intended weeds, but also nutrients and minerals which are important for the crop itself. With the help of a camera and digital image processing (machine vision), it is possible to know the exact position and amount of weeds on a field. With this information it is possible to regulate the gas pressure of each valve (and thus control the burner) with respect to the amount of weeds detected. As a consequence fuel can be saved drastically, and thus generate a system that is framed within the concept of precision agriculture.

There are variables that could decrease gas consumption; there is no need to carbonize weeds to guarantee their elimination; it is just necessary to damage the surface structure of the plant so that it can no longer perform its photosynthesis process. It has been reported that weeds die with temperatures ranging between 55 and 94°C. It has also been determined that the time of exposure to the flame should be between 0.065 and 0.13 sec. The system was designed with an angle 45° and a height of 12 cm approximately from the floor to the burner. This considerations were incorporated as design parameters since studies have shown that this may be the most appropriate way of burning weeds. The main advantage of using precision agriculture methodology is that the control of the vales results in significant fuel savings. Initial measurements indicate that gas consumption in a typical pre-emergence treatment in corn cultivation can be reduced form approximately 60 kg of fuel gas, to less than 15 kg.

**Keywords:** Machine vision, precision farming, weed detection

## Non- Parametric Techniques for Weed Detection

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There is few research and implementation of “precision farming” in Colombia despite the fact that agriculture is one of the most important sectors in the Colombian economy. Looking forward the development of Colombia in this area and considering that in the conventional procedure to cultivate there are several steps that must be performed prior to preparing the field. Weed elimination is extremely important because they could generate poor growth of the crop; the paper presented is framed in this context, and will pursue optimal weed elimination methodologies through the development of “intelligent” burners.

The process of preparing soil for crops is usually framed in tours of indiscriminate burning routines that weaken the soil and render an inefficient use of fuel. The objective of this study is to develop a new integrated system for weed detection and removal from agriculture fields by using machine vision and thermal control. The system proposed builds on the fact that weed identification can be done using colour detection techniques via machine vision. For weed detection, an image processing methodology is developed using non-parametric techniques for pattern recognition. The aim of implementing a machine vision system that consists of a sensor that acquires images and post-processing software that is in charge of detecting weeds, is to control the process of actuation of valves for each individual burner, and thus optimising fuel use and keeping the soil's properties intact; for correct removal of weeds thermal control was used. An important activity was the development of an electronic power amplifier and a communication interface that sends a signal to activate valves, allowing the correct operation of the flame-thrower device. Through the appropriate valve selection and calculation of the desired flame intensity, the balance between amount of fuel required and temperature needed to eliminate weed is obtained.

The proposed algorithm (based on the Kn-Nearest-Neighbour Estimation) showed good results in terms of computational costs and processing times. The algorithm developed reached 0.2135 s per image in the analysis, which allows the tractor to move with a speed of 7.6 km h<sup>-1</sup>. The response of the system was considered adequate for its application in actual farming operations.

**Keywords:** Kn-nearest-neighbour estimation, machine vision, non-parametric techniques, precision farming

## **Application of Microwave Energy to Control Maize Weevil (*Sitophilus zeamais*) in Maize Grains (*Zea Mays*)**

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The maize weevil *Sitophilus zeamais* (Motschulsky) is one of the most serious pests of stored cereal grains especially maize in tropical and sub-tropical regions. The major effect of infestation by maize weevil is the grain damage due to feeding activities of the adults and the development of immature stages within the grain. This has a negative impact on both quantity and quality of the grains. Despite the adverse effects of the chemical residues resulted from using chemical insecticides on humans and animals, chemical insecticides are using in a large scale for controlling maize weevil. Disinfestation of grains using microwaves can be an alternative technique for controlling grain insects. A laboratory microwave applicator operating at 2.45 GHz was used in this study to determine the mortality of maize weevil. Grain samples (300 g) each with 10, 14, and 18 % moisture contents (wet basis) were infested with maize weevil (20 adults). The samples were then exposed to microwave energy at 300 watt under different target temperatures (40, 45, 50, 55 and 60°C) for 3 min. A further treatment was carried out at 50°C using four exposure times (0, 1, 3 and 5 min). Results indicated that (100 %) mortality was achieved at 55 and 60°C with an exposure time of 3 min for all three grain moisture content levels. We observed that the 50°C treatment for 3 and 5 min was able to control the maize weevil. It can be concluded that a package of higher grain moisture content, higher temperature and longer application time leads to higher mortality percentage in maize weevil adults.

**Keywords:** Maize, maize weevil, microwave, mortality

# Biotic and abiotic stress (DPG session) - Poster session II

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## Phenotypic and Molecular Background of Resistance Induction by Single and Combined Application of Chitosan and Silicon in Tomato against *Ralstonia solanacearum*

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Bacterial wilt caused by *Ralstonia solanacearum* [syn. *Pseudomonas solanacearum*] is one of the most destructive diseases of tomato as well as of other commercially important crops such as eggplant, potato, peanut, banana, tobacco, ginger and geraniums. Its wide host range, geographical distribution and subsequent colonisation of different environments worldwide imposes a production problem. Different control strategies ranging from cultural, chemical and regulatory measures and resistance breeding have been used, but an effective control was not achieved. Therefore, enhancing plant resistance seems to be a potential approach to suppress the pathogen.

We investigated the effects of silicon which is shown to prime the defence capacity of treated silicon-non-accumulator plants against the pathogen, and possible synergistic effects when combined with chitosan a natural extract and an homopolymer of deacetylated  $\beta$ -1, 4-linked N-acetylglucosamine extracted from exoskeletons of crustaceans, mainly shrimps. Evaluations of symptom development in terms of disease incidence/severity (AUDCP) revealed a reduction of 74 % and 47 % in tomato genotype King Kong 2 (moderately resistant) and L390 (moderately susceptible), respectively. The number of bacterial in midstems quantified as colony forming units (CFU/g FW) resulted in the highest reduction of 42 % in King Kong 2 for the three replications conducted at different times. Moreover, effects on plant growth and development evaluated as fresh/dry weight revealed high significant differences between silicon-chitosan treatments and non-treated plants, indicating a possible synergistic effect of the two elicitors. To further confirm the elicitor-induced systemic resistance at molecular level, microarray experiments for global gene expression (transcriptomics) and quantitative real time PCR to quantify the level of expression of target genes involved in resistance signalling pathways in plants are being performed.

These results contribute to the development of new, integrated practices for the control of the soil borne bacterial pathogen *Ralstonia solanacearum* and provide an outlook to further investigate synergistic use of elicitors. Should these results be reproducible under field conditions, they can open new opportunities to study effects of chitosan and silicon on other difficult-to-control plant diseases.

**Keywords:** Chitosan, induced resistance, *Ralstonia solanacearum*, tomato, transcriptomics

## Assessment of Non-chemical Alternatives for Controlling the Burrowing Nematode in Banana in Costa Rica

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The objective of this study was to technically and economically assess the effect of biopesticides on the very serious plant parasitic nematode *Radopholus similis* in banana in Costa Rica. The following treatments were evaluated: a mixture of nematode trapping-fungi - *Arthrobotrys oligospora*, *A. botryospora*, *Dactylella brochophaga*, and *Drechmeria coniospora*; DiThera DF which consist of a “dead” fungus *Myrothecium* spp and its fermentation substrate; Savitan produced from desert plants extracts; QL Agri which contain *Quillaja saponaria* extracts; Japanese-style compost called Bokashi; two application of a chemical nematicide; and an absolute control. Results of root sampling on a six month basis showed that the biopesticides had lower nematode population densities than the control with the nematode trapping-fungi having statistically significant differences over the other treatments. Chemical control was highly effective and produced the lowest nematode density. However, there were no statistical significant differences between the chemical treatment over the trapping-fungi treatment. The functional root variable showed no significant differences between treatments even though the Bokashi treatment gave the highest functional root weight. No significant treatment differences were observed with respect to plant growth and production parameters. Nevertheless, treatment with the biopesticide DiTera gave the highest bunch weight. Conversely, economic analyses indicated that using nematode trapping-fungi, chemical nematicide, or the QL Agri treatments gave a detectable profit. The land expectation value of the banana plantation was higher than the price of banana land which indicated that under normal conditions in the banana sector, production is economically sustainable/profitable. Other results confirm that profit in banana production is affected by the price of a banana box, production, and discount rate. The optimal production cycle was obtained in year ten after farm establishment, which refers to the year with the highest profit following plantation renewal. Finally, economical results highlighted the importance of nematodes control, since profitability indexes were sensitive to the efficiency and cost of nematode management technology adopted by the banana company.

**Keywords:** Banana, biological control, economic analysis, land expectation value, profit, *Radopholus similis*

## Effects of Powdery Mildew (*Oidium neolycopersici*) Epidemics on Host Dynamics of Tomato (*Solanum lycopersicum* L.)

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*Oidium neolycopersici* causes powdery mildew on all aerial parts of tomato excluding the fruit. Severe infections lead to leaf chlorosis, premature senescence and marked reduction in fruit size and quality. Currently, it poses a significant threat to glasshouse-grown tomatoes and is also of increasing importance on field-grown tomato crops.

Epidemics of powdery mildew (*O. neolycopersici*) and their effects on host dynamics of tomato (*Solanum lycopersicum*) were investigated under controlled greenhouse experiments using the susceptible tomato cultivar Hildares F1. Fully established tomato transplants were artificially inoculated by blowing conidia from an additionally heavily diseased plant hence inducing an even distribution of the disease on the healthy plants. Temporal disease progress as well as host growth dynamics (leaf area, plant height, leaf number) were monitored on leaflet basis and compared with non-inoculated plants raised in a separate greenhouse compartment.

Progress curves of proportion disease severity (DS) and disease incidence (DI) were well described by a three parametric logistic growth function with a maximum disease severity and disease incidence on a plant basis of 0.6–0.65 and 0.85–0.9 respectively. A substantial effect of powdery mildew epidemics on host growth was particularly discernible in terms of healthy leaf area (HLA) from a comparison of inoculated and non-inoculated treatments. Heavy disease epidemics lead to a pronounced defoliation of the affected leaves with a perspective leaf area loss of 52–68 %. However, other host growth parameters such as plant height, total leaf number as well as total leaf area formed were not significantly affected by the artificial inoculation.

**Keywords:** Defoliation, disease epidemics, healthy leaf area, host growth, tomato

## Modelling the Influence of Climatic Factors on Dispersal of Codling Moth *Cydia pomonella* L. (Lepidoptera, Tortricidae)

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Fluctuations of insect population are influenced by the biotic and abiotic factors. With regard to the prominent role of weather factors on dispersal of codling moth we studied the influence of climatic factors on dispersal of male and female moths in detail. For this purpose, delta pheromone traps and cylinder shape pear ester traps utilised for sampling male and female moths. Weather data were measured as well. Several circadian climatic data including minimum, maximum and mean temperature, relative humidity, precipitation, wind speed, degree day, and the same factors for the twilight were utilised in the analysis. Diversity and plenty of variables led us to use Akaike's Information Criterion (AIC) for selecting appropriate regressors and fitting models for feral and marked insects distinctly.

The main influential regressors for the marked female moths were flight height, ageing, wind speed at twilights in low elevation and the twilight precipitation. For the marked male the

same regressors plus the distance from the releasing point were the best subset. In the case of the feral moths the flight height, relative humidity, degree day, twilight temperature and wind speed at low and high elevations were the best subset regressors. In general we concluded that the present study provided new knowledge in basic as well as in applied science. Twilight temperature, rainfall, wind speed and degree day impress the distribution of the moths in a superior way than the circadian weather data. Furthermore, relating climatic factors male and

female Codling moth capture in pheromone traps proposes behavioural insight to individuals and monitoring their flight patterns for commercial purposes.

**Keywords:** Climatic factor, Codling moth, dispersal, modelling, trap

## Evaluation of Selected Pesticidal Plant Extracts against Major Cabbage Insect Pests in the Field

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An evaluation of fresh extracts from three locally available pesticidal plants was carried out at the shores of Lake Victoria, in Central Uganda, against two important cabbage insect pests in the field in order to establish and assess their potency for future pesticidal application. This followed the farmers' view that the plants could have pesticidal features or at least have been observed to protect leafy crops against pests. Locally available plants were used as a result of getting a tip from local farmers that the plants could be of pesticidal importance. Although many plants were mentioned in our preliminary survey, only three plants investigated in this work namely: *Euphorbia tirucalli*, *Jatropha curcas* and *Phytolacca dodecandra* were seen to show reasonable pesticidal features. Results suggest that *E. tirucalli* fresh latex could reduce infestation of *Brevicoryne brassicae* below economic threshold levels. Extracts from *J. curcas* and *P. dodecandra* likewise reduced *B. brassicae* levels but could not do so to the required threshold levels. Their potency was therefore deemed incapable for the required pesticidal requirement. The same extracts were evaluated against the diamondback moth *Plutella xylostella* but none was able to cause reduction of the moth larvae to economic threshold levels. Only *E. tirucalli* latex seemed to be a potential management measure against *B. brassicae* and a contributory factor to managing *P. xylostella* infestations. Although the rest displayed some pesticidal characteristics, they were only seen as contributory to the purpose. It was concluded and recommended that the farmers could continue using the extracts but commercialisation and extensive use should await further research.

**Keywords:** Fresh extract, *Brevicoryne brassicae*, cabbages, *Euphorbia tirucalli*, Pest management, *Plutella xylostella*

## Antifungal Properties of Sesame (*Sesamum indicum* L.) Crude Extract and Purified Sesame Lignans

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Plant secondary metabolites have important ecological function not only as attractant for pollinators and seed dispersing animals but also as resistant factor against pathogens. Accessions that produce high levels of such compounds are a valuable source for sesame breeding. With this aim we screened 32 sesame accessions. We extracted leaves, stems and root and tested the extracts against pathogenic fungi, including a root pathogen specialised on sesame *Macrophomina phaseolina*, a leave pathogen with a broad host range *Alternaria alternata* and a vascular pathogen *Fusarium oxysporum*. Extracts obtained with 80 % ethanol were assayed in microtiter plates, changes in the optical density of growing fungal cultures were recorded as optical density at 550 nm. Most of the extracts had inhibitory effects on all tested fungal species. Some root extracts supported the growth of *A. alternata* and some leave extracts enhanced the growth of *F. oxysporum* as compared to the controls. The diversity of the effects observed for different accessions lead to the assumption that there is potential to improve plant disease resistance in sesame using metabolic pathway engineering. In a continuation of this research, crude 80 % ethanol extracts of the three sesame tissues were fractioned with different organic solvents and assayed for effects on fungal cultures. The inhibition of a complete crude extract was slightly higher than the effect of diethylether fraction, followed by the effect of ethanol fraction remaining after diethylether extraction. Two purified sesame lignans were also tested. Sesamin had no effect against said fungal species up to a concentration of 5 mg ml<sup>-1</sup> while sesamol and 2,4-dinitrophenol (used as a control) had strong inhibitory effects. Different IC<sub>50</sub> value was established for each fungal species. The results reveal that sesamol may help the plant by inhibiting the growth of invading pathogens.

**Keywords:** 2,4-Dinitrophenol, antifungal, crude extract, sesamin, sesamol, *Sesamum indicum*

## **Histological Studies on the Efficacy of *Bacillus amyloliquefaciens* on Early Developmental Stages of *Phytophthora infestans* on Tomato Leaves**

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*Bacillus amyloliquefaciens* has shown promising results in biological control of late blight caused by *Phytophthora infestans*. However, the mechanisms and metabolites involved are only poorly understood. To gain a better understanding of the mode of action of *B. amyloliquefaciens* histological observations were performed.

Cells of *B. amyloliquefaciens* and their metabolites excreted in the culture filtrate after 72 hour culturing were applied on tomato plants in the greenhouse 24 h before inoculation with the pathogen ( $5 \times 10^5$  sporangia ml<sup>-1</sup>). Samples of treated and non-treated detached leaves were taken during the early developmental stages of the pathogen. They were fixed and discoloured in saturated chloral hydrate. After staining for 24 hours in fuchsin acid solution (0.01 %) the infection structures were observed microscopically with Normaski interference contrast. The effects on pathogen development were compared to the assessments of lesion size.

Both treatments reduced significantly the development of late blight lesions. Three hours post-inoculation (hpi), the zoospores produced germ tubes which showed an increased elongation by 52 % and 12 % on cell- and metabolite-treated leaflets, respectively. Appressoria formation on treated samples decreased slightly. The ability of the pathogen to penetrate the epidermal cells and to form a primary vesicle at the infection was 6 hpi on untreated plants high with 96 %. In contrast, on treated plants this ability was reduced by more than 40 % (3hpi) and 23 % (6hpi). The results showed the effect of both the bacterial cells and the metabolites on pathogen development before penetration of the host plant cells.

However, the metabolites reduced additionally pathogens development inside of the plant tissue. The reduction of primary vesicles size was about 15 %. The number of infected cells was more than 30 % reduced, as well as the formation of haustoria and secondary hyphae. The direct effect of both cells and metabolites resulted in reduction of pathogen establishment in tomato leaf and the effect of treatments on the growth of *P. infestans* proved to be highest with metabolites. In advanced stages of the infection process, hyphal ramification and production of infection vesicles in epidermal cells were inhibited giving evidence for the induction of plant defence reactions.

**Keywords:** *Bacillus amyloliquefaciens*, histological studies, metabolites, *Phytophthora infestans*, pre-infection stages

## **Fusarium Wilt (*Fusarium oxysporum* F. sp. *cubense*) in Gros Michel (AAA) Bananas: The Incidence at Smallholder Level of Nicaragua**

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*Fusarium oxysporum* f. sp. *cubense* (Foc), the causal agent of Fusarium Wilt is an important disease for the growers of 'Gros Michel' dessert bananas throughout the world. 'Gros Michel' bananas in Nicaragua are grown primarily in agroforestry systems, often with coffee, for home consumption and the national market. Little research has been done on 'Gros Michel' in this smallholder production system, where the problems with Fusarium Wilt potentially could occur. In this study the incidence of Fusarium Wilt was evaluated, additionally disease occurrence, grower perception and management of the disease were characterised. A survey of 30 farms was conducted in two zones of northern Nicaragua, Monterrey in Jinotega and Yasica Sur, in San Ramón. Foc was occurring in 47 % of Jinotega farms with 2.24 % of Foc plant incidence while in Yasica Sur no Foc diseased plants with Foc were found, representing a good opportunity as local banana seed provider. Poor training on banana disease management and the absence of control were significantly correlated to Foc contamination in Nicaragua. In the 30 interviews performed: 90 % of the growers did not know the disease, 3 % described correctly the plant symptoms of disease and only 6.6 % had some disease control methods in place. This study demonstrated that Fusarium Wilt is affecting 'Gros Michel' in small holding farms in northern Nicaragua and that occurrence and incidence is influenced by banana crop management. It seems that distribution of infested planting material and the high proximity between farms allows the rapid dissemination of the disease in the region. Additionally 18 isolates of *Fusarium* sp. were recovered from diseased plants and pathogenic test will be carried out during this year.

**Keywords:** Banana, Fusarium wilt, smallholders

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## **Evaluation of Biological Components on the Infection of three Rose Varieties by *Peronospora sparsa* Berkeley under Controlled Conditions**

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Downy mildew is considered one of the most important diseases affecting greenhouse rose crops in the Bogota Plateau (Cundinamarca, Colombia). Under proper environmental conditions, rapid and hard to control epidemics of this pathogen may cause the total loss of a susceptible rose variety plantation, thus showing its importance to agriculture. In spite of this, no detailed research had been conducted on key aspects of the biology of this pathogen as it affects rose crops under Colombian conditions. Thus, the aim of this study was to investigate said biological aspects of *Peronospora sparsa* in rose under laboratory conditions, on samples of the pathogen collected from commercial crops in the Bogota Plateau. In order to determine the effect of temperature and light on spore germination, suspensions of the latter in water agar were poured into Petri dishes and incubated at 10, 14, 18 and 22°C and permanently in the light or darkness, or under 12 hour cycles of alternating light/darkness conditions. The latent period took place in detached leaves of cultivars Charlotte, Classy and First Red at detailed temperatures under a regular light/darkness regime. The effect of the interaction between temperature and light conditions on spore germination was found to be significant. Yet, the percentage of sporangia germination was significantly affected by temperature four and eight hours after incubation. Contrast analysis identified 14°C as an optimal temperature for spore germination, with a remarkable reduction at higher temperatures. However, this was not the case under darkness conditions, where the temperature increment did not cause a strong reduction in spore germination. Variety Classy showed the shortest latent period, whereas the longest one was observed in variety First Red. It can be concluded that higher temperatures favored pathogen sporulation. Latent period and sporulation intensity variations were temperature and variety specific.

**Keywords:** Downy mildew, pathogenicity cycle, roses

## Suppression of Cotton Bacterial Blight (*Xanthomonas campestris* pv. *malvacearum*) by Compost and Vermicompost

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Environmental pollution with pesticides and fertilisers is one of the world challenges. It is a common knowledge that burning the residues of these chemicals produces toxic compounds which disperse either as aerosols, especially during insufficient incineration, or remains associated with the soil or leach out into the water. These compounds are deleterious and are recycled over and again in the environment. The implementation of integrated solutions has been suggested to minimise these problems. About 200,000 tons of cotton and 500,000 tons per hectare of wheat and tons of other crops residues are annually burnt in the irrigated schemes of Gezira-Managil, Sudan. In particular cotton residues must be collected and quick burnt in order to prevent spread of residue-borne diseases such as bacterial blight (blackarm disease) which exacerbate up to 35 % loss in the productivity. Few studies have investigated the suppression of the soil-borne plant pathogen by vermicompost therefore, the study aimed to evaluate the potential of compost and vermicompost as possible alternatives to mitigate or suppress the pathogen survival using semi-selective media. Infected cotton residue was used to study the fate of the pathogen during these processes. The results showed that the pathogen colonies number was high in the first sampling date (first month) and progressively decreased with the subsequent sampling dates (up to the end of the experiment) ( $p < 0.0001$ ). The highest pathogen number was in the control and the lowest in the vermicompost followed by compost and the interaction between time and treatment was also significant ( $p < 0.0001$ ). The study revealed that the pathogen was significantly suppressed and treatments are invariably beneficial.

**Keywords:** Bacterial blight, blackarm disease, compost, cotton residue, semi-selective media, vermicompost

## **Induction of Resistance by Jasmonate and Salicylate Application to Control Western Flower Thrips (*Frankliniella occidentalis*) in Tomato and Sweet Pepper**

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Induction of plant resistance against herbivorous insects can be one strategy of pest management. Herbivore feeding induces defense reaction in host plants which are regulated by signalling pathways. Jasmonic acid (JA) and Salicylic acid (SA) are key signalling compounds. Beside herbivore attack, resistance can be enhanced by an exogenous application of those signalling compounds. Furthermore induced defense mechanism may vary in intensity in relation to interacting plant and herbivore species. Studies were carried out to investigate the effects of resistance induction with exogenous application of Jasmonic acid and (JA) Benzothiadiazole (BTH), a trigger of Salicylic acid, in tomato and sweet pepper plants towards western flower thrips (*Frankliniella occidentalis*). Plants were sprayed with JA and BTH in concentrations of 1.5 mM and 1 mM respectively and water was used as control treatment. Resistance induced was measured in terms of preferences, eggs deposition and fertility, development and feeding behaviour under greenhouse conditions. Plant reaction to the inducers was confirmed by measuring proteinase inhibitors (PI) and peroxidases (POD) activity which are well characterised enzymes responding to activation of JA and SA pathways respectively in plants tissue. In case of the choice experiment, thrips clearly avoided treated plants when released two days after plant treatment. Similarly egg deposition, fecundity and percentage of development of eggs to adults were significantly lower in both, tomato and sweet pepper, resistance induced plants. While studying the feeding behaviour, intensity of feeding damage (percentage of damaged tissue) was found to be significantly lower in case of the treated plants as compared to control.

**Keywords:** *Frankliniella occidentalis*, Jasmonic acid, resistance, Salicylic acid, tomato, sweet pepper

## Isolation and Mating Type Determination of *Phytophthora capsici* and Possibilities of its Biological and Chemical Control

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*Phytophthora capsici* was found to be pathogenic in seedlings of brinjal, tomato, cucumber, white gourd, water melon, ribbed gourd, snake gourd, khira and bangi. Collar and root rot diseases caused by *P. capsici* are very common diseases in chilli (*Capsicum annum*) throughout the world including Bangladesh. An investigation was conducted at the laboratory of the Department of Plant Pathology, Bangladesh Agricultural University (BAU), Mymensingh from January to May 2009 to isolate *Phytophthora capsici* from the field soils affected with collar and root rot of chilli and its *in vitro* control using fungicides and plant extracts. Soil and plant samples were collected from affected chilli fields in horticulture centre, Bangladesh Agricultural University, Brahmaputra river side and villages near BAU campus where 42.86 % tissue and 14.26 % soil samples from horticulture centre, BAU; 50 % tissue and 25 % soil samples from Brahmaputra river sides; and 16.66 % samples in both cases (tissue and soil) from villages near BAU campus were involved. All the sides showed positive result for *P. capsici*. The isolated *P. capsici* was found to be heterothallic. The efficacy of four fungicides *i.e.* Ridomil, Acrobat MZ, Macuprax and Dithane M 45 each with 2 different concentrations (0.1 % and 0.2 %) and plant extracts viz. Alamanda and Garlic with 3 different dilutions of 1:2, 1:3 and 1:4 were evaluated for control of mycelial growth of the organism *Phytophthora capsici* *in vitro* condition. All the different concentrations of fungicides and all the dilutions of plant extracts significantly controlled the mycelial growth of *P. capsici*.

**Keywords:** Biological control, chemical control, collar rot, isolation, mating type, *Phytophthora*, root rot

## Role of Ecosystem Services of Termite in Agriculture in Pendjari Region, Benin

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Termites and termite mounds revealed to be of multipurpose use for African local communities: termites and mushrooms for human food and chicken feed, and mounds for soil fertilisation, fungus and health care plants' nutrition, traditional ceremonies and construction. The african termite *Macrotermes bellicosus* are particularly impressive. The species build remarkable mounds, which can reach an extent of up to 30 meters and a height of 7 meters. Recently, studies executed by BIOTA West Africa teams observed the decreasing of termite mounds in the populated area of Pendjari region, Benin. We present here the approach used to investigate the relationship between mound population and sorghum yield and the causalities of the mounds decreasing in the region.

The methodology used is based on descriptive statistic and regression using SPSS 16.0. According to the relationship between "sorghum yield" and "termite mound density", a regression of the dependent variable "logarithm sorghum yield" gave a positive coefficient (0.168) for the explanatory variable "logarithm living termite mound" and confirms that the relationship between "sorghum yield" and the "density of living termite mound" respects the Cobb-Douglas function. The model is significant at 5% with Adj. R square equal to 20.9%.

According to the causalities of mound decreasing, a multiple regression of the dependent variable "living termite mound density" with its explanatory variables shows that the variable "cotton in crops' rotation" has a negative influence on "living termite mound density" (coefficient=-0.499). The model is significant at 0.1% (with Adj. R square equal to 20.6%).

Therefore, we define two categories of farming system: "the cotton based farming system" defined as the cropping system with cotton in the rotation during the last five years and "the no-cotton farming system" defined as the cropping system without cotton in the rotation during the last five years. Rice land without cotton hosted more living *M. bellicosus* termite mounds (90% of the total mounds or 1.8 living mounds per ha) than dead mounds (0.18). But in terms of number of mounds, the densities declined from cotton via beans, sorghum and maize to yams. Dead termite mounds had the highest percentage of mounds on beans (cotton system), sorghum (cotton system) and cotton crop land. This might suggest that mounds are destroyed during cotton farming.

**Keywords:** Benin, ecosystem services, Pendjari, termites



# Animal sciences

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# Animal breeding, husbandry and health

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## Predicted and True Herd Development Over Ten Years by Applying a Bio-economic Model to Village Cattle in South-western Niger

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The PRY Herd Life Model, developed in the 1990s by R. Baptist, is a species-independent tool that enables ex-ante evaluation of livestock productivity, population size and structure. For an initial population, a stochastic model component simulates births, losses and culls over time, whereby the fitness parameters are fixed for the modelled period. The current study used PRY to predict size and structure of a village cattle herd over 10 year periods and compared the results to actual population development.

Progeny history interviews were conducted in the same 40 cattle-keeping households in Chikal, Niger, in 1998 (data from 79 cows, covering 270 animals) and 2008 (96 cows, 151 animals), and age at first parturition (AFP, months), parturition interval (PI, months), mortality rate (MR, dead over live animals) and the combined offtake/culling rate of young and adult females were calculated. PRY was used to predict herd size and structure over ten years (1998–2008; 2008–2018) using average values of 100 simulation runs each.

Significant differences between 1998 and 2008 occurred in AFP ( $60.5 \pm 10.3$ ;  $72.3 \pm 15.1$ ) and offtake/culling rate (OCR) of adult females (45%; 27 %), while PI ( $25.5 \pm 5.3$ ;  $26.8 \pm 8.2$ ), MR (18%; 16 %) and the OCR of young females (30%; 29 %) were rather constant over time. Predicted herd sizes after 10 years were  $153 \pm 28$  (1998–2008) and  $110 \pm 48$  (2008–2018). The predicted population consisted of 44 % and 29 % adult females (1998–2008, 2008–2018), 45 % and 58 % young females and 11 % and 11 % young males, while actual population structure in 1998 and 2008 were 48 % and 52 % adult females, 18 % and 20 % young females, and 17 % and 22 % young males.

PRY thus realistically predicted herd size over the 1998–2008 period, while predicted 2008 herd structure was not in accordance with actual data. Main reasons for this divergence were farmers' changed offtake/culling strategies for adult females and the prolonged AFP, which were not captured by PRY. The model's assumption of unvarying management might therefore be changed to more flexible rules, so as to increase confidence when using PRY for *ex ante* assessment of longer-term herd development.

**Keywords:** Population growth, productivity indicators, PRY herd model, West Africa

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## **Bali Cattle Performance in Smallholder Mixed Systems of Indigenous and Transmigrant Farmers on Ceram Island, Indonesia**

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ZÁRATE

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Bali cattle production in smallholder mixed farming systems on Ceram Island, Maluku (Indonesia), was chosen by the government to be the backbone of meat production in the region to satisfy the demand of Maluku, North Maluku and Papua provinces. The increasing demand in recent years created however pressure on the Bali cattle population resulting in decreasing animal numbers. Development programmes meant to increase the population and its production on the island should take into account the performance and objectives of the current cattle production systems. This study assessed the performance of Bali cattle on Ceram according to districts and management systems, assuming that the management is largely influenced by farmers' migratory status, which may represent a proxy for further development planning. A total of 479 cattle from 121 households in three districts on Ceram Island, Maluku, were measured for live weight. Progeny history questionnaires were used to collect data on 121 breeding females and their calves. Structured interviews were conducted to collect data for triangulation. The effects of district and migratory status were tested by two-factorial analysis of variance for reproductive performance parameters, while multivariate analysis of variance was used for live weight analysis. Statistically significant differences among districts appeared in bull age at first mating and adult mortality rates. Live weight also differed significantly between districts and sex. Cattle live weight in transmigrant farms showed a tendency towards higher weights than in indigenous farms although the difference was not significant. No significant differences of the reproductive traits studied were found between the indigenous and transmigrant farms. The existing, but low variation in performance of Bali cattle could still be attributed to more site-specific differences in management practices, and environmental and economic frame conditions, which were not covered here but may be more decisive than migratory status alone.

**Keywords:** Bali cattle, Ceram, Indonesia, Performance

## Variation in Reproductive Performance of Sows Kept by Smallholder Farmers in Xishuangbanna, Southern China

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Despite millions of people who escaped poverty due to China's economic development, still many suffer from a low standard of living. Among these are people who earn their income in the agricultural sector, which employs 69 % of the Chinese population but only contributes 10.9 % to the country's GDP. In Xishuangbanna, China's most southern prefecture, about 600,000 people, many of them farmers, are spread over 19,700 km<sup>2</sup> of mountainous rural areas. Their mostly mixed farming systems combine annual and perennial crops and livestock. A previous study of the reproductive performance of pigs under local management in the area revealed firstly an overall low productivity and secondly a high variation in the number of piglets per litter and age of first parturition of sows. To determine the reasons for this variation, this study allotted the performance-tested pig farms to three major regional livestock production systems, namely L<sub>owland</sub> (n=87), commercial rubber farms with marginal subsistence livestock production, M<sub>idland</sub> (n=57) farms with annual crops plus higher livestock density and highly diverse H<sub>ighland</sub> (n=46) farms with a semi-commercial pig production branch. It was hypothesised that the coefficient of variation (CV) of the tested parameters is smaller within groups than for the total population of 182 sows.

Litter size (piglets) was 5.6 (CV 34 %), 5.7 (39 %), 3.4 (18 %) and 5.7(35 %) and age at first parturition (days) was 340 (14 %), 404 (34 %), 304 (59 %) and 353 (34 %) for sows of the groups L, M, H and the total population, respectively. A lower variance could thus only be found in litter size of sows on H farms and age at first parturition on L farms. Sows from M farms showed a lower performance and a higher variance than the total population. L farmers keep smallest number of pigs (2.4; 62 %) and showed good performance while H farmers (with 5.0 pigs; 70 %) had lowest litter size, which is a hint for extensive utilisation. In general, the variance might be due to the genetic diversity of pigs or farmers' heterogeneous feeding practices; the latter are presently investigated in more detail.

**Keywords:** China, pigs, reproductive performance, smallholder

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## **Livelihoods of Smallholders in South Kivu Depend on Small Livestock: The Case of the “Cobaye”**

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An assessment of livestock production in the South Kivu province of DR Congo, employing a rapid diagnostic survey (in June 2009 and February 2010) and a participatory rural appraisal (PRA; in March 2010), revealed that more participants held non-ruminant (monogastric) animals than ruminants. The survey and PRA included overall about 300 participants from eight so-called “groupements”, comprising 24 villages. Two thirds of interviewees held chicken, while more than half of them had “cobaye” and/or swine. As the frequency of cobaye (i.e. guinea pig) was rather unexpected, the importance of this species for the livelihoods of smallholder farmers in the region has been emphasised when analysing the data gathered. A thorough literature review on cobaye as a domestic animal was also performed.

Usually, cobayes are kept in the kitchen. Herd numbers held by roughly one third each of respondents was 1–4 animals, 5–10, and 11 to >20. Animals are fed on kitchen wastes and collected forages. The latter include grasses and herbs like *Galin-soga parviflora* and *Bidens pilosa*. Cobayes are predominantly raised by children and women, both of which are also responsible to gather their forage at field- or roadsides. When assessing wealth classes during the PRA in two groupements, cobayes were associated with poverty, regardless of the gender group. Possessing cobayes was not a criterion of asset ownership regarding animal wealth classification. When in large number, about 25, cobayes were said to be exchanged at the market for other animals, basically swine and chickens.

Typical rural households comprise 8–10 members. Meat will only be consumed once or twice a month. Cobayes are used for meat supply for the family, but also for paying the children’s school fees. A cobaye may fetch about 1–2 US\$ in the market, while fees are about 2–3 US\$/month/child for primary and 5–10 US\$ for secondary school. A considerable number of advantages for raising cobaye by smallholders in South Kivu has been identified; among them are its rapid reproduction cycle, its lack of competition for human food and, in case of looting, its potential to either be hidden or recover its population fairly quickly.

**Keywords:** Food security, forages, guinea pig, livelihood, livestock, smallholder

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## Indigenous Knowledge in Animal Management: Essential for Designing Community Based Sheep Breeding Programs

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The International Centre for Agricultural Research in the Dry Areas (ICARDA), the International Livestock Research Institute (ILRI) and University of Natural Resources and Applied Life Sciences Vienna (BOKU) in partnership with the national agricultural research systems in Ethiopia are implementing community-based breeding strategies for four local breeds (Afar, Bonga, Horro and Menz) in four sites. Understanding of local knowledge and practices of communities in animal management is of paramount importance for success of community-based breeding programs. Workshops were held with the project communities to learn their animal management practices (selection of rams and ewes, ram sharing, grazing management etc.). Breeding management skills were studied by conducting heritability and genetic correlation exercises. For this purpose, the most important animal traits for the different production systems were identified from a systems study. Overall, 9 to 10 phenotypic, production, and reproduction traits were used in the form of drawings and/or verbal explanations. All possible pair-wise combinations of traits were presented to the communities to express their impressions via voting. For evaluating heritability, the communities were asked which trait of a pair is relatively more heritable than the other. For the correlation exercise, they were asked to estimate the magnitude (high, low, and none) of relationship between the traits in each pair. The results indicate that farmers/pastoralists have excellent skills in sheep management. Mating is generally uncontrolled; however, the farmers have a tradition of ram exchange. All farmers/pastoralists exercise ewe and ram selection. The selection is based on phenotypic appearance and recalled pedigree. Farmers/pastoralists' knowledge on heritability of traits and genetic correlations between traits more or less concurs with scientific evidence in literature. For example, qualitative traits (like colour) were judged highly heritable followed by production traits. Knowledge of correlations is used for indirect selection when the target traits are either impossible to assess on the live animal or are sex-limited. Indigenous knowledge and existing practices in the communities, developed through years of practical experience, provide an excellent base for the design of sheep breeding programs.

**Keywords:** Community based breeding, indigenous knowledge, sheep

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## Fixing Multicollinearity Instability in the Prediction of Body Weight from Morphometric Traits of Bunaji Cows

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Body weight and nine morphostructural characters (withers height, rump height, heart girth, body length, head width, cannon circumference, shoulder width, rump width and rump length) of 83 Bunaji cows were used to study the problem of multicollinearity instability in the estimation of body weight from morphological traits. The animals, which were aged 1.5–2.4 years were semi-intensively managed at the Livestock Complex, College of Agriculture, Lafia, Nasarawa State, north central Nigeria. Pair-wise phenotypic correlations indicated a high and positive significant relationship between body weight and body dimensions ( $r = 0.61\text{--}0.94$ ;  $p < 0.01$ ). Among the linear type traits, the highest correlation was observed between withers height and rump height ( $r = 0.98$ ) while the lowest value was recorded for rump height and shoulder width ( $r = 0.51$ ). Severe collinearity problems were evident in 5 of the zoometrical variables as portrayed by variance inflation factors (VIFs) higher than 10.00 (VIF = 33.096, 31.421, 24.612, 22.726 and 13.327 for rump height, withers height, rump length, heart girth and body length, respectively). Tolerance (T) values were also lower than 0.1 (T = 0.030, 0.032, 0.041, 0.044 and 0.075 for rump height, withers height, rump length, heart girth and body length respectively). Collinearity problems were further confirmed from the computations of the Eigenvalues of the correlation matrix, condition indexes and variance proportions. Heart girth was retained among the collinear variables, and singly accounted for 87.9 % of the variation in body weight. From the stepwise regression model, body weight was best predicted from a combination of heart girth, cannon circumference and shoulder width.

**Keywords:** Body measurement, body weight, Bunaji cow, multicollinearity, stepwise regression

## Productive Performance of Holstein Friesian Cows under Tropical Conditions in Viet Nam

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The Holstein Friesian (HF) is one of the most common breed in the world. In Viet Nam, milk production is relatively low compared to other tropical countries. Therefore, the Vietnamese government has imported large number of HF cows from Australia and USA to improve the local milk production.

The objective of the present study is to evaluate productive performance traits of HF cows in Viet Nam. The study was based on the analyses of 3242 HF cows, including imported and farm born (breed groups). Performance of these cows was tested with respect to lactation milk yield, lactation length and birth weight of calves. The statistical model comprised the fixed effects of breed groups, calving season, parity and the random effect of sire using SAS 9.2 PROC MIXED. Covariance components were estimated through the restricted maximum likelihood (REML) procedure.

The overall least squares means for lactation milk yield, 305-day milk yield, lactation length and birth weight of calves were 4619 kg, 4416 kg, 271.5 days and 32 kg, respectively. Performance traits of imported HF cows were significantly higher than those of farm born HF. These differences could be explained by various genetic and physiological factors. However, the superiority of the imported cows indicates the high adaptability of the HF breed also under tropical conditions. Effects of season of calving and parity were significant. The highest milk yield was observed during autumn, whereas maximum lactation length and birth weight were observed in cows calving during winter. Milk yield of HF cows was higher in the fourth and fifth parity. Interactions between breed groups with season of calving and parity were also significant, but imported cows showed higher performance than farm born cows in each season and parity. The pooled estimates of heritability for the investigated production traits ranged from 0.50 to 0.65.

In conclusion, imported cattle in general performed better than farm born HF, and dairy HF cows were well adapted to the feeding and management systems as well as the environmental conditions in Viet Nam.

**Keywords:** HF cows, lactation length, lactation milk yield, parity, season of calving

## Milk, Fat Production and Reproduction Traits with Regard to Crossbreeding on Holstein and Local Dairy Cattle of Iran

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In this study 400 local cows were used during cattle breeding programme for productive parameters. The mating design produced the three cow genotype: Holstein-local F1 (H1L1: 1/2 Holstein<sup>-1</sup>/2local), and backcrosses (H3L1: 3/4 Holstein<sup>-1</sup>/4 local and H7L1: 7/8 Holstein<sup>-1</sup>/8 local). First, Holstein sire (AI) was put to local mothers and in the first and 2nd generation, Holstein sire (AI) was used. Dairy recording included milk and fat yield, fat percentage, birth weight, conception rate, calf mortality and calving difficulty. Milking was performed manually twice a day. Best prediction was used to determine actual production (milk and fat) for 305-day lactation and ten records monthly. Records were available from a total of 400, 218 and 127 local, F1 and F2 generation, respectively. Least squares mean were calculated and data were analysed using the GLM procedure (SAS institute, 2000) at level of ( $p < 0.01$ ). Least squares mean for milk and fat yield (Local, F1 and F2 generation) were:  $1827 \pm \text{se}12.2$ ,  $4264 \pm \text{se}18.54$ ,  $4571 \pm \text{se}24.88$  (milk yield) and  $73.16 \pm \text{se}0.42$ ,  $162.18 \pm \text{se}0.63$ ,  $164.64 \pm \text{se}0.81$  (fat yield) respectively. Fat percentage for Local, F1 and F2 generation were:  $4 \pm \text{se}0.03$ ,  $3.8 \pm \text{se}0.05$  and  $3.6 \pm \text{se}0.06$  and Birth weights were:  $20 \pm \text{se}0.1$ ,  $30 \pm \text{se}0.15$  and  $33 \pm \text{se}0.22$  respectively. Results on F1 and F2 crosses in this study confirmed their consistently better ranking for milk production compared with local cattle ( $p < 0.01$ ), but it was not observed significant difference between F1 and F2 generation for milk production. Local dairy cattle were superior for fat percentage compared with F1 ( $p > 0.01$ ) and F2 ( $p < 0.01$ ) generation and produced less fat yield apparently. Local breed had less birth weight compared with F1 and F2 generation ( $p < 0.01$ ). Conception rate for L×H, F1×H and F2×H crosses were: 55, 56.89 and 53.55 percent and calf mortality were: 3.5, 2.68 and 3.08 percent respectively. L×H, F1 and F2 crosses had not significant differences ( $p > 0.01$ ) for conception rate and calf mortality. Calving difficulty scores were 4.5, 3.1 and 2.8 for L×H, F1 and F2 crosses. L×H group had more calving difficulty (most problems) than F1 and F2 crosses ( $p < 0.01$ ). These results indicate to make heavy use of Holstein sire and the inadequacy of the local cattle as dairy animals.

**Keywords:** Birth weight, crossbreeding, Holstein, milk and fat production

## Growth Performance and Milk Yield of Crossbred Sahelian Goats in the Semi-arid Zone of Mali

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The objective of this study was to evaluate the effect of crossbreeding Sahelian goats with Anglo Nubian bucks on breed type, litter size, sex, and the growth performance of the kids as well as the milk yield of does from birth to 100 days of age. The study was carried out at the regional center of agricultural research of Samé (CRRR/Kayes, Mali). Forty four does were randomised and divided into two groups [Sahelian Goat (SG; n=22) and F1 Anglo Nubian × SG (ANS; n=22)]. Then, ninety kids of three breeds were allocated to three groups (SG; n=30), F1 (ANS; n = 30) and B1 backcross kids (F1AN; n = 30)]. Upon kidding, does and their offspring were kept in a pen until three weeks of age; they then stayed in an indoor system for 45 days after which they were permit to outdoor at suitable weather. Every category received a nutritional supplementation according to season (rainy, cold dry and dry hot). Live weight of kids and average daily milk production of does were recorded weekly throughout pre-weaning. The effect of all factors on birth height, growth performance of kids, and milk production of does, was determined using F-test ( $p < 0.001$ ).

Birth weight and body weight of kids were significantly affected by genotype, litter size, and sex ( $p < 0.05 - 0.00$ ). Live weights of kids were greater ( $p < 0.001$ ) in B1, compared to F1 and SG at all ages. The growth performance was greater in B1 kids until 100 days ( $131.9 \pm 8.12 \text{ g d}^{-1}$ ;  $p < 0.001$ ). Good correlation was found between overall birth weight and live weight at 100 days of age ( $r=0.85$ ). Similarly, daily milk production was significantly affected by genotype ( $p < 0.001$ ) throughout the observation period; therefore, the total milk production at 100 days for F1 was 103 % of that of SG.

The higher milk production of F1 crossbreeds could be well exploited in rural areas with good effect on farmers' revenue. The better growth performance of B1 does should be further investigated for probable economic impact on farm income.

**Keywords:** Anglo-Nubian, crossbreeding, growth performance, Mali, milk production, sahelian goat

## Production Objectives, Trait Perception and Breeding Goals of Sahiwal Cattle Keepers in Kenya

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Sahiwal cattle and their crosses with other Zebu and taurine breeds play an important socio-economic role in various communities in developing countries in the tropics. In Kenya the Sahiwal has been used for upgrading the East African Zebu (EAZ) for improved performance in the southern rangelands, mainly by the Maasai pastoralists. However there has been no deliberate effort to understand why these pastoralists keep Sahiwal and their crosses as well as traits they consider important. Understanding the existing production circumstances is an important prerequisite in diagnosing the status and trends of the systems, and also as a basis to identify areas for future interventions. A survey was conducted between May and October 2009 in Kajiado, Transmara and Narok North districts to identify reasons for keeping Sahiwal cattle and their crosses and assess the relative importance of various traits. Sahiwal and their crosses fulfilled several roles that mainly included milk and meat production, and source of cash income. In addition they were kept for breeding (mainly upgrading) and multiple objectives that included insurance against risks and social functions. These roles were however influenced to varying extents by various household characteristics such as literacy levels, age, region and number of livestock. Sahiwal and their crosses were generally perceived to be better in respect to production (size, growth performance and milk yield) and fertility (age at first calving, calving interval and ease) traits when compared to the EAZ. However, the EAZ were rated high with respect to adaptability traits (disease and drought tolerance). Traits that farmers perceived as being of primary importance were milk yield, growth, body size, fertility and adaptability. Results from this study provide prerequisite knowledge that is vital in optimising the Sahiwal cattle breeding programme to be responsive to the needs of the Sahiwal keepers.

**Keywords:** Breeding goal, Kenya, production objectives, Sahiwal cattle, trait perception

## Traditional Art Contest of *Sonok* as an Alternative for Selection of Good Quality of Madura Cattle

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Madura cattle is one of the prominent local cattle breeds in Indonesia; probably formed from Bali (*Bos javanicus*), Ongole (*Bos indicus*) and *Bos taurus* cattle. The uniformity of this breed was developed from tuft selection by Madura people. Madura cattle are embedded in cultural activities of the Madura people. One cultural events involving Madura cattle is the *Sonok* contest, which is a traditionally selection of good heifers and cows. Cultural practices for keeping *Sonok* animals and criteria applied to select it can be considered for conservation of Madura cattle. The aim of this study was to explore phenotypic characteristics of *Sonok* animals among different age groups.

In total, 166 heads of *Sonok* animals divided into 6 age groups were observed for their exterior characteristics, namely, body colour, existence of dewlap, hump, smear colour around eyes, mouth and legs, and existence of the coloured back line. In total, 106 heads of *Sonok* heifers and cows were observed for their body condition score (BCS).

Most *Sonok* animals in all age groups are dark brown (64 %), have medium dewlap (66 %) and small hump (61 %), non specific smear colour around eyes (55 %), mouth (52 %) and on legs (58 %), and no coloured back line (55 %). It seems that Madura cattle characteristics are a combination of the characteristics of Bali and Ongole cattle. These characteristics have been maintained by farmers as traditional selection criteria through the *Sonok* contest. Almost all *Sonok* heifers and cows had good body condition score (98.1 %). By applying traditional selection practices, Madura people have maintained the phenotype uniformities of this breed for a long time.

**Keywords:** Madura cattle, phenotype uniformity, *Sonok*, traditional selection

## Mountain Cattle Breed for Coping with Climate Change: Needs for Conserving and Reintroducing the Achai in the Hindu Kush Mountain of Northern Pakistan

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In the past 30 years better market access in the Hindu Kush Mountains of northern Pakistan led to land use changes. The extending of high payoff and off-season vegetable cultivation by mountain communities replaced staple crops, and vegetable fields even encroached over grazing areas on mountain slopes. This led to increasingly limited crop residues and grazing land that reduced cattle herd sizes and shifted livestock production from extensive to intensive. Artificial insemination and a growing demand for dairy products have favoured heavy dairy cattle breeds. This led to the rapid erosion of the indigenous livestock breeds, in particular the Achai cattle, well adapted to both sedentary and mobile extensive production systems in the Hindu Kush mountain valleys. Considering that with climate change the shrinking of glaciers and erratic rainfalls are limiting off-season vegetable cropping, livestock rearing on pasture seems to be again a rational form of agriculture in this region. The Achai cattle breed, currently being endangered due to the earlier erosion process explained, has excellent adaptation capacities to the changing climate. This study documents the phenotypic, productive and reproductive characteristics of the Achai cattle breed. The results show that it is one of the smallest cattle breeds, only weighing  $207.1 \pm 2.6$  kg, an important characteristic for steep slope grazing and has reasonable milk output considering the size of the animal. The breed has excellent fertility traits, with an average as high as 70 % conception rate at first service. The pastoral communities in the less accessible marginal mountain valley still keep a sizable Achai population and can provide space for its conservation. This paper elaborates a strategy for conservation of the Achai cattle breed

**Keywords:** Achai, adaptation, endangered cattle breed, extensive production system, genetic resources, mountain communities

## **Growth Performance, Blood Parameters and Return on Investment of Growing Weaner Pigs of Nigerian Indigenous Pig (NIP), Exotic (Large White $\times$ Landrace) and Hybrid (F1 Crossbred of NIP $\times$ Exotic) Origins under Intensive Management System**

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Thirty-six (36) weaner pigs were randomly selected and assigned to three treatment groups based on their origin: Exotic (Large White  $\times$  Landrace), Nigerian Indigenous Pig (NIP) and Hybrid (F1 crossbred of NIP  $\times$  Exotic). Twelve pigs per group were used in a completely randomised design, average initial body weight being  $10.3 \pm 2.03$  kg. The objective of this study was to evaluate the growth performance, economy of feed conversion, haematology, serum chemistry and return on investment.

The results showed that feed intake by the Exotic and Hybrid pigs was comparably higher than for the NIP. The weight gain of the pigs was directly related to the feed intake and its cost. Hence, the NIP had a lower gain compared to the Exotic and Hybrid pigs, which had comparable ( $p > 0.05$ ) gains. The feed:gain ratio, cost of feed per gain and measured haematological indices were comparable for pigs across the three groups ( $p > 0.05$ ). All serum metabolites were also comparable ( $p > 0.05$ ) across the groups; only the serum glucose was significantly ( $p < 0.05$ ) higher for the NIP than for the Exotic and Hybrid ( $E \times L$ ). Net benefit was higher for the Exotic breed (Naira 878) than for Hybrid (NGN 353) and NIP (NGN 976). The marginal rate of return of 43.8% and 104.9% suggests that farmers gain an additional net benefit of NGN 44 and NGN 105 for every NGN 100 incurred as costs when they change from NIP to Hybrid and Exotic breeds, respectively. Conclusively, the Hybrid pigs had comparable growth performance, economy of feed conversion, serum and haematological results as the Exotic breed of pigs. Returns on investment showed that even though rearing Exotic breeds of pigs was more cost-effective than the Hybrid, the latter was still an option to be considered for investment over the NIP by pig farmers.

**Keywords:** Blood chemistry, growth performance, hybrid pig, return on investment

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## **Fattening Performance and Carcass Characteristics of Awassi and their Crossbred Ram Lambs with Charollais and Romanov in an Intensive Feeding System**

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The objective of this study was to evaluate the effect of ram lambs genotype on fattening performance and carcass characteristics in an intensive feeding system.

Thirty ram lambs and two months old ram lambs of three genotypes Awassi (A) = 10, F1 crossbreds Charollais × Awassi (F1 ChA) = 10 and F1 crossbreds Romanov × Awassi (F1 RA) = 10 were placed in individual closed pen. All lambs were individually fed for seventy days on the same concentrate mixture. Live weight (LW) was recorded once weekly, daily was recorded feed offered and refused in individual lamb. At the end of study all thirty ram lambs were sacrificed to obtain slaughtering data. Daily weight gain (DWG), total weight gain (WG), feed conversion ratio (FCR) and cost on 1 kg weight gain were the best in F1 ChA and F1 RA, compared to A ( $p \leq 0.001$ ). The height at withers, height at back, height at rump, diagonal body length, rump height, chest girth and cannon-bone girth were in favour of crossbreds F1 ChA ram lambs ( $p \leq 0.01$ ). The F1 ChA hanging carcass recorded a higher body length, leg length, gigot width, width behind shoulder, Max. shoulder width ( $p \leq 0.01$ ) than the other genotype groups. The best ( $p \leq 0.001$ ) carcass meatiness was in F1 ChA group, while the lower carcass fatness was in F1 RA group ( $p \leq 0.01$ ). The highest percentage proportions of leg and loin, which represent the prime quality of the carcass, 48.64 % were in F1 ChA, 45.97 % in F1 RA and 45.91 % in A ( $p \leq 0.001$ ). The EMA, fat depth over EMA, lion fat depth and shoulder fat depth displayed highly statistically significant differences between the genotypes. In conclusion, the results of this study document that F1 ram lambs crossbreds ChA and F1 ram lambs crossbreds RA were superior than Awassi ram lambs in daily weight gain and total weight gain, feed conversion, lower cost of 1 kg meat gain and in most of the carcass characteristics.

**Keywords:** Carcass characteristics, crossbreeding, lamb fattening, sheep

## **The Effect of Subclinical Mastitis in Awassi Sheep on Milk Quantity and Quality in Northern Syria**

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Dairy sheep production systems contribute substantially to the livelihood of small-scale and resource-poor producers in the Middle East and Syria. Milk production and processing into yoghurt and cheese contribute as much as 48 % of the income of farmers in northern Syria and the demand for these products is expanding. One of the most common and widespread diseases registered in the dairy sheep flocks in Syria is subclinical mastitis. The effect of mastitis on milk yield and milk and cheese quality was tested in nine sheep flocks during the milking season (from 11 April to 7 July) 2006 in El-Bab region, northern Syria. With the assistance of the farmers, the ten best producing Awassi milking ewes were selected in each flock, all ninety animals were tagged, and milk production and physico-chemical properties of the milk were monitored individually. California Mastitis Test (CMT) was used to detect subclinical mastitis. The milk was also analysed on a microbiological level with the purpose to detect which organisms could be considered as main causes of mastitis. Furthermore, the study included an in depth-analysis of the effect of management factors on incidence and intensity of subclinical mastitis.

A clear linear drop in milk quantity was observed in association with increased values of CMT ( $p = 0.01$ ). This finding highlights the significant economic loss caused by the infection. Similarly, the quality of cheese (texture) decreased with the increased values of subclinical mastitis ( $p = 0.01$ ). Microbiological analyses demonstrate that the presence of *Staphylococcus aureus* was clearly associated to high scores of CMT and strongly related to decreased milk yields. Moreover, inappropriate managerial practices like the feeding condition and cleaning of milking area correlated positively with microbic values, specifically *Staphylococcus* (61 %) and molds (58 %), confirming the relation between the adoption of bad managerial practices and the presence of the major bacteria causing subclinical mastitis. Finally, incidence and degree of CMT was positively correlated with age of ewes, pH, electric conductivity and fat, protein and total solids contents of the milk. It was negatively correlated with milk yield, titratable acidity and milk density.

**Keywords:** Awassi sheep, milk production, milk quality, subclinical mastitis

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## Prevalence of Endoparasites in Ostriches (*Struthio camelus*) raised in Selected States of Northern Nigeria

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A study was carried out to determine the prevalence of endoparasites on seven ostrich facilities in Kaduna, Kano and Plateau States of Nigeria. A total of 121 ostrich faecal samples from 18 chicks and 117 adults were collected and analysed for the presence of endoparasites. On each farm, faecal samples were collected at random in the early hours of the morning using clean polythene bags and later transferred into a plastic container with 5 ml of 10 % formalin to preserve the eggs. All samples collected were labeled serially. The seven ostrich farms were identified as I to VII. Faeces were collected during farm visits between May and September 2004. Parasitological examination was performed on fresh faeces using floatation and sedimentation methods. Data collected were analysed using descriptive statistics. Thirty-two (26.4 %) of these samples were positive for endoparasites while seventy-five (62.0 %) were negative. Also, 14 (11.6 %) of the samples recorded incidental presence of mites. The positive samples comprised trichostrongylid-type eggs (8 samples), strongylate-type eggs (5 samples), *Amidostomum* eggs (5 samples), and *Eimeria* oocysts (14 samples). Faeces from chicks revealed *Eimeria* oocysts (7 samples) and mites (2 samples); 7 samples were negative for endoparasites. In adult faeces, 18 samples were positive for nematode eggs, 7 positive for *Eimeria* oocysts and 68 negative for endoparasites. Incidental presence of mites was recorded in 14 samples, two from chicks and twelve from adult ostriches. The significance of these findings was discussed with a view to suggesting ways to enhance the growth of this important emerging industry.

**Keywords:** Eggs, endoparasites, faeces, oocysts, ostrich

## Prevalence of *Brucella Abortus* Antibodies in Donkeys in Gaderef State of Eastern Sudan

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A cross-sectional epidemiological study was carried out from January 2009 to December 2009 to determine the seroprevalence and identify risk factors for seropositivity of equine brucellosis in Gaderef state of eastern Sudan. The study aimed to provide documented information in the prevalence of the disease with view to assisting veterinary authorities in disease control policies and planning research priorities in the state. The study populations comprised indigenous breed donkeys in the state, and samples were selected by random sampling. Serum samples collected from 412 donkeys above one year of age were screened for *Brucella* antibodies by the Rose Bengal Plate Test and reactor sera were further tested with the cELISA for confirmation. Moreover, information was gathered on donkeys herds' health and management and risk factors using a structured questionnaire. In this study, the overall seroprevalence of *Brucella* antibodies in the donkeys was 2.12 % based on RBPT. Although brucellosis is considered endemic in ruminants in the study area. The results of univariate logistic regression analysis revealed that seropositivity to brucellosis was significantly higher in donkeys reared on a dairy farm with a high incidence for *Brucella abortus* were serologically positive for *B. abortus* and no other *Brucella* spp ( $p < 0.001$ ). The results also indicated that there was a statistically significant increase in seroprevalence to brucellosis with increasing age ( $p < 0.01$ ). Significant increment of seropositivity was also observed as herd size increases from small to medium ( $p < 0.05$ ) and then to large sizes ( $p < 0.001$ ). In addition, Nevertheless, in the multivariate logistic regression analysis, systemic factor (odds ratio [OR] = 9.8 %, 95 % confidence interval [CI] = 1.9–48.3,  $p < 0.01$ ) and age (OR = 3.2, 95 % CI = 2.1–48.3,  $p < 0.01$ ) were identified as the major risk factors for individual animal seroprevalence. The results obtained suggest that equines may be a reservoir of brucellosis and may also play an important role in the epidemiologic patterns of this disease in Gaderef state in Sudan.

**Keywords:** *Brucella*, Donkeys, ELISA, Prevalence rate, Risk factors

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## A Transport Model for the Spread of Bird Flu

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Highly Pathogenic Avian Influenza (HPAI) is a major threat to the poultry industry worldwide. In developing countries backyard poultry production is often an important livelihood activity for women who use the additional income for unexpected household expenses. The disease can therefore have significant social impacts. To evaluate different options governments and public health authorities could employ to reduce the negative effects of HPAI outbreaks, it is necessary to have a means for simulating outbreaks of the disease. Models can aggregate the available information about the disease dynamics for conducting such simulations.

The underlying assumption of the model we propose is that the fastest way for HPAI to spread is through transport of infected material or chickens. Undoubtedly, other infection routes, like direct transmission between neighbouring villages or disease spread by migrating birds, play a role in the disease dynamics, too, but these are likely to be slower than transport of infectious material through trade. The speed of transport depends on the topography of the landscape: transport will be faster along roads and slower off roads.

In the model, the landscape is divided into quadratic areas termed grid cells. Grid cells contain information about the poultry population. Each grid cell is assigned a travel friction, which is the time it takes to cross the grid cell with the appropriate means of travel, i.e. by truck on roads and on foot off-road. The travel friction is computed from data on road type, vegetation, slope and other landscape features. The model calculates which area can be reached within 12 hours travel time for each grid cell.

Data of past outbreaks of HPAI in Nigeria were used to validate the model. The data were also used to calculate the expected number of secondary outbreaks resulting from an infected farm during the period the farm is infective. The probability distribution of the number of secondary outbreaks is used to predict the future spread of disease and to access the quantity of poultry affected. The model was then used to evaluate different control options.

**Keywords:** Bird flue, Highly Pathogenic Avian Influenza, spatial modelling

## A Strategic Model for the Simulation of Drug Resistance in African Animal Trypanosomiasis

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African Animal Trypanosomiasis (AAT) is a major constraint to the productivity of African agricultural systems, both where animals are used for dairy or meat production and where traction power is needed to cultivate the land. Tsetse flies of the genus *Glossina* act as vectors that transport the parasitic protozoan *Trypanosoma* spp. between hosts. The strategy most widely used to manage the disease is application of trypanocidal drugs, but the emergence of resistance has put into question the long-term viability of their use.

In certain areas of West Africa, drug resistant and drug susceptible strains of trypanosomes co-exist. When in such an area the disease prevalence is successfully reduced by removal of the majority of the tsetse vectors, the remaining numbers of diseased animals is so small that it becomes difficult to measure the impact of vector control on the development of drug resistance. Moreover, little is known about how resistance is likely to evolve if vector control is subsequently discontinued.

Dynamic system models can simulate the processes that drive the dynamics of vector, host and parasite populations. Such models can increase our understanding of the diseases dynamics even in situations where empirical measurement is problematic.

We describe a model in which cattle hosts are represented as individuals. Cattle can be infected by a drug resistant or drug susceptible strain of the pathogen, or a mix of both. Tsetse flies, represented as cohorts, can spread disease between hosts. The model incorporates processes that potentially alter the ratio of drug resistant to drug susceptible trypanosomes, such as reaction to medication, and keeps track of the proportions of drug resistance and drug susceptible strains in the trypanosome population.

The model is strategic in the sense that it doesn't attempt to represent a particular situation in a particular region, but more generally aims to improve our understanding of a situation in which empirical science is constrained.

**Keywords:** African Animal Trypanosomiasis, drug resistance, Simulation model

## Management of Trypanocide Resistance in the Cotton Belt of West Africa: Lessons Learnt During the 10 Years of the BMZ Funded Regional Coordinated Project

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Animal trypanosomosis still remains a major constraint to livestock production across sub-Saharan Africa. Drug use is the principal method to control trypanosomosis. Unfortunately, the development and spread of chemoresistance against trypanocidal drugs severely threatens the sustainability of this approach in the high trypanosomosis risk areas of West and East Africa. For about 10 years, a regional collaborative project funded by BMZ involving research institutions in West Africa, the International Livestock Research Institute (ILRI) and German universities identified and mapped trypanocide resistance hot spots using field and laboratory methods in Mali, Burkina Faso, Guinea, Ghana and Benin. Resistance is found frequently in pockets in the central area of southeastern Mali and western Burkina Faso, but less frequently and at levels more difficult to detect to the west into Guinea where trypanotolerant cattle breeds are reared, and to the east across the zone from northern Ghana to northern Benin where a weak river network is making the riverine species, the only ones present, scarce. Among the lessons learnt was that trypanotolerant (TT) cattle breeds are, to some extent, capable in tolerating the disease but the majority of farmers in the region are preferring the larger trypanosusceptible zebu cattle. Increasing introgression of zebu genotype into the TT breeds threatens the survival of these indigenous genetic resources. There is need to sustain TT cattle as a fall-back option in case resistance worsens in southwest Mali and Guinea where they are still common. Tsetse control at village level was effective in trypanosomosis management but the still high transaction costs required in setting up and maintaining control structures makes its sustainability difficult without external support. Rational Drug Use (RDU) was another effective method of managing trypanosomosis. Promotion of RDU resulted in improved knowledge, practices and animal health outcomes. RDU has potential for adoption as a resistance prevention strategy although the limited understanding and appreciation of resistance, weak extension delivery systems and perceptions that it is inconsistent with veterinary professionalism make its promotion difficult.

**Keywords:** Chemoresistance, rational drug use, trypanosomosis, vector control

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## Camel Breeding Management among the Somali, Sakuye, Gabbra and Rendille Pastoralists of Northern Kenya

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Camels are a key livestock species in pastoral production systems in the arid and semi-arid areas of Kenya. Over 90% of Kenya camels are owned and managed by pastoralists. However, as a result of climatic variability, camels are adopted by traditional cattle keepers. For instance, Turkana camel keepers claim that camel rustling has taken precedence over cattle rustling after their neighbours realised the value of camel. Camels' main importances are food security and transport. Despite high demand for camels, the pastoral camel keepers expressed concern over declining performance of their camel herds. A survey was conducted in Turbi, Merille, Thambas and Dabel to gather information regarding breeds of camels kept, the age at which bulls and heifers attain reproductive maturity, number and sources of breeding bulls, age of retiring breeding bulls, and how to refrain closely related animals from mating. The study used semi-structured questionnaire to gather the information from 240 respondents across four study communities. Systematic random sampling was used to identify the respondents. Data was entered and analyzed using SPSS version 12. The result showed that the dominant breeds kept by Sakuye and Somali communities are Somali breed while Gabbra and Rendille kept mainly their own breed. Heifers attained reproductive maturity at age of  $3.9 \pm 0.43$  years in Gabbra herds,  $4.1 \pm 1.01$ , in Sakuye,  $4.5 \pm 1.70$  in Somali and  $4.7 \pm 0.45$  in Rendille. Bulls attain reproductive maturity at  $4.2 \pm 0.73$  years in Gabbra herds,  $5.7 \pm 1.79$  in Sakuye, and  $5.9 \pm 1.76$  in Somali and  $5.8 \pm 0.80$  in Rendille. Number of breeding bulls in herds range from one to four and are sourced within own herds and neighbours. Bulls are refrained traditionally from mating its mother but not sisters and daughters. The study concluded that the preferred breed of camel is Somali. To prevent inbreeding, the study recommends timely swapping of bulls and sourcing for bulls from far areas and retiring bulls at age of about 10 years to prevent them mating their daughters.

**Keywords:** Adoption strategies, camel management, climate change, pastoral communities



## **Characteristics of Beef Buffalo and Beef Cattle Farming and its Benefits to Farm Households in Northeastern Thailand**

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Under shifting conditions towards high valued products and non-traditional crops and animals, the roles and practices of buffalo and cattle farming in northeastern Thailand have changed over the last decades. The aim of this study therefore was to characterise present-day beef buffalo and beef cattle production and their contribution to households' livelihoods. To this end, a semi-structured questionnaire was used to interview 121 farmers in 12 selected districts of the Nakhon Ratchasima province through a single-visit, multiple-subject survey during October 2007 and May 2008. Beef buffalo and beef cattle production are traditional agricultural production systems in northeastern Thailand. The small livestock farms are mainly integrated with mixed cropping systems to cover farm household needs. The most important roles of beef buffalo and beef cattle were income earnings including a savings role (21.5 % of responses), covering of anticipated (19.4 % of responses) as well as unexpected expenses (18.8 % of responses), main cash income earning (11 % of responses) and additional cash income earning (9.3 % of responses). Social aspects (18.3 % of responses) also played an important role. Only few farmers (1.7 % of responses) were using animals for draft power, as an inherited asset and for traditional activities. With an increasing number of animals per farm, the socioeconomic status including dwelling construction, the number of household assets and holding a commercial health insurance was better than on small-scale farms. This indicates that beef buffalo and beef cattle farming still plays an important role in improving rural households' wealth and livelihood.

**Keywords:** Beef farming, livelihoods, livestock roles, socio-economics

## Vietnamese Animal Genetic Resources Conservation: Achievements and Future Strategy

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Conservation and development of local breeds is important because of their contribution to the livelihoods of farmers and biodiversity as well as their social and cultural importance. In Viet Nam, the convention on biological diversity was adopted in 1994. A total of 97 local breeds are recorded in the FAO's global databank (<http://dad.fao.org/>). Within the country, the Vietnamese Government has issued a number of policies and decisions to support the management and to promote the development of animal production. Furthermore, national programs on conservation of the Vietnamese domestic animal genetic resources have been initiated under the direction of the National Institute of Animal Sciences (NIAS) since 1990. These policies and national programs have had positive impacts on the use and conservation of farm animal genetic resources. Three different conservation schemes practised in Viet Nam are *in situ* live conservation, *ex situ* live conservation and cryo-conservation, with the *in situ* live conservation including intensive farmer participation being the most common. Almost all of the conservation programs implemented by NIAS have been conducted on farms with farmer participation. Due to the limitation of conservation funds, these programs prioritised conservation of certain local animal breeds. Conservation decisions were made mainly based on only information on population size and population trend of the breeds. Other indicators affecting on extinction probability of the breeds and the contribution of the breeds to total genetic diversity have not been included. Some recent reports on genetic diversity between and within Vietnamese local breeds which were assessed at the molecular level have been published. This information should be combined with extinction probability of the breeds estimated by socio-economic factors to estimate conservation potential for each breed. Furthermore, it is also necessary to maximise efficiency of funding allocation for conservation when the conservation funding is limited as suggested by FAO.

**Keywords:** Conservation priority, Viet Nam, Vietnamese animal genetic resources

# Forages and feeding systems

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## Intake of Supplementary Feeds by Cattle and Goats in an Indian Pastoral System as Estimated by Direct Observation, Micro-histology and Owner Survey

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Little is known about the quantitative use of crop residues in the diets of free-ranging or herded livestock close to Indian national parks, regions where conflicts about scarce feed resources are prevalent. The knowledge of type and amount of crop residues is important to improve the management of natural resources like trees and shrubs. From November until April (beginning dry period), 2 × 25 distinct female cattle and goats from two villages close to the Bandhavgarh National Park were followed for one day each during daytime. Plants species ingested were recorded by continuous direct observations (DiO). Faeces of these animals were collected for micro-histological analysis (MiA) of the diet's botanical composition. Additionally, livestock owners were questioned about the feeds supplemented to their livestock during the night feeding. The results for each crop were analysed by ANOVA considering animal species (cattle vs. goats), season (cool winter vs. hot summer), and agreement between techniques (DiO vs MiA). Crop species (mostly straws) used as residues in feeding were *Cicer arietinum*, *Dolichos lablab*, *Lens culinaris* (lentils), *Oryza sativa* (rice), *Triticum aestivum* (wheat) and *Zea mays* (maize). According to DiO and MiA, these crops made up between 16.4–31.9 % of cattle's and 0.4–1.2 % of goat's diet in winter and 12.1–12.7 % and 0.6–2.2 % in summer, respectively. *C. arietinum* and *D. lablab* never exceeded 2 % of the diet. For the four other crops, MiA findings were higher ( $p < 0.05$ ) than DiO results. Interaction between animal species and season were significant ( $p < 0.05$ ). Animal species was only important for maize and rice straw consumption (>10 % in cattle, merely nil in goats). Lentil straw and maize stover consumption depended on season (more in summer). Opposing owner statements to MiA and DiO confirmed an intensive use of crop residues on the fields (cattle: more than half ate maize stover and lentil straw afield; goats: more than half ate lentil and wheat straw). The combination of DiO, MiA and owner statements results is assumed to improve the reliability of the results as the respective uncertainties are compensated.

**Keywords:** Crop residue, forage, grazing, India, livestock, nutrition

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## **Digestibility of Nutrients and Evaluation of Energy of Pangola Grass in Sheep as Compared to Napier Grass**

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In this study, sixteen cross-bred native × Merino sheep were randomly allocated to 4 treatments, and confined in metabolic cages with clean water supply at all times. The experiment was conducted at the farm and laboratory of the Department of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Thailand. Sheep in each treatment were fed as follows: T1 fed with Napier grass, T2 fed with fresh Pangola grass, T3 fed with Pangola grass hay, and T4 fed with Pangola grass ensiled with 5 % molasses.

The results showed that the crude protein (CP), ether extract (EE) and ash contents of the Pangola grass + 5 % molasses silage in T4 were significant higher than those from the other treatments (9.3, 2.6 and 13.3, respectively;  $p < 0.05$ ) while organic matter (OM), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and nitrogen free extract (NFE) contents of T3 were higher than the rest (91.5, 73.5, 42.2, 4.9 and 51.2, respectively;  $p < 0.05$ ). However, crude fibre (CF) content of fresh Pangola grass (T2) was higher than of Napier grass, Pangola hay and Pangola grass silage (31.4, 31.2, 31.1 and 30.5 %, respectively;  $p < 0.05$ ). The digestibility coefficients of DM, OM, CP and EE of Pangola grass silage (T4) were the highest (75.7, 65.2, 57.8 and 50.9, respectively;  $p < 0.05$ ). The metabolisable energy (ME) of T4 was also significantly higher than those of T2, T3 and T1 (8.5, 8.4, 8.1 and 7.7, respectively;  $p < 0.05$ ). The net energy lactation (NEL) in T4 was higher than in the other treatments (4.95, 4.38, 4.85 and 4.63, respectively;  $p < 0.05$ ).

**Keywords:** Metabolizable energy, net energy lactation, Napier grass, nutrient digestibility, Pangola grass

## Growth of Pigs Fed with *Vigna unguiculata* Herbage Meal as Protein Supplement

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Smallholder pig producers in tropical countries often have limited access to protein concentrates or are confronted with fluctuating, often high prices, which decrease their profit considerably. Thus, the suitability of cowpea (*Vigna unguiculata*), an herbaceous annual legume, which could be grown on-farm in a range of different subhumid and humid tropical environments, was assessed as a protein supplement.

Fourteen female pigs (Piétrain-Large White  $\times$  Landrace-Large White) were utilised to evaluate the productive behaviour in the phase of 25–60 kg live weight, being fed with cowpea herbage meal (*Vigna unguiculata* 9611) as partial protein supplement. They were kept in individual units with feeder and sipper tubes. A completely randomised block design with 3 treatments and 5 replicates was employed. The diets were balanced in protein, energy and fiber according to their theoretical chemical composition to equally nutritive contribution for fattening pigs with high genetic potential, thus: Control (a mix of maize, soy, wheat bran and vegetable oil), cowpea 15 %, cowpea 30 % (cowpea meal representing 15 or 30 % of the protein of the diet). The adaptation period was 7 days, the measuring period 49 days. The diet was offered according to the appetite of the pigs during the week of acclimatisation, *i.e.*, 90 g dry matter (DM)/kg metabolic live weight ( $LW^{0.75}$ ). This quantity was maintained throughout the experiment, distributed in 2 rations per day.

There were no significant differences ( $p > 0.05$ ) between treatments for the variables daily live weight gain ( $640 \pm 100$ ,  $570 \pm 30$  and  $590 \pm 50$  g d<sup>-1</sup>), daily feed consumption ( $1582 \pm 82$ ,  $1484 \pm 91$  and  $1590 \pm 35$  g d<sup>-1</sup>), daily feed consumption in terms of kg DM/ $LW^{0.75}$  ( $85 \pm 1.8$ ,  $84 \pm 2.1$  and  $85 \pm 1.0$  g kg<sup>-1</sup>  $LW^{0.75}$ ), nor in terms of feed conversion (2.49, 2.59 and 2.69). It was concluded that an inclusion of 33 % cowpea herbage meal in the total diet can give good growth results.

**Keywords:** Growing pigs, feed conversion, herbaceous legume, tropical forage, *Vigna unguiculata*

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## Biomass Production and Relative Palatability of Possible Supplementary Forage Plants of the Northeastern Amazon

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In the Bragançana region of north-eastern Pará, Brazil, the sustainability of extensive small-holder pastures is constantly jeopardised by resprouting trees of the native secondary vegetation. While most trees are feared weeds, some of them might be useful on farms as they are often completely defoliated, thus obviously palatable to cattle. As these species might be cheap supplementary forage alternatives, we compared its leafy biomass production and relative palatability against well-known forage legumes. An on-farm buffet trial was conducted on a 0.5 ha pasture at Igarapé-Açu (47°36'W/1°08'S). Six native species, namely *Attalea maripa* (Arecaceae), *Cecropia palmata* (Cecropiaceae), *Phenakospermum guyanense* (Strelitziaceae), *Abarema jupunba*, *Inga edulis* (both Fabaceae), and introduced *Tithonia diversifolia* (Asteraceae), *Mangifera indica* (Anacardiaceae), and *Racospermum mangium* (Fabaceae) were tested against *Cratylia argentea* and *Flemingia macrophylla*. Twenty-five saplings of each species were planted on 25 m<sup>2</sup> plots, repeated eight times in a randomised block design (n=80 plots, n=2000 saplings). After 24 months of establishment time, the buffet trial was grazed by four mixed-bred steers (mean liveweight: 506 kg; 2 AU ha<sup>-1</sup>) for one week. The results showed that most tested species had a comparable leafy biomass production and palatability: *R. mangium* 455 kg ha<sup>-1</sup> (standard deviation: 429) / consumed biomass: 21%; *F. macrophylla* 260 (89)/ 13%; *C. argentea* 164 (87)/ 40%; *P. guianensis* 156 (13)/ 1%; *M. indica* 156 (19)/ 25%; *A. jupunba* 140 (13)/ 29%; *I. edulis* 94 (9)/ 8%; *C. palmata* 88 (20)/ 60%; *A. maripa* 60 (13)/ -%; and *T. diversifolia* 57 (62)/ -%. The establishment of the buffet trial was problematic and transplantation of saplings to a soil-compacted pasture can not be recommended to farmers as mortality was high and growth rates were low. For instance, individuals of *A. maripa*, *P. guianensis*, and *T. diversifolia* were still too small to be evaluated for their palatability. However, as most species showed a palatability between the two reference legumes and had an acceptable biomass production, they are interesting supplementary forage plants. Consequently, smallholders possess freely accessible forage alternatives that should be at least tolerated if not fostered on pastures.

**Keywords:** Agro-silvo-pastoral systems, cafeteria trial, cattle browsing, secondary vegetation, smallholdings

## Energy and Protein Supplementation can Improve Liveweight Gain of Steers Grazing Good Quality Tropical Pasture in the Wet Season

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To achieve market standard weight at younger age requires a higher growth rate of grazing steers either in the wet and the dry season. The present experiment aimed at maximising wet season growth rates by providing extra energy and protein to steers grazing good quality tropical pasture during the wet season. Twenty-five Brahman crossbred steers ( $203 \pm 4.2$  kg) were allocated to 5 treatments, namely control (Con; grazing only), Con + molasses/urea (3 % urea) at an intake of 0.5 % liveweight (W) (5MU) or 1.0 % W (10MU), and Con + mixture of molasses/urea (55 %), fish meal (25 %) and whole cottonseed (WCS; 20 %) at an intake of 0.5 % W (5MWF) or 1.0 % W (10MWF). All steers grazed fertilised Pangola grass pasture (*Digitaria eriantha* cv Steudal) for 84 d between January and April (wet season). Total dry matter (DM) for all paddocks was maintained at  $> 1.9 \text{ t ha}^{-1}$ . Mean green leaf yield was  $1.9 \text{ t DM ha}^{-1}$ . *In vitro* dry matter digestibility was 64 % and crude protein content was 15 %. Control steers gained weight at  $960 \text{ g d}^{-1}$ . Providing molasses/urea did not increase liveweight gain (LWG) but inclusion of fishmeal and whole cottonseed markedly increased ( $p < 0.05$ ) daily LWG above control by 34 % and 39 % for 5MWF and 10MWF, respectively. There was no statistical difference in the LWG response between the levels of supplement feeding. It was concluded that provision of molasses/urea as rumen fermentable energy and protein alone will not increase LWG of steers grazing good quality Pangola grass pasture, but the inclusion of whole cottonseed and fishmeal will significantly increase LWG, most probably as a result of the higher bypass protein and energy intake from the MWF supplement.

**Keywords:** Energy bypass protein, grazing, Pangola grass pasture, steers, tropical pasture

## Quality Characteristics of Wheat and Rice Straw Traded in Indian Urban Centres

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Mainly due to dietary traditions, dairy production is the most important livestock activity in South Asia. Feed may constitute over three quarters of input costs and is therefore a major constraint. On the other hand, increasing milk yields for higher productivity demands feeds with a higher concentration of nutrients. Currently, over half of all feed is contributed by crop residues. This also applies to the irrigated areas, where both human and dairy animal populations are concentrated. Here, wheat and rice straw form the most important crop residues. In order to assess the potential for improving the quality of these feeds, chopped straw samples were collected monthly over a period of one year from markets in three urban centres and characterised both by trader expertise, laboratory analysis and market data.

It appears that overall perceived quality is mainly determined by quality traits linked to harvest technology (particle length) and post-harvest factors (colour, moisture content, purity). Despite some knowledge on the quality differences between crop varieties, this information is not carried through the value chain and is therefore not considered in evaluating straw. Alone “thinness of whole straw” in rice is an important price determinant and could be linked to variety. Compared to previous analyses on a large number of rice cultivars, the average digestibility in the analysed samples is low. It is not clear whether this is due to the varieties grown or management factors. Of the investigated nutritional qualities only digestibility appears to have an effect on price, but it is weak compared to the effect of “city” on price. This can be explained by differing supply and demand developments. For instance, the degree in which the two straw types were seen as substitutes and the seasonality in straw supply varied considerably between the studied cities.

**Keywords:** Cereal straw, feed quality, fodder markets, India, price determination

## Impact of Rangeland Degradation on the Pastoral Production Systems and Livelihoods of the Zanjan Pastoralists in Iran

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Arid and semi-arid rangelands that serve as the resource basis for the livestock production system known as the pastoral production system in Iran are under enormous threat. Unsustainable production is an inevitable consequence which, in turn, causes declining trends in rangelands, transformation of good rangelands into poor ones and of the latter into non-productive lands. Zanjan province (Iran) with an area of 36,400 km<sup>2</sup> has a mostly rural, population of 964,601. There are over 12 920 km<sup>2</sup> of rangeland in Zanjan representing some of the most ecologically diverse areas within the province.

A survey was conducted in two pastoral areas (districts; Mahneshan and Tarom) in the North and South zone of Zanjan region with the aims of assessing the status and trends of rangeland degradation, and understanding the impact on livelihoods and perceptions of the pastoralists over a 30 year period (1979–2009). According to population four villages in Mahneshan and two villages in Tarom, 65 households per village and one elder pastoralist (60–75 years old) per household were randomly selected. The elders were interviewed by using of questionnaires and open discussions. Additional Data were collected from Natural Resources office in capital of province and current rangeland conditions were calculated by modified four factor method. The results revealed that drought, aridity and rangeland degradation have increased over time due to environmental degradation and mismanagement of rangeland resources.

Changes in vegetation ecology have drastically ( $p < 0.05$ ) altered the livestock productions and consequently households income was decreased dramatically. Poor and very poor rangelands couldn't support pastoralist systems and livestock production didn't provide sufficient income for food, house and education especially for new generation and many younger peoples leaves their occupation in village and immigrated to Zanjan city. These results show that poverty has increased over time. Traditional coping mechanisms are reported to be failing due to increasing environmental and rangeland degradation and lack of national policies to minimise or solve the problems. These findings offer a new perspective for communal rangeland management research, particularly in arid and semi-arid areas.

**Keywords:** Livestock, mismanagement, pastoral, rangeland, Zanjan

## The Role of Key Resources to Ensure Livelihood Security and Ecological Sustainability: A Range Management Modelling Study

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Semi-arid grazing systems are prone to ecological change due to rising climatic variability and land use change. While facing increasing vulnerability, range management needs to focus on ecological factors that limit livestock in the long term. We therefore present a mechanistic approach, which enables us to identify key resource areas for sustainable land use during droughts. Key resources are suspected to preserve livestock herds during scarce times while, in the absence of these areas, animal numbers decline. It is crucial that pastoral people whose livelihood depends solely on a minimum number of livestock identify limits of local key resources and determine the time when external resources are needed (bottle-necks).

We present an innovative holistic approach using resource portfolios to identify and to assess resources within the variable environment and within different socio-economic contexts. With a grazing model, simulating a heterogeneous distribution of vegetation, seasonal shifts of growth periods, and stochastic rainfall, we evaluate the relative value of each pasture to maintain the number of livestock. We show how different socio-economic contexts such as market access and external fodder resources change the importance of local key resources during droughts. We hypothesise that, when external fodder is supplemented, the relative contribution of natural resources in fulfilling the fodder demand decreases. However, during crisis (*i.e.* droughts, market crisis), the value of key resources may increase again. But for that, it is required that key resources have previously not been degraded by non-adapted use. Thus, times of crisis reveal potential pitfalls in a vulnerable rangeland if the maintenance of a certain amount of buffer was neglected.

Hence, our modelling approach allows the evaluation of how socio-economic conditions influence the role of natural resources for livelihood security and ecological sustainability in rangelands.

**Keywords:** Ecological sustainability, key resources, livelihood security, resource portfolio, semi-arid rangeland

## Management for Optimal Grazing Distribution of an *Andropogon lateralis* Community in Corrientes, Argentina

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Heterogeneous subtropical grassland in central Corrientes (Argentina) comprises a great number of communities. The “pajonal”, dominated by *Andropogon lateralis*, accumulates a high density of inflorescences during the fall which difficult the grazing by herbivores. Undesirable grazing distribution results in inefficient forage utilisation. Managers can increase uniformity of grazing and increase the utilisation. The aim of this study was to determine the pattern of cattle distribution on pajonal in winter after cutting it to facilitate grazing. The study was carried out in a paddock (90 ha) at INTA’s Mercedes Experimental Station with 5 ha of pajonal. Seven Braford heifers fitted with GPS collars were used to determine spatial distribution of grazing during 6 consecutive days pre-cut and 6 consecutive days post-cut the pajonal, in August 2009. The GPS collars were provided by the Project PICT 06 N°1488, AN-PCyT/UNMDP, Argentina. Stocking rate was 1 heifer ha<sup>-1</sup> (average 210 kg heifer<sup>-1</sup>), they were supplemented with 1.3 kg heifer<sup>-1</sup> día<sup>-1</sup> of sunflower pellets on a deferred grassland. GPS collars recorded animal locations at one minute intervals. Only grazing locations were considered. Locations recorded 20 m around water points, mineral supplement, and data points with animal velocities < 0.5 and > 10 m min<sup>-1</sup> were discarded. An index was calculated to determine the site selection:  $ISci = Tri \times Sri^{-1}$ ; where  $Tri = (\text{grazing time in community}) \times (\text{total time of grazing})^{-1}$  and  $Sri = (\text{face of community}) \times (\text{face of the paddock})^{-1}$ . Similar indices between communities indicate similar preference in the selection. The ISci was analysed by ANOVA ( $\alpha = 0,05$ ). Post-cut forage availability of pajonal was 32 % lower than pre-cut and cut forage was conserved as hay. During pre-cut the ISci was smaller in pajonal than in the rest of the paddock (0,13 vs. 1,10 respectively). When the pajonal was cut, the heifers grazed it and there were no differences between ISci for the pajonal and the non-pajonal areas of the paddock (0,84 vs. 0,90 respectively). Cutting pajonal improves its utilisation efficiency.

**Keywords:** Argentina, Corrientes, GPS-collars, grazing behaviour

## Forage Strategies to Overcome Extreme Weather Events in the Humid Subtropical Argentina

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Corrientes province located in northeastern of Argentina has 5 million of cattle. Mean annual rainfall is 1300 mm (1890/2004 series) with neither markedly dry or a markedly wet season, and no frosts. Adapted cultivated pastures need these rainfall conditions to grow. In the last five years (2004–2009) total annual rainfall decreased and seasonal distribution was modified falling on late autumn and winter. Long periods of drought affected quantity, quality and distribution of forage supply. The objective of this study was to evaluate forages species adapted to less than 1000 mm rainfall and 100 day length of the growing period to increase supply fodder forage in critical periods of rainfall deficit. The experiment was developed at the Experimental Station INTA Corrientes on a flooded Aquic Argiudol, acidic and poor phosphorus contents during a period of negative water balance (December to February). Five different forage species were sown: *Cenchrus ciliaris* cv and cv Bisset, *Panicum colouratum* cv Klein, *Panicum maximum* cv Bambatsi and *Chloris gayana* cv Epica in the two different dates D1 = 18/12/2009 and D2 = 2/03/2010. Several variables were recorded weekly: temperature, soil moisture and as the days post sowing (DPS) emergence (EM), vegetative state (VS), flowering (Flo) and end of cycle and mature seeds (ECMS).

In this work we present the results of D1. Average temperature (°C) and humidity (%) respectively were in December: 29°C and 10 %, January: 27°C and 13%; February: 28°C and 9 % and March: 24 °C and 9 %. *Cenchrus ciliaris* cv Biloela and *Panicum maximum* cv Bambatsi, showed similar EM = 16 DPS, VS 43 DPS; Flo = 50 DPS and ECMS = 101 and 94 DPS respectively. Preliminary results indicate that *Cenchrus ciliaris* cv Biloela and *Panicum maximum* cv Bambatsi are promising for grazing or hay for periods of shortage rainfall.

**Keywords:** Argentina, *Cenchrus ciliaris* cv Bisset, extreme weather events, forage strategies, *Panicum maximum*,

## **Beef Cattle Feeding Systems and Measuring Sustainable Agriculture in Bac Kan Province, the Northern Mountainous Region, Viet Nam**

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Indigenous cattle in Northern Mountainous Region of Viet Nam (NMR) are often kept in free ranging, part-time grazing and Cut & carry systems. Local Yellow beef cattle breeds are predominantly raised by small farmers in free ranging or part-time grazing systems. H'Mong cattle are often kept in Cut & carry feeding system. In Bac Kan, cattle production is accounted for an important proportion in the total output of livestock sub-sector (29 %), while it is accounted for small part in the country. To help local people in uplands to escape from poverty, many organisations have initiated projects to develop beef cattle. Modalities for a sustainable cattle production have been promoted as a perspective solution to enhance economic growth and livelihoods for farmers, especially poor farmers. However, cattle sub-sector still remains under-developed, hence generally high poverty faced by farmers. The study is carried out to determine the impact of selected beef cattle feeding systems on economic, environmental and social dimensions of sustainable agriculture.

A formal survey using structured questionnaire was conducted in 97 households in three systems. To measure sustainable cattle feeding systems, social (employment opportunity, proportion of time used in cattle production, role of women), environmental (stoking rate, manure utility, manure storage, farmers' awareness in manure issues) and economic indicators (gross margin) were selected.

Keeping cattle in Cut & carry system creates better employment opportunities, higher economic efficiency, but larger risk on environment from manure. Ranking second in efficiency of economics and employment opportunities is part-time grazing system. The lowest employment opportunities and rather poor economic efficiency are presented in Free ranging system. High proportions of manure running out to environment is recorded among systems, which are indicated by lack of favourable preservation methods in households and low level of cattle manure using resulting in high pollution for households living in study sites.

**Keywords:** Cattle feeding systems, economic efficiency, environmental sustainability, northern mountainous region, social solidarity, sustainable agriculture, Viet Nam



## Performance of West African Dwarf Sheep Fed *Andropogon tectorum* Interplanted with *Lablab purpureus* I.147 in the Derived Savannah Zone of Nigeria

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The project examines the performance of West African Dwarf sheep randomly assigned to four different experimental diets of *Andropogon tectorum* interplanted with *Lablab purpureus* at 0 (T1-control); 2.5 (T2) ; 5.0 (T3) and 7.5 m (T4) inter-row spacing.

Proximate analysis was carried out after twelve (12) weeks of plant regrowth. It revealed that the nutritive value of the grass was enhanced by the legume (*Lablab purpureus*) interplant. The crude protein, ether extract and ASH contents of the grass increase as the inter-row spacing decreases with the heighest value observed in treatment T2. Dry matter and nitrogen free extract (NFE) showed no significant ( $p > 0.05$ ) difference. Crude fiber content was observed to decrease with decreasing *Lablab purpureus* inter-row spacing. The performance of the WAD sheep revealed that dry matter, crude fibre, ether extract and NFE intakes were similar ( $p > 0.05$ ) among the various treatment. The crude protein intake and ash intake (g) was the lowest in animals fed T1 (25.49 g and 11.85 g, respectively) while the highest values were found in T2 with (31.66 g) and (17.75 g, respectively). Digestibility coefficient followed the same trends with crude protein, ash and ether extract being the highest in animals fed T2. Though animals fed T2 showed the highest daily weight gain (49.4 g), it was similar ( $p > 0.05$ ) to animals on T3 while the lowest gain was observed in animals fed T1 (sole grass). This study shows that animals would thrive well on wide legume inter-row spacing even up to 5.0 m to reduce the cost of seed procurement.

**Keywords:** *Andropogon tectorum*, WAD sheep

## The Effect of Forage Based Diets on Milk Composition, Lactation Stages and Growth Rate Kids from West African Dwarf (WAD) Goat in South West Nigeria

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In Nigeria, there are three dominant breeds of goat in the hand of smallholder farmers. These are Sahel, red sokoto and West African dwarf (WAD) but the most common breed in southern part of Nigeria is WAD goat. The study, therefore, investigated effects of five different forages using *Panicum maximum* as control on milk composition, stages of lactation and growth rate of WAD goat kids. Twenty one (21) WAD does with their kids were randomly allotted to different forages in a complete randomised design. The forages were: *Albizia odoratissima*, *Gliricidia sepium*, *Leuceana leucocephalla*, *Spondias mombin*, *Ficus thonningii* and *Panicum maximum* as control. The forages were available all year round suggesting their utilisation as dry season feed for ruminants. All forages, except *P. maximum*, contained per kg of dry matter (DM): 14–24 % crude protein (CP), 5–9 % ash, and 45–60 % neutral detergent fibre (NDF). Animals were supplemented with a compounded ration at 2 % body weight.

The lactation length was 12 weeks (84 days) and the effect of diet on milk composition was significant ( $p < 0.03$ ) with a CP content ranging from 3.5 to 4.2 %, milk fat 3.5 to 4.2 %, solid-not-fat 11.7 to 13.3 %, and total ash 0.76–0.96 %. The highest value for CP in milk was found for the treatment with *Albizia odoratissima*. Also, the contents of milk protein (3.00 to 3.80 %), fat (3.47 to 3.88 %) solid not fat (11.31 to 13.24 %), lactose (4.20 to 4.53 %) total ash (0.64 to 0.82 %), and total solid (14.83 to 17.12 %) varied significantly ( $p < 0.05$ ) among the different stages of lactation. In contrast, the pH of milk (6.75 to 6.99) did not vary among the treatments.

The weaning weight of kids at twelve weeks of age was found to be significant ( $p < 0.005$ ) different. This value ranged between 3.73 and 5.47 kg. The study revealed that the forage quality had an effect on milk composition which then influenced weaning weight of kids. It is therefore suggested that browse plants or concentrate supplementation should be encouraged for low quality pasture like Guinea grass.

**Keywords:** Forages, milk composition, WAD goat, weaning weight

## Effect of Alternative Feeds Characteristic for Mediterranean Dry Areas on the Quality of Milk and Dairy Products from Awassi Sheep

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Small ruminants constitute an integral part of the farming system in many dry areas of the Mediterranean basin. Alternative feeds may provide a solution to overcome the frequent shortage of feeds but their successful integration depends on their ability for improving milk production without negatively affecting the quality of milk and dairy products. In the present study, five alternative feeds were compared to a control diet in an experiment conducted at ICARDA, Syria. Per diet, ten Awassi ewes ( $51.0 \pm 6.5$  kg) were allocated in a randomised block design considering days-in-milk, milk yield and composition. Diets were isonitrogenous and isoenergetic, and had forage:concentrate ratios of 0.3:0.7. The test feeds constituted 30 % of the diets replacing control diet ingredients (barley straw by lentil straw, olive leaves or Atriplex leaves; and wheat bran/cottonseed meal by olive cake or tomato pomace). Animals were group-fed with 2.5 kg dry matter/day and water ad libitum. The experiment lasted for 50 days and milk sampling and yield were recorded weekly. Three times milk was pooled per group and processed to yoghurt and fresh cheese. In addition to mechanical texture measurements, compositional analyses and sensory tests were performed. Data were subjected to GLM (effects: diet and time). Milk yield and composition of milk and processed products changed with time, but did not significantly differ among treatments, except after six weeks, with a high milk fat content from diets containing tomato pomace (7.5 %) and olive cake (7.4 %). The traditional feed resulted in the highest yogurt firmness (0.266 N) followed by the Atriplex diet (0.190 N), while yoghurt was softest with tomato pomace (0.114 N). The olive cake diet provided the hardest cheese (0.726 N) while cheese was softest with lentil straw (0.429 N). Consequently, the sensory panel ranked yoghurt from traditional feed (4.2/5) and cheese from olive cake (4.0/5) first, while diets with olive cake (3.7/5) and olive leaves (3.2/5), resulted in lowest scores for yoghurt and cheese, respectively. The results suggest that balanced diets with alternative feeds can be successfully introduced as the quality of dairy products is mostly similar or even slightly better than those from traditional feeds.

**Keywords:** Atriplex, Awassi sheep, livestock, olive cake, ruminant, tomato pomace

## Is the Methane Mitigating Potential of Tropical Woody Forage Species Reduced after Adapting the Ruminants to Tanniniferous Forage?

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Forages obtained from woody plants are important for tropical livestock feeding, especially during the dry season. A special feature is their often high content of plant secondary compounds (PSC) which are, although being potentially adverse with respect to forage intake and digestion, of great interest because some of them are able to mitigate the greenhouse gas methane. One persistent concern in that respect is that methanogens might rapidly adapt to PSC thus making this effect short-lived. Therefore, the present study investigated the *in vitro* fermentation of woody plants in ruminal fluid obtained either from PSC-adapted sheep (n=3), or from non-adapted control sheep (n=4). Adapted sheep received tanniniferous *Leucaena leucocephala* and concentrate with 15 % *Mimosa caesalpiniaefolia* besides grass hay during 6 weeks before ruminal fluid sampling while control sheep grazed on cultivated *Brachiaria* pastures and were supplemented with concentrate without *M. caesalpiniaefolia*. Experimental plants included four rarely studied woody species (*Caesalpinia* spp., *Sida cordifolia*, *Astronion urundeuva*, and *Desmanthus virgatus*; harvested at three sites of the semi-arid Caatinga region, NE-Brazil) and *L. leucocephala*. Ruminal fermentation traits were determined *in vitro* using the gas pressure transducer technique. The crude protein contents ranged from 206±33 g/kg dry matter (DM) (*L. leucocephala*) to 110±2 g/kg<sup>-1</sup> DM (*Caesalpinia* spp.). The highest total phenol and total tannin contents were found in *A. urundeuva*, with 243±77 and 201±64 g/kg<sup>-1</sup> DM, respectively, while values were lowest with *D. virgatus* (45±13 and 29±9 g/kg DM). Overall, ruminal fluid from control sheep showed higher ( $p < 0.05$ ) ammonia concentration, net gas production and net methane yield (% of total gas) than that of PSC-adapted sheep. In contrast, there was no significant difference between the two treatments in *in vitro* organic matter degradability. Overall, the plant species effect was significant for all fermentation traits mentioned, with the plant-treatment interaction being not significant. The lowest percentage of net methane yield found with *A. urundeuva* was consistent with the prevalence of phenolic compounds. The present results indicate that a 6-week adaptation to tanniniferous plants did not result in a noticeable adaptation of ruminal methanogens which otherwise would make these plants' methane mitigating ability useless.

**Keywords:** Agroforestry, Brazil, greenhouse gas, livestock, nutrition, rumen

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## Silages of Tropical Forages for Feeding Pigs

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Tropical legumes and some grasses show high levels of crude protein content which makes them attractive not only for ruminant nutrition but also for monogastric farm animals. The use of fresh forages for pig feeding is however limited because of different reasons: their fiber, bulkiness, high water content and low energy concentration, their seasonal availability sometimes being restricted and their content of anti-nutritional components such as tannins and trypsin inhibitory activity. Thus, processing to silage was tested as one option for conservation, during which water content and anti-nutritional factors might be reduced.

The legumes *Vigna unguiculata*, *Stylosanthes guianensis*, *Centrosema brasilianum*, *Cratylia argentea*, *Flemingia macrophylla*, *Desmodium velutinum*, *Leucaena diversifolia* and the grass *Brachiaria* hybrid Mulato II were harvested before flowering, chopped and ensiled at a target dry matter of >30 % in small plastic bags on lab scale in 4 different treatments: control, addition of sucrose (2 % of fresh weight), inoculated with a lactic acid bacteria (LAB) strain and LAB+sucrose.

Samples were analysed before ensiling on their nutritional value. After 3d and after 90d of ensiling, silages were evaluated at 25°C on DM losses, quality and aerobic stability. Buffering capacity before ensiling, which can restrict acidification, was highest in *Vigna* (13.6) and lowest in *Flemingia* (3.3). The pH after 3d of ensiling was always lowest in the treatment with LAB+ sucrose. This trend was maintained over the 90d of ensiling. In the control treatment after 90d, lowest pH was found in the grass (4.5) as expected, and was  $\geq 4.9$  in all legumes. Both are too high according to Deutsche Landwirtschafts-Gesellschaft in relation to the corresponding DM. The five best silages in this respect were obtained with *Desmodium* with LAB (without or with sugar), *Flemingia* and Mulato II when treated with LAB+sucrose and *Stylosanthes* with sucrose (without or with LAB). Worst silages were from *Centrosema* without sucrose indicated by a strong butyric acid smell. Highest overall DM losses were observed in Mulato II, *Cratylia* and *Vigna* silages (30–19 %), followed by *Desmodium* control silage (16 %).

In general, silages were stable over 4 days of exposure to air.

**Keywords:** *Brachiaria*, *Centrosema*, *Cratylia argentea*, *Desmodium*, *Flemingia macrophylla*, *Leucaena diversifolia*, pigs, silage, *Stylosanthes guianensis*, *Vigna*

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## **Intake and Digestibility of Ensiled Cassava Wastes and *Albizia saman* Pod Mixture by West African Dwarf Sheep**

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One of the major problems of feeding ruminants worldwide is the seasonal variation in the availability and nutritional value of native pasture. Conserved Cassava waste and *Albizia saman* pods have great potentials to bridge the gap in forage supply during this period.

The study was conducted to determine the effect of ensiling on feed intake and digestibility by WAD sheep. The nutritive value of cassava wastes (CSW) and *Albizia saman* pod (ASP) silage as indicated by chemical constituents were also determined. Yearling ewes with an average live weight of 17.10 kg were randomly assigned to five treatments with three (3) replicates each comprising: 100 % CSW, 75 % CSW + 25 % ASP, 50 % CSW + 50 % ASP, 25 % CSW + 75 % ASP, 100 % ASP. The result of the feeding trial showed that there were significant difference ( $p < 0.05$ ) in feed DM intake ( $284.25 - 469.14 \text{ g day}^{-1}$ ), weight gain ( $-0.62 - 4.80 \text{ g d}^{-1}$ ), apparent digestibility of crude protein (CP) ( $35.48 - 75.21 \%$ ), nitrogen balance ( $-1.04 - 16.71 \text{ g d}^{-1}$ ) and nitrogen retention ( $-11.59 - 71.01 \text{ g d}^{-1}$ ). Ewes fed with 25 % CSW + 75 % ASP had highest feed intake and the least for those on sole CSW. Weight gain of ewes fed 25 % CSW+75%ASP silage increased significantly while those fed 100 % CSW lost weight and 100 % ASP maintained theirs. Nitrogen balance was apparently highest in ewes consuming 100 % ASP and the least for 100 % CSW. The nitrogen retention of the ewes on 100 % ASP diet was significantly higher ( $p < 0.05$ ) than that for 100 % CSW diet.

It can thus be concluded that ensiling cassava wastes or *Albizia saman* pod solely as a dry season feed for sheep may be unsuitable, but when in combination will give a good feed resource

**Keywords:** *Albizia saman* pod, cassava wastes, ewes, intake, weight gain, yearling

## Effect of Management and Feed Supplement on the Performance and Fertility of Desert Sheep Raised under Range Conditions of Kordofan

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The study was conducted in North Kordofan State, Sudan with the objective to study management effects and addition of concentrates on desert ewes' fertility, lambs' body measurements, and birth weight as well as live weight changes of lambs grazed on natural pasture.

The study used (80) Hammari desert ewes and three rams by the rate of 1 ram per 27 ewes, the ewes were randomly divided into four equal groups of 20 ewes. No significant differences were detected among groups at the beginning of the experiment. The first group left to graze natural pasture from 6: pm to 7: am, stayed under shade from 8: am to 5: pm and were watered once every 3 days, the second group was allowed grazing natural pasture from 6: pm to 7: am, stayed under shade from 8: am to 5: pm and drank daily, the third group was also kept on natural pasture from 6: pm to 7: am stayed under shade from 8: am to 5: pm, drank daily and received a concentrate at the rate of 1 kg per ewe and day, while lambs in the same group were offered concentrate at the rate of 250 g per head and day, and the fourth group was left on the natural pasture all the day long and watered once every five days (control: as simulating the traditionally management method).

The birth weight, weekly body weight of the lambs, and the monthly body weight of the ewes was recorded. Also number of pregnant and non-pregnant ewes, and the number of delivery and abortion was recorded.

The results showed that the supplemented ewes of the third group recorded higher fertility rates, number of twins, weaning percentage and low abortion percentage compared to the control. The results also revealed that the third group lambs had the highest birth weight. Type and sex of birth of lambs had positive effects on birth weights so that single birth lambs were heavier than twins and the birth weight of males was higher than that of females.

**Keywords:** Feed supplementation, Fertility, Kordofan, management, Performance

## Treating Baled Wheat Straw with Urea is better than Treating Chopped Wheat Straw with Urea

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This study was conducted to test the simplicity of treating wheat straw with urea. Wheat straw was prepared in two physical forms including chopped straw (ChS) and baled form (BS). then it was sprayed with urea mixed water in amount of 5 % urea and 100 liters of water per 100 kg of straw (DM basis). After 4 weeks the treated straw as well as initial straw (IS) were sampled for *in vitro* measurements. The *in vitro* digestibility was determined for DM and OM. *In sacco* degradability was measured, using of 3 fistulated male cows. Results indicated that treatment significantly ( $p < 0.05$ ) increased the DM and OM digestibility of the straw. The degradability of DM in 8, 16, 24 and 72 h post incubation was significantly ( $p < 0.05$ ) higher in treated straw than the IS. The gas test method was used to measure the gas production of the samples. The treated straw showed significantly ( $p < 0.05$ ) higher amount of gas production after 2, 4, 6, 8, 12 and 24 h of incubation as the other samples.

In a feeding trial, 3 diets containing 40 % of IS, ChS or BS, respectively, were fed to Holstein male calves (6 head per diet) for 4 months. During this trial DM intake and daily gain were recorded and *in vivo* DM digestibility of the diets was measured. Results showed that the DM intake and average daily gain were significant ( $p < 0.05$ ) different among the diets, but no significantly differences was observed for the DM digestibility of the diets. Economic estimation showed that the feed cost per kg of live weight gain was 13 104 Rial for the normal straw diet while these costs for the baled treated straw diet amount 12 194 Rial.

**Keywords:** Baled straw, chopped straw, degradability, Wheat straw



# Animal nutrition and supplementation

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## **Inference of Ruminant's Activity using GPS-based Animal Tracking Technologies**

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Evaluations of range-animal behaviour and its relation to resource selection have been limited by reliance on human observation with high data collection costs, radio telemetry with poor spatial precision or GPS at long logging intervals. With the recent advances in technology, it has become possible to continuously record animal positions via GPS logging at very short intervals. However, continuous logging produces enormous amounts of data which are difficult to analyse without special algorithms. The objective of this study was to develop new techniques for identifying locations where animals were stationary, classify animal movement and to relate this information to traditional behavioural activities. We designed and tested three algorithms to help not only interpret the position data but also classify animal activity. Animal with GPS collars were periodically observed during daylight hours by trained technicians who recorded the time and related activity of animals on data forms. Three algorithms were tested to separate positions into two classes, moving and stationary. Algorithm 1 identified and classified sequential points in close proximity as non-moving; Algorithm 2 searched the data for a user-defined number of positions. Mean and standard deviation of the position were calculated then sequential adjacent positions (in time) were added to the growing group as long as they were a non-significant distance from the position of the group. The computer then searched for the next best seed group. Groups were constructed until the remaining GPS points did not meet requirements for seed groups, then minimum convex polygons were created around the point clusters and an information file created that recorded group number, position, surface area, start time, end time and duration of occupancy at that location. The third algorithm examined the pattern of velocities recorded by the GPS by calculating running means over 1-minute intervals for the entire day. These algorithms were first tested on cattle and goats in eastern Oregon, then on sheep in northwestern Syria. The proposed techniques enables behavioural scientist to analyse animal spatial and temporal behaviour and resource selection at a resolution that could not be accomplished in the past without extreme investment in time and capital.

**Keywords:** Animal behaviour, GPS collars, grazing, small ruminant, spatial analysis

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## Evaluation of Protein Quality of Seed Materials of *Mucuna pruriens* as a Feed Ingredient for Broiler Birds

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The seed materials of velvet bean (VB) [*Mucuna pruriens* (L.) DC. var. utilis (Wall. ex Wight) Baker ex Burck], an under-utilised food legume collected from South India, was analysed for nutritional profiles and also the effect of incorporation of velvet bean meal (VBM) as an alternative protein ingredient in the poultry feed on growth performance of broiler birds was investigated. The VB seed samples were found to contain appreciable levels of crude protein (265 g kg<sup>-1</sup> DM), crude lipid (65.1 g kg<sup>-1</sup> DM), neutral detergent fiber (84.3 g kg<sup>-1</sup> DM) and ash content (49.2 g kg<sup>-1</sup> DM). Soaking in sodium-bi-carbonate solution + autoclaving treatment was found to cause substantial reduction on the levels of antinutritional compounds such as tannins (decrease by 75 %), L-Dopa (81 %), phytic acid (70 %), raffinose (92 %), stachyose (89 %), verbascose (71 %), haemagglutinating activity (75 %), trypsin inhibitor activity (78 %) and  $\alpha$ -amylase inhibitor activity (77 %) without affecting the nutritional quality of VB seeds. Such processed VBM was incorporated as an alternative protein source by replacing the soybean meal protein at 0, 20, 40, 60, 80 and 100 % levels in the commercial type broiler diets. Replacement of soybean meal up to 40 % level with VBM as an alternative protein ingredient in the poultry diet, which corresponds to the inclusion of VBM up to 15.7 % in the starter feed and 11 % in the finisher phase poultry feed, exhibited better growth performance of the broiler birds without any adverse effects. Hence, after conducting a large-scale trial and extensive toxicological evaluation, VBM could be recommended as an alternative and economic source of protein ingredient in the poultry feed, which will reduce the over-dependence on the conventional legume proteins and also reduce the feed production cost to some extent and ultimately improves the growth of poultry industrial sector in many developing countries.

**Keywords:** Antinutritional compounds, broiler diet, growth performance, nutritional value, processing method, protein ingredient, velvet bean

## Effect of Supplementation with Agro-industrial By-products on Milk Fatty Acids in Awassi Sheep

MUHI EL-DINE HILALI<sup>1</sup>, LUIS IÑIGUEZ<sup>1</sup>, HELMUT MAYER<sup>2</sup>, WILHELM FRIEDRICH KNAUS<sup>3</sup>, MONIKA ZAKLOUTA<sup>1</sup>, MARIA WURZINGER<sup>3</sup>, MATTHIAS SCHREINER<sup>2</sup>

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Resource-poor dairy sheep farmers in Middle Eastern countries face high and increasing feeding costs in particular during the milk production period. The conventional supplementary feeds used by farmers (control) are based on barley grain, wheat bran and barley straw and are often unbalanced in energy and protein contents. It has already been demonstrated that locally available feeds like cotton seed cake (CSC), molasses, sugar beet pulp (SBP) and urea-treated wheat straw (UTS) can be utilised to design balanced cost optimised diets (COD). However, the changed feeding regimes may affect product quality. This paper examines the effects of CODs on milk fatty acid profiles that are important for product quality.

Six CODs were compared with a control at the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria. Fifty-six Awassi ewes were randomly assigned to the seven groups. Animals in all COD treatments were kept on grazing as a basal diet, supplemented with the same level of crude protein (229 g d<sup>-1</sup>) and energy (18 MJ, d<sup>-1</sup>), only one group of the CODs was based on molasses and on vetch grazing. The control group received less protein (190 g/d) and similar energy levels as the COD groups. Milk samples were collected on weekly basis in April.

In three out of six COD, saturated fatty acids (SFA) decreased by 0.5–5 %, while they increased by 11 % in the vetch-COD ( $p < 0.01$ ). The vetch-COD resulted in remarkable increases in C6:0, C8:0, C10:0, C12:0 and C14:0 and decreases in C18:0 and C20:0 ( $p < 0.01$ ). An increase in C6:0, C8:0 and C10:0 was also observed in the Molasses and SBP-CODs. Monounsaturated fatty acids (MUFA) increased by 1–14 % with 3 out of 6 COD, whereas MUFA decreased 32 % in the vetch-COD ( $p < 0.01$ ). Polyunsaturated fatty acids (PUFA) increased in all CODs by 1–12 % compared to the control group ( $p < 0.01$ ). However, conjugated linoleic acid CLA c9t11 was not affected by the treatments. The observed differences in the fatty acid profiles will directly impact on the organoleptic properties of yogurt and the quality of ghee and thereby influence their market value in the Middle Eastern countries.

**Keywords:** Agro-industrial by-products, Awassi sheep milk, fatty acid

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## Prececal and Cecal *in-vitro* Digestibility of Tropical Legume Grains for Pig Nutrition

JULIETA TORRES<sup>1</sup>, CARLOS A. MONTOYA<sup>2</sup>, LUZ STELLA MUÑOZ<sup>1</sup>, SIRIWAN MARTENS<sup>3</sup>, MICHAEL PETERS<sup>3</sup>

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The high price of commercial protein sources as animal feed drives small producers to seek for alternative non-traditional sources. An experiment was conducted with tropical multipurpose legumes as possible protein sources for pigs: *Lablab purpureus* (LP), *Canavalia brasiliensis* (CB) and *Vigna unguiculata* (white WVU, pink PVU, red RVU) grains were compared to extruded full-fat soybean (SB). Nutritional composition and *in-vitro* enzymatic digestibility of protein (PD) and starch (SD) were determined (pepsin 120 min + pancreatin 240 min). Finally, an *in-vitro* cecal fermentation of the residue of the *in-vitro* enzymatic digestibility trial was modeled according to France et al. (1993) and volatile fatty acids (VFA) quantified. Protein was higher in CB and SB (291–367 g kg<sup>-1</sup>) as compared to WVU (208 g kg<sup>-1</sup>). The legume grains studied contained 316 to 560 g starch kg<sup>-1</sup>. The highest ( $p < 0.001$ ) PD was recorded for SB and WVU (76 and 66 %, respectively) and the lowest for LP (21 %). PD was negatively correlated ( $R = -0.71$ ,  $p < 0.05$ ) with trypsin inhibitor activity [LP-VU (26 vs. 22 TUI g<sup>-1</sup>), SB-CB (7 vs. 14 TUI g<sup>-1</sup>)]. SD was higher ( $p < 0.001$ ) for PVU, WVU, RVU (70, 64, 53 %) followed by LP and CB (52, 38 %). It was negatively correlated ( $R = -0.75$ ,  $p < 0.05$ ) with NDF content [CB (275 g kg<sup>-1</sup>), WVU (143 g kg<sup>-1</sup>)]. The gas production was highest ( $p < 0.001$ ) with WVU (482 ml g<sup>-1</sup> DM) and lowest for CB (335 ml g<sup>-1</sup> DM). Butyric acid production was highest in PVU and WVU vs. SB (83 and 82 vs. 29 mg g<sup>-1</sup> DM incubated,  $p < 0.011$ ). In conclusion, the superiority in PD, SD and composition of VFA suggest that *Vigna*, especially WVU, is an interesting alternative to SB because it can be produced locally by small farmers in the tropics. The raw, unprocessed application of the other grain legumes (LP and CB) is limited for pigs. Further studies on heat and other treatments as well as *in vivo* tests are indispensable for final recommendations.

**Keywords:** *Canavalia brasiliensis*, *in vitro* digestibility, *Lablab purpureus*, nutritional composition, pigs, tropical legume grains, *Vigna unguiculata*

## The Effect of Concentrate Supplementation on Feed Intake and Weight Gain of Sheep Grazing the Inner Mongolian Steppe, China

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Sheep grazing is the main reason for grassland degradation in the Inner Mongolian steppe, China. Strategies to protect the natural vegetation while satisfying farmers' interests are strongly needed. Hence, this study analysed the effects of concentrate supplementation on feed intake and live weight gain (LWG) of grazing sheep to evaluate its potential contribution to steppe conservation and sustainable livestock production.

In September 2009, a grazing trial with 77 Mongolian fat-tailed sheep ( $40.1 \pm 4.4$  kg live weight (LW)) was conducted on the Inner Mongolian Ecosystem Research Station near Xilinhote ( $116^\circ 42'$  E,  $43^\circ 38'$  N). Sheep were allotted to two moderately (GI M) and two intensively (GI I) grazed plots according to herbage allowances of 1.5–2.5 (GI M) and  $<1.5$  (GI I) kg herbage dry mass/kg LW. Organic matter intake (OMI), digestibility of ingested organic matter (dOM), and LWG were determined in four non-supplemented and four supplemented sheep per plot. The latter received  $250 \text{ g d}^{-1}$  of a corn-based concentrate for 24 d. Fecal grab samples were collected on days 19–24. dOM was estimated from fecal crude protein content and fecal excretion quantified using the external marker titanium dioxide. All sheep were weighed before and after the experiment to determine daily LWG.

Sheep's daily OMI varied between 73 (GI I) and 82 (GI M)  $\text{g kg}^{0.75} \text{ LW}$ . Although dOM was higher in supplemented than in non-supplemented sheep at all plots ( $0.60 \pm 3.7$  vs.  $0.57 \pm 1.6$ ;  $p < 0.05$ ), concentrate feeding did not increase their OMI ( $p > 0.05$ ). While OMI during grazing of GI M sheep was similar with ( $1.11 \pm 0.26 \text{ kg d}^{-1}$ ) than without concentrate feeding ( $1.04 \pm 0.11 \text{ kg d}^{-1}$ ;  $p > 0.05$ ), supplementation tended to decrease herbage intake of GI I sheep ( $1.15 \pm 0.36$  vs.  $0.97 \pm 0.35 \text{ kg d}^{-1}$ ;  $p > 0.05$ ). Concentrate feeding increased LWG of supplemented GI M ( $43 \pm 29 \text{ g d}^{-1}$ ) and GI I ( $34 \pm 61 \text{ g d}^{-1}$ ) sheep compared to non-supplemented sheep in the respective plots ( $6 \pm 44 \text{ g d}^{-1}$  and  $-33 \pm 69 \text{ g d}^{-1}$ ;  $p < 0.05$ ).

Feeding concentrates to grazing sheep increases their LWG and might compensate for farmers' economic losses caused by the recent de-stocking policies of the local government. At high grazing intensities, it decreases the animals' feed intake during grazing and thus appears to offer a promising contribution to sustainable sheep production.

**Keywords:** Inner Mongolia steppe, overgrazing, sheep, supplementation



## Effects of Urea Supplements on *in vitro* Microbial Protein Synthesis and Fermentation of two Tropical Grasses

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In diets based on low digestible forages and grasses the primary limitation for microbial protein synthesis in the rumen probably is ammonia-N. A study was conducted to evaluate the effect of two urea sources on microbial crude protein (CPM) synthesis and fermentation of *Panicum maximum* cv. Tobiatá and *Saccharum officinarum* (sugarcane) with the Rumen Simulation Technique (RUSITEC) apparatus. Sugarcane and Tobiatá (2.6 and 9.3 % CP on dry matter basis) were supplemented with a slow-release urea (SRU) or untreated urea (UU) to reach 16 % CP on dry matter basis. In total 6 treatments with four replications per treatment were considered, including non-supplemented urea (controls). Fifteen g of each diet were filled in nylon bags and incubated in the RUSITEC. Feed residues after 48 h incubation were sampled and microbes were isolated from the effluents from day 7 to 13.  $^{15}\text{N}$  was used as marker to quantify microbial protein synthesis. Fermentation of organic matter (OMfer) was corrected for OM originating from solid associated microbes which were isolated from feed residues at the last day of incubation. The results were subjected to two factorial ANOVA and significant differences were declared at  $p < 0.05$ . OMfer was higher for sugarcane than Tobiatá. Among sugarcane treatments, OMfer was higher for UU than SRU and control (51.8, 49.8, and 48.5 %, respectively). OMfer of Tobiatá was similar for both urea sources (31.7 %). Urea sources did not affect fermentation of detergent fibre fractions of Tobiatá, but incremented fermentation of fibre fractions of sugarcane, being greater for UU followed in decreasing order by SRU and control. There were no differences between urea sources in efficiency of CPM synthesis. CPM was higher for sugarcane than Tobiatá (187 vs. 163 g CPM kg<sup>-1</sup> OMfer) and both urea supplements were different compared to their respective controls. Among controls, the efficiency was higher for Tobiatá than sugarcane (36 vs. 106 g CPM kg<sup>-1</sup> OMfer). Urea improved fermentation more in sugarcane than in Tobiatá. This confirms the need for N supplementation especially in sugarcane, but also in Tobiatá. Supplementation with SRU does not advantage microbial protein synthesis and fermentation in a RUSITEC compared to UU.

**Keywords:** Efficiency, microbial yield, neutral detergent fibre, non-protein nitrogen, nutrient fermentation

## Effect of Dried *Elaeis guineense* Supplementation to Basal Hay Diet on Energy and Protein Metabolism of West African Dwarf Sheep

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Considerable attention has been focused on the use of multipurpose trees as feed supplement for small ruminant during dry season. Multipurpose trees provide a cheap source of protein supplement during the dry period, when both the quantity and quality of pasture herbage is limited. Few experiments with nitrogen and energy balances have been performed with poultry, pigs and sheep, but information on nitrogen and carbon balances with Djallonke sheep are very scanty in literature. It was against this background that the effect of anti-nutritional factors (condensed tannins) in *Elaeis guineense* on quantitative energy and protein retention as well as utilisation in West African Dwarf (WAD) sheep was investigated. Twelve castrated WAD sheep averaging ( $22.0 \pm 2.1$  kg BW) were used in nitrogen and energy balance trials. Dried leaves of *E. guineense* were offered as supplement at two levels 25 % (diet 2) and 50 % (diet 3) of dry matter intake (DMI), replacing hay in the basal hay diet. The basal hay diet without supplementation was the control. Measurements were performed by means of nitrogen and carbon balances and with the use of indirect calorimetry. The digestibility and utilisation of protein were influenced ( $p < 0.05$ ) by supplementation. Metabolisability of energy (ME/GE) was on the average 42.9 (SEM 3.9) % being significantly ( $p < 0.05$ ) different among treatments. Protein digestibility decreased linearly ( $p < 0.05$ ) with supplementation. Protein retention and utilisation showed that supplementation led to a negative balance. A significant ( $p < 0.05$ ) decrease in heat loss ( $709 \text{ kJ day}^{-1}$ ) was observed at the higher level of supplementation. The lowest ( $p < 0.05$ ) heat loss was observed in diet 2 which amounted to 45 % of total energy intake, giving rise to a loss of 8.4 % of the energy retained in fat and protein by these animals. It was concluded that *Elaeis guineense* is a plant of low fodder value especially when fed as dry feed, no wonder it is fed fresh in most parts of West Africa.

**Keywords:** *Elaeis guineense*, energy, fat utilisation and retention, protein, WAD sheep

## Growth Response, Carcass Evaluation and Hematology of Broilers Fed Graded Levels of Enzyme Treated Cocoa Bean Shell Based

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Cocoa bean shell (CBS) is a waste from cocoa processing industries in Nigeria and it constitutes a serious disposal problem. Previous trials revealed that addition of Rovabio (a multi-substrate enzyme) reduces theobromine (an anti-nutrient in CBS). Hence this study focused on evaluating the growth response, carcass characteristics and hematological parameters of broilers fed graded levels of enzyme treated CBS based diets.

A total of 150 day old broiler chicks were randomly distributed to five dietary treatments in a completely randomised design with each treatment having 3 replicates of 10 birds per replicate. The treatments were: A (0 % CBS-control diet); B (5 % CBS with the enzyme Rovabio); C (10 % CBS with enzyme); D (15 % CBS with enzyme) and E (20 % CBS with enzyme). Each of the diet was fed *ad libitum* and the trial lasted 8 weeks. There were no significant differences ( $p > 0.05$ ) in feed conversion ratios of birds fed control diets and those on diets B (2.13), C (2.23) and D (2.40), however, those on diets E had the significantly highest value of 2.60. The hematological parameters of the experimental animals showed no significant ( $p > 0.05$ ) difference between birds fed the control diet and their counterpart on the different levels of CBS inclusion. Although no significant variation was observed for liver weight among birds fed enzyme treated diets (means varying from 2.76 % to 3.38 %), birds on the control diet had the highest liver weight (4.20 %). The gizzard and heart percentages of birds on the control diets increased significantly ( $p < 0.05$ ) compared to those on the enzymes treated diets.

The result revealed that enzyme (Rovabio) treated CBS can effectively replace up to 15 % maize in the diets of broilers without a deleterious effect.

**Keywords:** Broiler, carcass, cocoa bean shell, feed intake, hematology

## Modulation of Cholesterol in Eggs of Laying Hen Fed Raw Dietary Garlic

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This experiment was conducted to investigate the dietary effect of raw garlic on the performance, cholesterol content of egg yolk and serum lipids of laying hens. A total of sixty 18 weeks old Isa Brown layers were randomly assigned to six diets containing raw garlic (0, 1, 2, 3, 4 and 5 %) in five replicates of two birds each. The experimental period lasted 20 weeks. Feed intake was assessed weekly. Egg production and egg weight were measured daily. Blood samples were collected from all the birds at week 5, 10, 15 and 20 of the experiment. The serum samples collected were analysed enzymatically for total cholesterol, triglyceride and high density lipoprotein cholesterol. Samples of egg yolks were analysed for cholesterol at the 5<sup>th</sup>, 10<sup>th</sup>, 15<sup>th</sup> and 20<sup>th</sup> weeks of the experiment. There were no differences ( $p > 0.05$ ) in feed efficiency, average egg weight and egg mass. High inclusion of raw garlic (4 %) significantly ( $p < 0.05$ ) reduced feed intake by 6.5 %. There was a significant ( $p < 0.05$ ) increase of 15.7 % in production per hen and day at 2 % inclusion of raw garlic. There was a significant ( $p < 0.05$ ) reduction in serum total cholesterol, triglycerides, low density lipoprotein and egg yolk cholesterol by 36.6 %, 18.1 %, 70.6 %, and 27.1 % respectively. The values of high density lipoprotein cholesterol concentration increased ( $p < 0.05$ ) linearly in response to increasing levels of dietary garlic ( $r^2=0.80$ ). This study demonstrated that inclusion of raw garlic up to 4 % in layers diet could increase hen-day production and decrease egg yolk cholesterol concentration ( $\text{mg g}^{-1}$  yolk) and serum lipids without adverse effects on performance of laying hens.

**Keywords:** Cholesterol, garlic, laying hens, lipid metabolism

## Feed Intake and Survivability of Edible Land Snail Species under two Moisture and Temperature Conditions

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The effects of moisture and temperature on the feed intake and survivability of the giant African land snails (*Archachatina marginata* and *Achatina achatina*) housed under cage system were investigated, using 60 juvenile (5- month-old) snails of each species. The experiment was based on a  $2 \times 2 \times 2$  factorial design with 3 replicates of five snails per replicate, that is, snails (*Archachatina marginata* and *Achatina achatina*), moisture (high moisture defined by 65 ml of water to moisten the soil on daily basis versus 65 ml of water on 2-days intervals) and temperature (ambient versus controlled temperature unit). The temperature, relative humidity of the experimental unit, feed intake and mortality rate in percentage were recorded. The experiment was carried out between the months November and March. From this study, a difference of 6°C was observed between the average daily temperature of the units, with average of 29.40°C and 22.61°C for ambient and controlled units respectively. Average daily relative humidity of 62.7 % and 73.3 % for ambient and controlled temperature units respectively were observed. Feed intake was significantly affected by temperature and species ( $p < 0.05$ ). The interaction between temperature, moisture and species was highly significant on feed intake of the snails ( $p < 0.01$ ). Feed intake was higher under ambient temperature than under controlled temperature ( $1.50 \pm 0.03$  vs.  $1.17 \pm 0.03$  g/snail/week). Different of 0.50 g/snail/week was observed, with *A. marginata* consuming more. Moreso, the overall mortality rate was 23.3 %, of which *A. achatina* and *A. marginata* had 4.2 and 19.1 % respectively. This result showed higher mortality under controlled unit for *A. marginata* compared to that of ambient unit (46.7 % vs. 30.0 % respectively). The rate was low with high moisture compared with low moisture either under controlled or ambient temperature unit. In conclusion, this paper relates the significant effects of temperature and moisture on the feed intake and mortality rate of giant African land snails. Thus, low ambient temperature, and moistening the soil with 65 ml of water on daily basis increase feed intake and reduced the mortality rate of these snails, thereby increasing their survivability.

**Keywords:** *Achatina achatina*, *Archachatina marginata*, feed intake, moisture and temperature, mortality rate, survivability

## A Two-step *in vitro* Examination of Some Carbohydrate-rich Substrates for Possible Prebiotic Potential

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An *in vitro* experiment was conducted to screen ten carbohydrate-rich substrates for the following prebiotic characteristics; 1. resistance to gastric acidity, enzymatic hydrolysis and gastrointestinal absorption, and 2. fermentation by intestinal microflora. The substrates were starches and starch by-products of different origins.

In the first study, the test substrates were subjected to a 2-step digestion in pepsin/HCl solution for 1.5 hours followed by incubation in potassium phosphate buffer containing pancreatin and amylase for 1, 2, 3 and 6 hours while in the second study, the cumulative gas production technique was used to study the fermentabilities of the test substrates using buffered caecal inoculum from 28-day old broiler chicks fed a standard diet free of antibiotics and any of the test substrates. Gas production, fermentation kinetics, pH, ammonia and organic matter loss (OMloss) were measured.

The total starch content of the substrates ranged between 57.5 % for sweet potato meal and 84.4 % for sago starch. While *in vitro* foregut digestion measured at the end of study 1 showed values of 95.04 %, 50.46 %, 22.36 %, 42.47 %, 82.7 %, 68.58 %, 42.69 %, 54.54 %, 50.88 % and 50.8 %, *in vitro* organic matter disappearance measured at the end of study 2 showed values of 96.58 %, 89.26 %, 28.18 %, 53.42 %, 92.49 %, 98.28 %, 98.28 %, 92.43 %, 81.98 % and 67.13 % for sago starch, sweet potato starch, arrowroot starch, rice starch, tapioca, cornstarch, cassava pulp and sweet potato meal respectively. The difference between these values represented estimates of proportion of the substrates that would be fermented in the hindgut *in vivo*.

Results from studies 1 and 2 showed that all the substrates tested were resistant to acidity and enzymatic hydrolysis in the foregut and fermentable by intestinal microflora to varying degrees. Tapioca, sweet potato starch, cassava pulp and wheat starch had the highest resistance to gastric acidity, enzymatic hydrolysis and gastrointestinal absorption and the top five fermentability by gastrointestinal microflora and thus were selected for subsequent studies.

**Keywords:** Caecal inoculum, cumulative gas production technique, foregut digestibility, prebiotic, starches

## Promising Alternative Diets for Honey Bees in Saudi Arabia

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Pollen grains are the main source of nutrients for honey bees. As in Saudi Arabia the lack of these natural diets during dry seasons is of concern, this experiment was carried out at the Agricultural Research Station of King Abdul Aziz University at Hadda-Elsham, Mecca, Saudi Arabia in 2001–2002 to look for promising alternatives to pollen grains. Twenty bee hives of a same strength were allocated in RCB design with 5 treatments; pollen + yeast powder, Chickpea powder + yeast powder, compressed date, Maize flour + yeast powder and pollen grain as control, all treatments were replicated 4 times. The brood area of the hives inch<sup>2</sup> and the quantity of honey kg<sup>-1</sup> were calculated.

The percentage of increase in the brood area inch<sup>2</sup> due to feeding bee hives with different diets is 78.1, 77.3, 76.0, 65.0 and 62.1 % for compressed date, maize + yeast, chickpea + yeast, pollen grain + yeast and pollen alone (control). Honey production was increased by 196, 89.8, 78.9 and 152.1 % in hives provided with Pollen + yeast powder, Chickpea powder + yeast, compressed date and Maize flour + yeast powder respectively when compared with the control. According to the results obtained, availability of using cheap and easy prepared alternatives and due to the scarcity of pollen grain during the dry season is highly recommended for honey bee keepers to use pollen + yeast powder, Chickpea powder + yeast and compressed date as alternative for pollen grains to enhance the strength of their hive increasing the areas of brood and at same time produce more honey to boost their profits.

**Keywords:** Bees, broad area, Chickpea powder, honey, pollen grain

## **Chemical Composition of Different Parts of Wild Yam (*Anchomanes difformis*) and the Nutritive Potentials of its Tuber for Inclusion in Small Ruminant Diet**

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Two separate trials were carried out to evaluate the chemical composition of different parts of *Anchomanes difformis* (Wild yam) and the nutritive value of its tuber. A toxicity study with 20 albino rats was carried out to ascertain the level of toxicity of *A. difformis* tuber and then, a feeding trial with 25 West African dwarf sheep ( $12 \pm 1.3$  months;  $10 \pm 0.6$  kg) fed diets containing graded levels (0, 10, 15, 20 and 25 %) of *A. difformis* as supplement to basal diet of *Pennisetum purpureum*. The rats were drenched with 2 ml varying concentrations of *A. difformis* tuber extract (0, 200, 400, 600 and 800 mg per 50 ml distilled water) over 21 days. Results showed no significant ( $p > 0.05$ ) difference in the dry matter (DM) contents of the parts ( $109\text{--}115 \text{ g kg}^{-1}$ ). The leaves recorded the highest ( $p = 0.001$ ) crude protein content of  $138 \text{ g kg}^{-1}$  DM. Similar trends were observed in the ether extract and ash contents of the parts. The non-fibre carbohydrate content was highest ( $p = 0.001$ ) in the tuber ( $439 \text{ g kg}^{-1}$  DM) and lowest in the leaves ( $111 \text{ g kg}^{-1}$  DM). This shows a preponderance of soluble carbohydrates in this fraction. Results from toxicological studies with tuber extract showed lesions in major organs like lungs, liver, kidney and intestine. The severity increases with increasing concentrations of *A. difformis* extracts. The inclusion of *A. difformis* in the diets of the sheep resulted in decreased DM intake. The highest ( $p < 0.05$ ) nutrient intake for animals on *A. difformis* based diets was recorded at 10 % level of supplementation. The nutrient digestibility coefficients were generally high for sheep in all the treatments. The live weight gain of the animals decreased from  $27.3 \text{ g d}^{-1}$  in the control diet to 20.24, 18.93, 16.07 and 12.50 for 10, 15, 20 and 25 % levels of inclusion respectively. It was concluded that the average nutrient intake and daily weight gain of animals on 10 % *A. difformis* was the best among animals fed *A. difformis* based diets. The study therefore, recommended 10 % level of *A. difformis* inclusion in ruminant animals concentrate diets as a safe level that will guarantee no negative effect on nutrient intake and performance.

**Keywords:** Albino rats, Dry matter intake, Sheep, Toxicological effects, tuber extracts

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## Varying Levels of Dietary Fibre on the Performance of Growing Grasscutter (*Thyonomys swinderianus*) Temmnick

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Grasscutter, a micro-livestock is being domesticated to enhance the dietary protein needs of Nigerians. Fibre is an essential feed component required for optimal performance. Imbalances in the level of dietary fibre have effect on nutrient digestibility and utilisation. There is paucity of information on the utilisation of this component in growing grasscutter. Varying levels of dietary fibre on the performance of growing grasscutter were therefore evaluated.

In this study, 36 twelve-week-old growing grasscutters of mixed sexes and mean weight of  $501 \pm 3.4$  g and were used. The animals were randomly allotted into four dietary treatments in a completely randomised design, replicated three times with three grasscutters per replicate. Four dietary treatments were formulated to contain 9 % (C1), 11 % (C2), 13 % (C3) and 15 % (C4) crude fibre. The four pelleted diets contained 16 % crude protein and 2600 kcal ME kg<sup>-1</sup> dry matter. The experiment lasted 16 weeks. Parameters measured were feed intake and body weight changes. Feed conversion ratio was calculated. Data were analysed using ANOVA and DNMRT at  $p < 0.05$ .

There were no significant differences observed in feed intake ( $9419 - 9469$  g  $\pm 14.1$ ), weight gain ( $2837 - 2882$  g  $\pm 61.3$ ), dry matter digestibility ( $79.3 - 79.9$  %  $\pm 4.3$ ), crude protein digestibility ( $68.4 - 69.0$  %  $\pm 3.8$ ) and crude fibre digestibility ( $61.4 - 61.9$  %  $\pm 3.2$ ) of growing grasscutters fed pelletized diets containing 9–13 % crude fibre. Feed conversion ratio was, however, significantly lower in the 13 % crude fibre group ( $3.24 \pm 0.06$   $p > 0.05$ ). The lowest weight gain was recorded in the 15 % crude fibre group. The efficiency of feed utilisation, weight gain, feed conversion ratio and cost per unit of gain were best in the diet containing 13 % crude fibre content. Nutrients digestibility were better in the diet containing 13 % crude fibre ( $p < 0.05$ ). Based on the results, diets of growing grasscutter should contain 11 to 13 % crude fibre.

**Keywords:** Cost/weight gain, feed conversion ratio, fibre requirement, nutrients digestibility

## Nutritional and Histopathological Assessment of Earthworm Meal as Dietary Protein Source for Broiler Starters

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The potential of earthworm meal (EWM) as a source of dietary protein for poultry was evaluated. EWM protein replaced fish meal (FM) protein at 0 to 100 % in diets based on soyabean meal (SBM) as major plant protein source and fish meal (FM) as animal source.

Six iso-energetic (13.34 – 13.63 MJ/kg) and iso-nitrogenous (237.3 – 247.6 g/kg) diets were evaluated with broiler chickens between age one and four weeks. The diets comprised the control diet (Diet 1) with SBM as main protein source and diets 2 – 6 having either SBM and FM (Diet 2) or a combination of SBM, FM and/or EWM (Diets 3 – 6) as protein source. Taking the protein supplied by FM in diet 2 as 100 %, FM and EWM were combined in other diets to supply: 75:25 (Diet 3), 50:50 (Diet 4); 25:75 (diet 5); 0:100 % protein (Diet 6). A completely randomised design was employed in which birds were randomly allocated to five replicate groups of four birds per treatment. A nutrient retention trial was conducted in the last week of the experiment.

Results indicate that EWM is rich in nutrients; 670 g/kg protein, 60 g/kg ether extract, 881.2 g/kg dry matter (DM) and 18.2 MJ/kg gross energy (GE).

Birds on the basal diet ate significantly ( $p < 0.05$ ) less feed than those on other diets. Diets in which 25 and 100 % EWM replaced FM had similar rate (22.5, 24.04 vs 24.8 g/day) and efficiency (2.25, 2.08 vs 2.02) of daily weight gain compared with diet 2 having 100 % FM protein. Nitrogen retention (NR) and digestibility of crude fibre and fat of basal diet, diets 2 and 3 were significantly ( $p < 0.05$ ) higher than those of other diets. NR (63.8 %), DM (72.8 %) and ash (24.4 %) digestibility of diet in which EWM completely replaced FM were the poorest.

Histopathological results revealed normal organs for the basal diet while the other diets revealed multiple foci of bile duct hyperplasia. This study indicates that EWM with a microbial count of  $2.5 \times 10^5$  CFU/ml appears a wholesome protein source and could completely replace FM in diets for broiler starters.

**Keywords:** Broiler starter, earthworm meal, growth rate, histopathology, Nigeria, nutrient retention, protein source

## Occurrences of Linoleic Acid and $\alpha$ -linolenic Acid in Tropical Plants and their Disappearances when Incubated in Buffered Rumen Fluid *in vitro*

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Feeding forages rich in polyunsaturated fatty acids (PUFA) is only the first step towards increased PUFA contents in animal-source foods. The second is related to the extent of PUFA modification by ruminal microbes, respectively the ruminal bypass of intact plant PUFA. Studies so far have concentrated on temperate climate plants including mountainous plants. In the present study, a screening was conducted for the contents and ruminal disappearance of the two major PUFA, linoleic acid (LA) and  $\alpha$ -linolenic acid (ALA) in tropical forage plants. Leaves from 27 tropical plant species were obtained from the area of Bogor, Indonesia. The plants were analysed for their chemical composition, including LA and ALA contents. Approximately 200 mg dry matter of each plant was incubated in duplicate *in vitro* with 30 ml of rumen fluid/buffer mixture (1:2; v/v) for 24 h at a constant temperature of 39°C using the Hohenheim Gas Test apparatus. After incubation, the fermentation fluid was analysed for the fatty acid composition using transesterification and subsequent gas chromatography. The disappearance of fatty acid was defined as the proportionate decline of the individual fatty acid in the lipids from feed to fermentation fluid. The results showed that PUFA contents in the plant samples varied widely, ranging (g/kg DM) from 0.3 (in *Myristica fragrans*) to 3.5 (in *Calliandra calothyrsus*) for LA and from 0.2 (in *Hibiscus tiliaceus*) to 11.1 (in *Carica papaya*) for ALA, respectively. Incubation of *C. calothyrsus* (a plant rich in condensed tannins) resulted in the highest LA (50 %kg total FAME) and ALA (36 %kg total FAME) proportions in fermentation fluid lipids. The proportionate disappearance of LA and ALA was comparably low with proportionately 0.69 and 0.90 of total, respectively, when incubating *C. calothyrsus* in relation to the other plants. For *Paspalum dilatatum*, a grass species, LA and ALA almost completely disappeared, leading to very low concentrations in the fermented rumen fluid. It was concluded that ruminal modification of PUFA from tropical plants varies largely, confirming previous studies suggesting that tannins partially inhibit biohydrogenation but also limiting the predictive information of plant PUFA concentrations for the lipid profile of ruminant-source foods.

**Keywords:**  $\alpha$ -linolenic acid, biohydrogenation, *in vitro* screening, linoleic acid, livestock, polyunsaturated fatty acid, rumen, tropical plant

## **The Technology of obtaining Water Extracts from Herbs and Plants of Tropics and Subtropics and their Influence on the Greenhouse Gases Emissions and the General Health of Animals**

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This work describes problems concerning obtaining of extracts from herbs and plants with a water-extraction technology. It gives a detailed description of the unique technology, its pros and cons, possibilities of utilisation (usage of the water extracts not only in many branches of agriculture – fertilisation and feeding additives – but also in spheres of industry, pharmaceuticals, spa, wellness, etc.), as well as a review of plants, which were used for the preparation of water extracts that are further being studied in consequent research, which focuses on the usage of these plant-water-extracts as a substitution for chemical food additives – especially for the reduction of greenhouse gases (GHG) and ammonia and subsequently also for improvement of the general animal health and well-being. It is divided in several consecutive steps. The first phase was to find proper plants that would fit most in the desired concept of GHG reducing and health improving food additives, which lead to former researches that showed that mainly plants with high saponin content (like for example *Yucca* or *Hedera helix*) reduce the GHG emissions by animals and that *e.g. Urtica dioica* and *Artemisia abrotanum* were examined many decades ago as a supplement for animal health and wellbeing improvement. In the next stage the water-extracts are being produced and characterised. Subsequently the most suitable extracts will be applied *in vivo* – to the experimental herd and the GHG emissions and health changes will be recorded. In the end of the project, all collected data will be evaluated and consideration of pros and cons of the water-extracts as food additives as well as possibilities for additional research, usage and transfer to less developed countries will be done.

**Keywords:** Ammonia, feeding additives, gain from feedstuffs, GHG, greenhouse gas, pasteurisation, water extract, wellbeing

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## Effect of Seasons and Larval Food Plants on the Quality of *Gonometa postica* (Lepidoptera: Lasiocampidae) Cocoons

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The African wild silkmoth, *Gonometa postica* Walker (Lepidoptera: Lasiocampidae) is known to produce high quality silk comparable to that of the domesticated silkmoth, *Bombyx mori* L. (Lepidoptera: Bombycidae). Currently, it is the species being utilised for wild silk production in Kenya and is known to feed on several *Acacia* species. The effect of food plants [*Acacia elatior* Brenan, *A. tortilis* (Forssk.) and *A. nilotica* (L.) Del] on the developmental time of *G. postica* larvae and the quality of their cocoons were studied in the Imba and Mumoni forests of Mwingi, eastern Kenya, during the long (March-May) and short (October-December) rainy seasons of 2006 and 2007. Larvae were reared in semi-captivity in net sleeves attached to branches of the plants. The period between hatching of eggs and spinning of cocoons as well as weight as determinants of cocoon quality were recorded. In addition, collections of cocoons from the wild were done in the two forests from the same host plants for assessment of their quality. In the cage experiment, larval developmental period and quality of cocoons differed according to food plants, seasons, and sites while quality of cocoons sampled from the wild habitat was similar for all food plants and seasons but varied according to site. Generally, there was a positive correlation between weight of cocoon, its length and width for the two seasons for both the semi-captive population and those from the wild. Larvae reared on *A. elatior* had a shorter developmental period and higher cocoon quality than those raised on *A. tortilis* and *A. nilotica*. Generally, temperature and relative humidity significantly influenced larval developmental time and the effect was both positive and negative. Rainfall was generally higher in Mumoni than in Imba. The above findings will help improve the semi-captive rearing of *G. postica* to increase the quantity and quality of cocoons for silk production.

**Keywords:** *Acacia* species, cocoon quality, *gonometa postica*, larval developmental period, semi-captive rearing

## Effect of Feed Supplementation on the Performance of Nomadic Dairy Cows in Rangeland of Kordofan, Sudan

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Three experiments were carried out with Dar El-Reih cows of northern Kordofan (Sudan). Records were kept for daily milk production and body weight, body condition score and progesterone profile. The cows that recently calved were monitored for the first and sustained progesterone (P4) rise to assess the interval from calving to ovulation and conception.

In the first experiment, 36 cows were selected from a nomadic herd and divided into three groups. Groups A, B and C were supplemented with high energy high protein concentrate mixture (ration A), medium energy medium protein concentrate mixture (ration B), and low energy low proteins concentrate mixture (ration C), respectively. The cows were in their early lactation and were fed their respective concentrate mixture for six weeks at the rate 2 kg per cow and day after grazing on the available natural pasture.

Group A cows had a significantly higher milk yield ( $p < 0.05$ ) than group B or group C cows, and group C cows had lowest milk yield of all groups. Group A cows had also attained the highest body weight and body condition .

In the second experiment, the same groups of animals (A, B, C) were supplemented with the same rations (A, B, C) at the same rate for a period of eight weeks after the rainy season when the cows were at their mid-lactation. Significant differences in milk yield were observed between the experimental groups ( $p < 0.05$ ). Group A cows had the highest milk yield, followed by group B and group C cows, respectively. In the third experiment, three trials were conducted to study the effect of molasses supplementation on milk yield in comparison with conventional concentrate feed used in the region. Twelve cows were selected for each trial and divided into two groups. One group received a test ration with molasses instead of grain sorghum or sorghum brewery residue. The results revealed significant differences in milk yield between the two groups.

**Keywords:** Feed supplementation, Kordofan, nomadic dairy cows, performance, Sudan

# Aquaculture and fisheries

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## **Management of Fish Diversity in Lake Bam, Burkina Faso: Indigenous Knowledge and Implications for Conservation**

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About 30,000 people are involved in commercial inland fisheries in Burkina Faso, where approaches to natural resources are shifting from centralised to community-based and participatory ones. There is a need to understand the indigenous approach to fisheries management and to consider it in the framework of conservation efforts and food supply.

Lake Bam is the most important natural water-body in Burkina Faso. Mismanagement, however, has depleted its resources to the extent that the lake will soon require restoration. This study depicts how local communities formerly protected the lake and its catchment resources. In August 2009, we held a workshop with Lake Bam fishermen and farmers. We also interviewed fishermen and leaders of traditional authority in natural resource issues.

The traditional approach to natural resources management has its roots in religion, beliefs, anthropology and economy; local contexts were properly incorporated. Almost every village has two decision-making centres regarding the management of land, forest, wildlife, water, fish and other resources. The leading persons work in close partnership and are assisted by groups of counsellors. Having the right of use was strongly associated with observing the rules and participating in monitoring, surveillance and control. Closed seasons and closed areas were set for specific resources, which helped maintain (fish) biodiversity and ensure livelihoods.

Since the colonisation period, indigenous institutions have been much altered by the European styles of managing people and resources: religion, science and technology. Although certain aspects of the traditional (ecological) knowledge are inappropriate to guarantee sustainable management of fish and other resources, the indigenous authority still holds considerable power.

This constellation should be adequately considered by the republican institutions, which then should help build local community capacity in order to move towards sustainability in natural resources.

**Keywords:** Biodiversity, Burkina Faso, fisheries, natural resources, traditional knowledge

## **Biodiversity in Organic Managed Shrimp Farms in Bangladesh and their Interaction with Ecosystem Services**

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Shrimp aquaculture is practised since old times in Bangladesh. Extensive shrimp and fish polyculture in exchange with paddy culture and salt pans was and is still the main agri-aquacultural activity. However in the recent years chemical fertilisers and pesticides are displacing cow dung or compost, in the context of culture intensification. This can have a negative impact on the pond ecosystem and on biodiversity.

The Organic Shrimp Project (OSP) was established in 2007 in the southwestern part (Khulna division) of Bangladesh. The production of Naturland organic certified shrimps for western markets, while supporting the local farmers, are some of the goals of the project. Participating farms are managed extensively, socially, ecologically and economically sustainable, according to Naturland standards.

The objective of this study was to understand the ecosystem of these ponds and to compare the biodiversity in shrimp ponds with different management practices (organic with conventional) as well as rice paddies, as an alternative “aquatic” culture in the research area.

Biodiversity is chosen as an indicator for the evaluation of these ecosystems, since it is a key issue in the sustainable aquaculture vicinity. Chosen categories were benthos, pelagic fauna and flora, plankton and dike coverage. All results were summed up in the context of ecosystem services. The more ecosystem services are provided by the system itself, the less it relies on adjacent ecosystems, like in this case of the Sundarban Mangrove Forest.

The study revealed more species with higher abundance in the organic shrimp ponds than the conventionally managed and the paddies throughout. A positive impact on biodiversity by the organic management practices was concluded.

**Keywords:** Aquaculture, Benthos, biodiversity, ecosystem services, organic shrimp production

## Kernel Meal from a New Non-toxic *Jatropha* Species - *Jatropha platyphylla* - as a Protein Source for Nile Tilapia (*Oreochromis niloticus* L.) Diet

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*Jatropha platyphylla* (local name: “sangregrado”) is a drought-resistant shrub, available in Mexico and belongs to *Euphorbiaceae* family. Its seeds are rich in oil and protein. The kernel meal from *J. platyphylla* obtained after oil extraction 70–75 % crude protein. The meal is free of phorbol esters, the main toxins present in other *Jatropha* species; however, it contains phytate, lectin and trypsin inhibitor. Levels of essential amino acids (except lysine) are higher in the meal than soybean meal (SBM). Using Nile tilapia (*Oreochromis niloticus*) fingerlings, a 12-week experiment was conducted to evaluate nutritional quality of heated *J. platyphylla* kernel meal (H-JPKM) and to compare it with that of SBM and fishmeal. Two experiments were conducted simultaneously. The first experiment was in a recirculatory-system to evaluate the nutritional and haematological responses and the second in a respirometric-system to evaluate the metabolic responses. Fingerlings, 15 fish; average weight  $13.7 \pm 0.21$  g for the recirculatory-system and another 15 fish,  $13.9 \pm 0.17$  g for the respirometer-system were randomly distributed in three groups with five replicates for each system. In both experimental set ups the control diet containing fishmeal and the two other diets replacing 62.5 % of the fishmeal protein with H-JPKM (*Jatropha* group) and SBM (Soybean group) were fed to fingerlings. The last two diets contained phytase at a level of 500 FTU kg<sup>-1</sup> and all diets were iso-nitrogenous (crude protein 36 %). Growth performance, feed conversion ratio, protein efficiency ratio and energy retention did not differ significantly among the three groups in both experimental (recirculatory and respirometer) set ups. Higher protein productive value was observed in plant protein fed groups; whereas, apparent lipid conversion exhibited reverse trend in both the experimental set ups. RBC count, hematocrit and blood-glucose were higher in plant protein fed groups than control group, while WBC count, haemoglobin, calcium and sodium ions, bilirubin, urea-nitrogen and alkaline phosphatase and alanine aminotransferase activities in blood did not differ significantly among the three groups. Average metabolic rate, energy expenditure per g protein fed and retained in the body were also similar. The results demonstrate that H-JPKM is a good quality protein source for Nile tilapia feed and it can replace 62.5 % of fishmeal protein in their diet.

**Keywords:** Fish meal replacer, *Jatropha platyphylla*, kernel meal, Nile tilapia, protein source

## **How Fishing Communities on the Sangihe Islands, Indonesia Struggle to Maintain their Traditional Livelihood while Adapting to the Modernisation of Fisheries**

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Small-scale coastal fisheries have undergone a rapid process of modernisation in many parts of the developing world in the last few decades. The fishing communities on the remote Sangihe Islands in Indonesia are an interesting example of how traditional fishing techniques are being replaced by more modern methods. The study investigates how fishing technique modernisation is affecting social structures and institutions in four traditional fishing communities on the Sangihe Islands; it characterises the influences and drivers acting on coastal fisheries communities during such process of change.

Information derived from interviews and discussions with local fishermen, and a thorough review of available literature was used to characterise changes that have occurred in each of the four fishing communities during the past three decades. In all four communities, the fishery has significantly changed in terms of techniques and social organisation. The “seke” fishery, based on a traditional purse-seine made of bamboo and operated on the beach by communal groups has increasingly been replaced by private, offshore operated fishery with synthetic nets. Correspondingly, changes to the local fishery are transforming community structures that were strongly integrated with fishing practices. As fishermen adopted more modern techniques, group sizes for fishing operations declined while the number of private fishing parties rose. Additionally, a loss of local beliefs and traditions corresponding to fishery came along with these changes in fishing practices. Nevertheless, traditional communal practices, such as marine tenure and communal sharing, were still maintained to a certain degree. Although fishing technique modernisation has propelled individualism and profit thinking, many of the deep rooted communal institutions were preserved or adapted to the changing fishery.

The results of the study suggest that the main influences for modernisation of fishery and transformation of social structures originate from outside the communities. Governmental incentive programs, improved market conditions and the depletion of fish stocks in local waters are the main drivers. Communities have to react to those outside influences and their dynamics, seeking a balance to adapt to the changing world while maintaining their traditional livelihood.

**Keywords:** Communal sharing system, fishery modernisation, Indonesia, social transformation, traditional marine tenure

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## **Inventory and Sustainable Exploitation of Edible Mollusc Resources of the Guinean Coastline: Case Study in the Tristao Islands Marine Protected Area (Tristao MPA)**

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The numerous mounds of mollusc shells that one meets on the Guinean coastline testify the great importance of molluscs and crustaceans in the economy of the Guinean coastal communities. Today, these gastropods and marine bivalves represent a main component of the food security of the inhabitants of the West-African region and have become more and more one of the main sources of incomes for women. Other uses of these shellfish include the making of paint, the production of lime, the feeding of poultry, or as decoration or jewellery for tourism. Gleaning these resources, collecting them by hand, and their pickup all around the Tristao islands are exclusively the work of women.

The present case study achieved by interviewing 300 women in the Tristao Island MPA aimed to gain a better understanding of the operating systems and traditional management of the edible molluscs in this important site. The results show the importance of the traditional exploitation of the shellfish, describe the harvesting techniques and present traditional processing and storage methods. These women have recently begun selling the shellfish, which provides a new source of income for the community.

Thus, 6 species of bivalves and 7 species of gastropods have been identified in Tristao Island and have been described in their habitats. Most species are food sources, but exploited to different degrees by the women who gain financial autonomy from the industry. The collection and the pickup of these molluscs are practiced within natural sites (mangrove and low tide zones: beaches, muddy zones, creeks and rivers, etc.). The products are preserved by cooking and sun drying when the product is used for household consumption and by cooking, sun drying and smoking, when the products are offered on the markets in Kamsar and Boké, situated far away from the islands. Among these molluscs, the bloody cockle (*Senilia senilis*) and the oysters (*Crassostrea gasar*) play the most important role in socioeconomic aspect. Culturally, the bloody cockle (*Senilia senilis*) is harvested exclusively for the local consumption and its merchandising is forbidden by the Nalou indigenous community.

The merchandising of the oyster (*Crassostrea gasar*), of which the harvested quantities can be substantial, is one of the most lucrative income generating activities practiced on the islands by the women.

**Keywords:** Biotopes, bivalves, gastropods, marine protected area, merchandising of oysters, traditional processing

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## Detoxified *Jatropha Curcas* Kernel Meal as a Protein Source for White Leg Shrimp (*Penaeus vannamei*) Diet

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*Jatropha curcas* (L.) is a multipurpose and drought resistant tree, widespread throughout the tropics and subtropics. Its seeds contain up to 35 % oil and therefore are being promoted as a biofuel plant. *Jatropha* kernel meal (JKM) obtained after oil extraction from shell-free kernels is an excellent source of protein (60–65 % crude protein, similar to fish meal). The levels of essential amino acids (except lysine) are higher in JKM than in soybean meal. However, presence of toxic and antinutritional constituents restricts its use in fish and shrimp feeds. JKM was detoxified (DJKM) and an eight-week experiment was conducted to evaluate its nutritional quality for white leg shrimp (*Penaeus vannamei*). White leg shrimp (60) with an initial average body weight of  $4.46 \pm 0.64$  g were randomly distributed into three treatments with four replicates and fed iso-nitrogenous and iso-energetic diets (crude protein 35 %, crude lipid 9 %): Control (fish meal based protein), JC25 and JC50 (25 % and 50 % of fish meal protein replaced by DJKM). Higher body mass gain, specific growth rate and metabolic growth rate were observed in DJKM fed groups than in control group. The ranges for body mass gain (BMG), specific growth rate and metabolic growth rate were 138–209 %,  $1.54\text{--}2.00\text{ \% day}^{-1}$  and  $5.51\text{--}7.22\text{ g kg}^{-0.8}\text{day}^{-1}$  respectively. A lower feed conversion ratio (g feed consumed/g BMG) was observed in DJKM fed groups than in the control group, whereas protein efficiency ratio exhibited opposite trend. Feed conversion ratio and protein efficiency ratio were in the range of 2.3–3.2 and 1.0–1.4 respectively. Cholesterol level in plasma was highest in the control group, followed by in JC25 and JC50 groups; all being significantly different. The results from the present study demonstrated that the DJKM is a good quality protein source for white leg shrimp. It can replace fish meal protein by 50 % in the diet of white leg shrimp. Further research should be conducted to evaluate the nutritional quality of diets containing the DJKM beyond 50 % fish meal protein replacement.

**Keywords:** Fish meal replacer, growth, *Jatropha curcas*, nutrient utilisation, white leg shrimp

## **Fish Production in and around Refugee Camps/Settlements in Zambia**

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While per definition, refugees are to stay in a country only temporarily, the harsh reality is that half of all refugees stay in camps or settlements for over 5 years. In Zambia there are 4 camps at present: Two long term settlements which have been running for 38 and 43 years respectively, and two short term camps that have been running for 8 years.

Livelihood options, including aquaculture (mostly official) and fishing (mostly unofficial) have been integrated into all 4 refugee camps and settlements in the hope that these activities can be used by the refugees to achieve sustainable food and income resources. However to date, there is no literature capturing detailed experiences and strategic integration of fish production into refugee camp environments.

The FishRef project which started this February, will help gain an understanding of fish production techniques most suitable for providing food and income to people living in and around refugee camps or settlements. A total of 180 refugees will be interviewed in order to systematically document experiences in integrating fish production into refugee camp regions in Zambia, highlighting past challenges and opportunities. Government officials and extension workers will also be interviewed or provided with questionnaires in order to assess which problems each of these stakeholders face. Additionally, locals and fish sellers living around the camps will be questioned about their interactions with the refugees.

The field work will be finished by the end of April and preliminary findings of the data analyses can be presented at this year's Tropentag.

**Keywords:** Aquaculture, fish farming, fishing, refugees, Zambia

## Detection of Non-additive Genetic Effects on Temperature Dependent Sex Determination in Nile Tilapia (*Oreochromis niloticus*)

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Sex determination in Nile tilapia is governed by major and minor genetic factors as well as temperature. The temperature dependent sex ratio is heritable and selection lines giving high and low proportions of males had been produced. Here, the effect of male and female breeders on temperature dependent sex ratios in *O. niloticus* is investigated using these selection lines and crosses of clonal lines. First, the response to temperature treatment (36°C/10 days) of clonal line crosses (XX × ΔXX) was tested. Second, clonal crosses were mated to temperature treated males (XX × XY/ΔXX) from progeny groups of the high line (> 90 % males by temperature treatment). Third, diallels within the 1<sup>st</sup> and 2<sup>nd</sup> generation of selection between the low- (< 60 % males) and the high-line were conducted. For the 1<sup>st</sup> generation 24 matings between the low-line as sires and high-line as dams (LH) and 27 reciprocal crosses (HL) were done. For the 2<sup>nd</sup> generation 11 LH matings and 8 HL matings were generated. All matings were conducted by artificial fertilisation. Ten days post fertilisation batches were divided in a control (28°C) and a treatment group (36°C). The temperature treatment lasted for ten days. There was no effect of temperature treatment on sex ratios of the clonal crosses. Both, temperature treatment and controls yielded sex ratios of 0 % males. Even when clonal crosses were mated to high temperature sensitive males (XX × XY/ΔXX), male ratios in temperature treated progeny groups were unexpected low (XX × XY: no deviation from 1:1; XX × ΔXX: 0–15.9 % males). The diallel crosses achieved similar results. The low-line exhibited a stronger negative effect on male ratio in the diallel crosses when it was used as the maternal line. Within the 1<sup>st</sup> generation HL matings produced significantly less males on average than LH matings. This effect was also visible in diallel crosses within the 2<sup>nd</sup> generation of selection. Therefore, these experiments show that non-additive genetic effects act on temperature dependent sex ratios. Maternal insensitivity to temperature dependent sex determination has a strong influence on the temperature susceptibility of the progenies.

**Keywords:** Diallel, Nile tilapia, sex determination, temperature



## Growth Functions of Fish Species Cultured in Small Scale Upland Aquaculture Systems under Traditional and Modified Pond Management Schemes in Yen Chau, Northern Viet Nam

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Pond aquaculture significantly contributes to the protein supply and cash income of Black Thai farmers in Yen Chau, Son La province, northern Viet Nam. The current aquaculture system is a polyculture of the macroherbivorous grass carp as main species together with 3–5 other non-herbivorous fish species like common carp, silver carp, bighead carp, mud carp, silver barb and Nile tilapia. The productivity amounts to about 1.5 t fish ha<sup>-1</sup> a<sup>-1</sup>, which must be considered as low for a tropical, feed-based aquaculture system. Feeding predominantly leave materials and a constant flow of water through the ponds, causing high turbidity and a loss of mineral nutrients for primary production, are seen as major reasons for this.

An ongoing research project, (subproject D7.1 of the Special Research Program 564), aims at increasing the productivity of the aquaculture system of Black Thai farmer in Yen Chau, northern Viet Nam, by means of several changes in pond management and the application of supplemental feed especially for the non-macroherbivorous species. In 2009, three pairs of neighbouring ponds were chosen to compare the current pond management with a modified pond management including control of water flow, liming and application of supplemental feeds in order to overcome the limitations mentioned above. All ponds were drained before starting the experiment, stocked with fingerlings at a density of 1.5 fish m<sup>-2</sup> and harvested completely after seven months, during this period, no fish were removed for home consumption. Fish weight was monitored by monthly sampling in all ponds in order to establish growth functions.

It could be demonstrated that the new management an increase of pond primary productivity, higher oxygen supply by photosynthesis and higher growth of several non-herbivorous fish species. After seven months, the new management resulted in more than twice the total fish mass and much higher net profit compared to the current pond

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management.

Results from this experiment, especially the growth functions of fish, are used in an extension project to educate farmers in aquaculture skills to increase the nutritional and economical outcome of aquaculture in the small scale farming systems of Black Thai farmers in the mountainous northern Viet Nam.

**Keywords:** Fish growth, pond management, upland aquaculture, Viet Nam

## Effect of a Saponin Fraction Extracted from *Trigonella foenum-graecum* L. and two Commercially available Saponins on Sex Ratio and Gonad Histology of Nile Tilapia (*Oreochromis niloticus*, L.) Fry

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Besides cyprinids, Nile tilapia (*Oreochromis niloticus* L.) are the most abundantly produced freshwater fish. Several production systems exist but for high gross profit margins only male monosex production is of interest. This is usually achieved by adding androgens to the diet of first feeding tilapia. The most abundant androgen used is 17 $\alpha$ -methyltestosterone (MT), which is prohibited for use as feed additive in the EU. Furthermore, MT is carcinogenic for humans and MT-rich effluents can cause environmental problems. In our previous experiment, saponins extracted from *Quillaja saponaria* (M.) inhibited aromatase activity *in vitro*. It has been shown that aromatase inhibition leads to masculinisation in fishes. We report the results of an experiment in which three different saponins were tested for their effect on sex ratio and gonad histology of Nile tilapia.

A saponin fraction extracted from *Trigonella foenum-graecum*, and commercially available saponins (*Quillaja* saponin and Diosgenin) were added in different concentrations (150–1000 ppm) to the diets. A total of 1080 Nile tilapia fry were divided into nine groups and stocked at 40 fish per tank in 27 tanks in a flow-through system. Starting six days after hatching, tilapia larvae were fed a control diet and eight different experimental diets (150 and 300 ppm *Trigonella* saponins, 150, 300 and 1000 ppm each for *Quillaja* saponins and Diosgenin) for 28 days. There were three replicates for each treatment. At the end of the experimental feeding, fish were transferred into a recirculation system and fed for 10 more weeks with a commercial tilapia diet. Thereafter they were killed, sexed and random gonad samples taken for histology. Sex ratios in some treatments ranged from 28 % to 67 % males. No treatment group was, however, statistically different ( $p > 0.05$ ) from control and the other treatments. There

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were no obvious differences in the histology of the gonads. The results of this study are different from those obtained in a previous study in which *Trigonella foenum-graecum* saponins showed a masculinisation effect in Nile tilapia. We conclude that the tested saponins in the applied concentrations are not suitable to be considered as an alternative to MT.

**Keywords:** Aromatase, masculinisation, methyltestosterone, Nile tilapia, saponins

# Markets and rural development

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# Value chains

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## Value Chain Analysis of Medicinal Plant Market in Kerala

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Kerala with its abundance of luxuriant flora is synonymous with ayurveda (plant based system of traditional medicine system native to India) and is possibly the only state in the country where ayurveda continues to be practised in its purest form. The demand for ayurvedic medicine is growing at a compound rate of 10–12 % per annum in Kerala. The increasing awareness on effectiveness of traditional systems has resulted in higher demand for plant based formulations prepared by ayurvedic pharmaceutical industries followed by a higher demand of medicinal plants, used by these industries. The area under medicinal plant cultivation, on the other hand remains the same. Insufficient supply, market imperfections, increasing demand for herbal medicine followed by unscientific and destructive harvesting methods from the wild is tampering the forest resource. Considering this, the study focuses on the role of different intermediaries, the method of procurement of raw materials by the industry, their cost of production of different formulations and the price elasticities of demand of medicinal plants for augmenting the supply of medicinal plants to the industry. The study probes into the entire value chain of selected medicinal plants from production to final stage of consumption in the form of different prescribed medicinal formulations. The estimated demand elasticities were positive varying from 1.27 % in *Plumbago zylanica* to 2.85 % in case of *Sida* sp. The margin of the pharmaceutical industries always stood high irrespective of the plants and the channels which was around 50 % of the sale price. The share of cultivators in consumers' final price was comparatively more than of collectors. Price spread for those plants which were collected from the wild were lower than that of cultivated. The results indicate the absence of a price regulatory body in herbal medicine sector. Contractual agreements between the cultivator/collector and the pharmacies should be encouraged at a negotiated price to increase the share of cultivator/collector in the industry coupled with educating the collector about scientific harvesting methods for reducing the demand-supply gap and the loss in forest wealth due to indiscriminate and unscientific harvesting.

**Keywords:** Elasticity, herbal medicine, medicinal plants market, price spread, value chain



## **Agricultural Marketing Information System (AMIS)**

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The present paper relates the Agricultural Marketing Information System (AMIS) development and establishment in Republic of Moldova. The system has been formulated and programmed by a specialised team of experts at the Agency for Sustainable Development ACSA in Chisinau thanks to financing by the project “Support to Rural Development – Increasing Qualifications of Management and Advisory Capacities” implemented by the Czech University of Live Sciences in Prague. The AMIS is destined to play a very important role as an operator offering comprehensive access to the information on: agricultural products, marketing services, business environment and trade component, agricultural producers, advisers and operators of the agricultural industry in the Republic of Moldova and European Union member states (input-output oriented).

An extensive survey of agricultural producers (farmers, KSP enterprises, input suppliers etc. had been conducted before the AMIS system was developed. First approach to the system was done by creating D-bases of agricultural producers and products. Both of them were merged into one system which enables a fast information exchange between producers, traders, clients and input suppliers.

The information system's main objective is to provide and supply operational information related to agricultural inputs and outputs, marketing services and available markets. According to the structure and function, the AMIS operates as a facilitator system with internal databases. The programme is designed on the Microsoft Windows Access D-base.

The producers, suppliers, products and services are classified according to many parameters which allow the interested producers, tradesmen and middlemen to quickly find the desired information and use it accordingly. It is structured into nine major groups which contain sub-groups and products/services. The main groups are seeds and planting materials, animals for reproduction, agricultural producers, plant protection, animal welfare, agricultural equipment and machines, wholesalers and processors, packers and others, and research and certifying institutes. The system includes as an addition a biweekly integrated agricultural market analysis which provides in-depth information on prices and their fluctuations as well as products available on six major markets in Moldova.

**Keywords:** agricultural marketing system, input supplier, template form, KSP enterprise, agricultural producer, commodity trader

**Keywords:** Agricultural marketing system, input supplier, KSP enterprise, template form

## **Agricultural Value Chain Modelling and Governance: The Case of Shea Butter in Benin**

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The value chain reasoning in agriculture and food business is mounting. It considers a product from its conception through production process till consumption. The value chain promotion is a development strategy that helps to get small holders farmers to the global market. The objective of this study is to analyse an agricultural value chain as an integrated system comprising many actors playing each a specific function. Ultimately, this can help to anticipate (or to evaluate) impacts of policy and development project actions on value chain actors, specifically, on small holders farmers.

The methodology used is based on the modelling of agricultural value chain using a non linear programming approach with the General Algebraic Modelling System (GAMS). The objective function is defined as global added value generated annually by all actors involved in the chain. The shea butter value chain of Benin has been used as case study. Three main functions have been identified along the shea supply chain: The function of shea nuts collection, the one of processing and one of marketing.

The results show that the global added value generated yearly along the shea supply chain is approximately 304,848 FCFA (approximately 470 Euros). From this amount, collectors gain 10 %, traders gain 65 % and processors 25 %. The analysis reveals that the shea business is financially profitable for all actors belonging to the supply chain. Globally one can conclude that 1FCFA invested in the shea supply chain generates 3,175 FCFA.

The introduction of new processing equipments contributes to reduce the work load and increase the frequency of processing by reducing the duration of processing from 4 to 2 days. The simulation of the model with new equipment shows a high impact on processors' income which increased almost for 50 %.

**Keywords:** Benin, non linear programming, shea butter, value chain modelling

## **Socio-economic and Spatial Determinants of Farm Production and Local Livelihoods in the Middle Mountain of Nepal**

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The middle mountains, a broad strip of sharply dissected and highly variable hill country, occupy about 30 % of Nepal's land covering 42,000 km<sup>2</sup> area which accommodate 48 % of Nepal's population including densely populated broad shallow basin of the Kathmandu Valley. This shallow basin is enriched with varieties of production practices, local resources and biophysical make-ups. Market oriented production that dominates in peri-urban fringe is a key factor driving land-use intensification in the valley bottom. Subsistence farming that predominates in rural areas is based on marginal hill slope cultivation and both of these production practices illumine the scar on sustainability of local livelihood.

This paper attempts to find the socio-economic and spatial determinants of farm production and livelihoods of the farmers in the highly populated peri-urban and rural transects of middle mountains. Socio-economic factors were based on micro-survey while biophysical factors were assessed using GIS, both of which were integrated to establish a link between people to pixel. Multivariate regression analysis shows that vegetable area, dependency ratio, family labour, credit and road availability are the crucial socio-economic determinants of farm income and livelihoods and most of these variables are spatially correlated implying that these attribute start becoming better-off in the accessible areas and worse-off in the remote areas. Spatial differences in socio-economic variables are mainly related to road, market and other infrastructure which are crucial for livelihood development. Households with poor access to these infrastructures have low farm and family income and poor livelihood and opposite is true in accessible areas. The results of GIS based cost distance modelling shows substantially higher time to reach to the market from rural areas. Some parts of the peri-urban areas have agro-chemical based market oriented vegetable production and some parts have organic vegetable farming while rural farming due to relative inaccessibility is subsistence based with commercial dairy farming which is a major component of rural livelihood. The findings also pinpoint that most of the socio-economic parameters are governed by spatial position of the household and therefore any intervention to uplift the livelihood through agriculture development should take this spatial variation in account.

**Keywords:** Cost distance model, farm income, GIS, Nepal, peri-urban fringe

## Value Chain Analysis of Beef Cattle Production in Different Cattle Feeding Systems in Bac Kan Province

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Prevalence of cattle markets with high demand in uplands of northern Viet Nam leads to ease of marketing of cattle, giving a positive condition for cattle development. This has not been as vigorous as expected despite existence of supporting policies. Market for cattle in uplands is still underdeveloped although marketing of cattle is considered as essential factor influencing their development. Herd sizes have not increased, in some cases, farmers have decreased size or ceased production altogether. This paper uses a value chain analysis approach to examine cattle subsector in Bac Kan and will attempt to identify potential entry points for improving value chain to assist cattle production.

A significant proportion of marketed cattle come from neighbouring provinces and China and amount of cattle traded in local markets depends on seasons and outbreaks. Live cattle prices have fluctuated significantly due to economic crisis and cattle lean meat capacity. Tay minority farmers producing cattle in free-ranging and part-time grazing systems often sell cattle at local markets but have poor negotiation capacity. H'Mong minority farmers producing in cut-and-carry systems bring their cattle to markets to achieve best price, as having a better capacity for valuation, many H'Mong also work as cattle traders. Middlemen working in groups with tight relation with each other play a key role in price determination, but need for high capital investment to undertake this business.

Middlemen and slaughterhouse owners have strong relationships to ensure cattle supply. Most farmers lack information on correct pricing for cattle, deciding value of cattle based on middlemen. Farmers who are not grouped or working in collaboration together get less benefit than others. The value chain analysis suggests that formation of community farmer groups for collective marketing and capacity building with formal regulation is a critical option to improve bargaining power, position and linkages of farmers with other actors, and there should be more government intervention in control of cattle smuggling, control of quality of products, defining procedures for cross-border trading and paperwork. Specific policies related to slaughterhouse conditions, location should be implemented in the Northern provinces in order to improve development of beef cattle.

**Keywords:** Cattle development, cattle systems, value chain, Viet Nam, uplands

## **Impact Assessment of Direct Marketing of Small- and Mid-sized Producers through Food Industry Electronic Infrastructure MarketMaker**

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MarketMaker is a free in-depth marketing tool to help small and mid-sized producers get sophisticated data to help them reach thousands of potential buyers. NY MarketMaker is one avenue farmers across New York can utilise to make connections with their customers. This powerhouse database which contains over 3,000 food producers and over 84,000 New York food-related references, connects buyers, sellers and transportation services and is easily searchable, even for the ‘technologically’ challenged. Cornell University Cooperative Extension in New York City began this project with the University of Illinois in 2007. The main purpose of MarketMaker is to level the playing field. With this tool, small and mid-sized producers have similar market intelligence as the bigger producers.

In order to measure farm-level impact of MarketMaker usage by producers registered with the site, the producer evaluation survey was conducted in August 2009. The structured questionnaire forms were sent to 700 selected producers who actively visit and use the site. The level of producers’ interests is shown by the high response rate of 53.4 % (374). Questions were focused on “how many percentage of producers’ farm-level income increased from direct and niche marketing activities”, “how many marketing contact did they get through MarketMaker”, what market channels do they use or plan to use in the near future, how would they use MarketMaker site effectively and many other questions. Producers estimated the dollar value of their business sales helped/started by MarketMaker in seven groups ranged from under \$100 to \$25,000 or more. The majority of the total respondents described that 10–25 % of their farm-level income increased from direct and niche marketing activities. The survey results show that MarketMaker helps small and mid-sized producers in many different ways by getting marketing contacts; using the MarketMaker Directory to contact others; connecting direct to individual consumers, restaurants, farmers markets, and institutional buyers; finding producers and their farm products; and finding food industry business partner. NY MarketMaker helps increase availability of regional grown foods for the urban market and improve diet and health of NYC residents by providing a free access to locally grown fresh fruits and vegetables: <http://nymarketmaker.cornell.edu>

**Keywords:** Consumers, food industry, market, processors, producers, retailers, wholesalers

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# Market development

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## Crop-Livestock Interactions in Smallholders' Market Participation in Ethiopia

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Most studies on household level market participation decisions are analysing either crop or livestock market participation separately. However, in mixed crop-livestock farming systems, smallholders' participation decisions in crop and livestock markets may not be separate as a household's position in one market is influenced by its position in the other. Where there is limited income from off-farm and/or non-farm activities, household cash requirements in crop production or consumption are usually met by selling livestock. Similarly, livestock purchase is usually financed by income from crop sale. But to what extent the position in one market affects the other is still not well explored in the literature. The aim of this paper is to examine determinants of household market participation positions both in crop and livestock markets jointly. Household level data collected in 2009 from 1190 sample households in ten districts of the four major regions of Ethiopia is used for the analyses. Descriptive statistics show that there is no autarkic household in crop markets. Thus, our sample households are classified in six categories, combinations of net buyer and net seller positions in crop market, and the three possible positions (net seller, autarkic, and net buyer) in livestock market. Using simultaneous equation models, we have tested whether the position to be a net seller in crop market is affected by the position to be a net buyer in the livestock market, and vice versa. Results show that the decision to be a net buyer in crop market affects the decision to be a net seller in livestock market. Similarly, the decision to be a net buyer in livestock market is affected by the decision to be a net seller in crop market, but not the other way round in both cases. Results imply that crop purchase is financed by livestock sale and excess income from crop sale is saved in a form of livestock asset. Thus, policies/strategies enhancing smallholders' participation in crop and livestock markets particularly in mixed crop-livestock system should pay attention to the production and marketing of both commodities simultaneously.

**Keywords:** Crop-livestock system, Ethiopia, market participation, market position, smallholder

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## **The Impact of Agricultural Technology Adoption on Marketed Surplus: the Case of Improved Groundnut Varieties in Malawi**

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The participation of farmers in markets is widely acknowledged as a key path to welfare improvement for them. Through the adoption of improved technologies, farmers may increase their productivity and consequently increasing the portion of the production which enters into the market- also referred to as the marketed surplus and their incomes. An understanding of the behaviour of marketed surplus and the variables affecting it is an essential element of effective planning and programme design as it can facilitate the development of sound policies with respect to agricultural marketing and prices, imports and exports and the overall national rural development objectives. This study examines the causal impact of the adoption of improved groundnut varieties on marketed surplus. The study is based on a household survey data of 400 groundnut producing households in rural Malawi collected by the International crops research Institute for the semi-Arid tropics in the year 2008. The paper applies the counterfactual outcomes framework of modern evaluation theory to estimate the Local Average Treatment Effect (LATE) of adopting improved groundnut varieties on the amount of marketed surplus and that of marketable surplus of groundnuts. We find that 45 % of the groundnut producers are autarkic while the rest are net sellers. The econometric analysis shows that the adoption of improved groundnut varieties has a positive and significant impact on the amount of marketed surplus as well as that of marketable surplus. The adoption of improved groundnut varieties significantly increases the amount of marketable surplus by 12 kg per capita and it increases the amount of marketed surplus by 8 kg per capita. We also find that increased production and higher prices are some of the other important determinants of the quantity of marketed surplus. The findings suggest that there is a scope for increasing the participation of farmers in the marketing of groundnuts through increased cultivation of improved groundnut varieties.

**Keywords:** Counterfactual, groundnuts, Malawi, marketed surplus

## **The Level of Social Cohesion and Risk Aversion among Cotton Farming Households: Economic Experiments in North Benin**

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Cotton production is the main source of income and foreign exchange in Benin. The crop has a long tradition and since 1995 a growing minority of farmers also produces biological certified cotton. Cotton production is one activity of a production system involving the production of cereals, vegetables and other activities.

This study explores the role played by social cohesion and risk attitudes as important determinants for small scale farmers' decision making both theoretically and empirically. Yield, price, and income risks that farmers face in adjusting their cropping patterns arise due to several biophysical factors (*e.g.* irregular rainfalls, diseases or pest infestations), introduction of new technologies or changing economic environment, and the absence of institutional innovations (*e.g.* crop insurance, disaster payments, emergency loans). Networks and groups are extremely important for cotton growers in Benin. Cotton farmers belong to village groups of cotton producers giving them access to input and credit as well as to more intensive and regular extension services. Groups result in a cotton community which makes possible for farmers to share risk. Two producer groups were considered: conventional and organic cotton growing households. First a trust game was conducted to shed light on the level of social capital in both groups of cotton producers. The argument of a special social cohesion that is raised in connection with structure and organisation of the organic farming could not be confirmed. It was shown that the degree of trust between the producers of both farming systems do not differ significantly. In a second step, an experimental gambling approach was applied to identify risk attitudes using experimental procedures with real payoffs. Farmers of both groups were found to be severely risk averse. Differences in the level of trust and risk aversion could rather be attributed to the gender structure of the two different cultivation methods. The strong trust and risk scheme differences between men and women have to be considered in economic assessment to generate useful predictions of innovation adoption or policy measurements.

**Keywords:** Benin, field experiments, risk aversion, trust game

## **Adoption of Food Safety and Quality Standards among Chilean Raspberry Producers – Do Smallholders Benefit?**

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Higher international trade volumes and increasing consumer concerns have led to an increasing importance of food safety and quality standards in recent years. While the compliance with standards might entail benefits such as better market access or higher incomes for smallholders, non-compliance can lead to an exclusion from important markets. High initial investments that need to be made to fulfil the requirements of standards, certification costs, and managerial skills can be a barrier for small-scale farmers, who often lack access to credits and training. The present study aims to identify the factors that influence the implementation of US GAP and Chile GAP standards and the impact on farm management and income. For this purpose, survey data from 57 certified and 169 non-certified Chilean smallholder raspberry farmers are analysed using descriptive statistics and econometric analyses.

Based on statistical tests, it is shown that credits and trainings are important prerequisites for a certification. Certified farmers have better quality management and higher yields on the average. Product quality is positively influenced by a certification. Although there is no price premium on the average for certified raspberries, overall, certified farmers perform better in terms of raspberry income.

Results from a probit regression model show that larger farms are more likely to obtain a certification. Further factors which positively influence the adoption of a certification include education, family labour endowment, and membership in a farmer's association. We find no selection bias with respect to certified and non-certified farmers' performance. Consequently, we estimate two linear regression models that confirm the positive effect of certification on product quality and of product quality on raspberry income.

Based on the results, we conclude that certified farmers mostly benefit from the quality and yield-enhancing effects of training and standard implementation, whereas the certification of raspberries is not associated with premium prices. As long as price premiums are absent and certification is not mandatory, implementing standards rather than certification should be the focus of policy makers. Should a certification become an asset or even a prerequisite on the export market, the smallest farms are threatened by market exclusion.

**Keywords:** Certification, Chile, food safety, quality standards, raspberry export, small-scale farmers

## **Third Party Socio-environmental Certifications: A New Perspective for Small-scale Coffee Producers in Honduras?**

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The coffee value chain has evolved rapidly over the past decades. On one hand, the consumers in industrial countries have become more aware and educated on social-environmental concerns. On the other hand, there has been an increase in the number of companies and corporations promoting clean production, enforcing the compliance with social and environmental regulations among coffee producers. These third party certifications have an impact on the price of the coffee, usually favouring small-scale producers. Nevertheless, many coffee producers in Honduras consider the process of complying with standards and acquiring certifications as complex and all the requisites and costs involved seem too confusing. The study focused on identifying the main causes that limit the participation of coffee producers in western Honduras in the process of third-party socio-environmental certification of their farms. The results indicate that the limited information on the characteristics of these markets, the high implementation costs, the lack of a national policy promoting certifications and a cultural weakness of keeping records and registries at the farm level are the main causes hindering the acquisition of certifications (ej. Organic, Fair Trade, Utz Certified, Rainforest Alliance, Starbucks C.A.F.E. Practices). Coffee producers regard these causes as external to their production activities, but recognise that there is an internal responsibility that must be undertaken in order to find solutions or options in order to participate in these markets. Because the monetary benefits are not immediately palpable, they do not consider acquiring certifications a priority. Finally, the promotion of the Participatory Guarantee System as a tool to access local and international coffee markets in substitution of third-party certification programs was explored.

**Keywords:** Coffee, Honduras, participatory guarantee system, third-party certification

## How were Vietnamese Upland Farmers Affected by the Recent Strong Fluctuations of Food Prices on the World Markets?

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In recent years, agricultural commodity prices were subject to vast fluctuations on the world market. To understand the effects of international price fluctuations on rural households, the study of the transmission of world market prices to local markets which are most relevant for small-holder farmers and households offers important insights. Covering the dominant cash crop and the primary food crop, this research analyses the integration of maize and rice markets in Son La province, northern Viet Nam, with national and world agricultural markets.

Following an in depth analysis of the value chains of maize and rice, monthly as well as weekly time series of wholesale and retail-prices in the periods from 2001 to 2009 and from 2007 to 2009, respectively, are employed to analyse price dynamics and interrelationships using cointegration analysis and Vector Error-Correction Models.

We find that domestic production and marketing of maize are largely liberalised and highly competitive. However, no cointegration of Son La markets with world markets is found. Also, cointegration is not present between all markets studied along the domestic value chain. Yet, perfect price transmission is found between cointegrated markets.

The analysis of the rice markets yields that domestic production and local trade are largely deregulated as well. Son La markets are found to be cointegrated with the ones in the country's south as well as with world markets. However, long-run price transmission appears to be weak, so that only about 27 % of a price change on the world market is transmitted to Son La province.

In conclusion, for the commodities investigated farmers in the mountainous north of Vietnam are only partly affected by world market price fluctuations. The main underlying reasons are seasonality of production and fluctuations of international shipping rates in the case of maize and high governmental influence in international and long distance domestic trade in the case of rice.

**Keywords:** Cointegration analysis, food prices, maize, market integration, price transmission, rice, Vector error-correction model, Viet Nam



# Rural development

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## Village Bylaws Strengthen the Sustainable Management of Exclosures in the Drylands of Northern Ethiopia

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In Ethiopia, deforestation and over exploitation of forests compromised the efforts of local and external bodies to reduce rural poverty and improve livelihoods of the poor. To address this problem, communities in Tigray established exclosures on formerly degraded grazing lands for promoting natural regeneration of plants, and getting economic benefits. The communities devised village byelaws to prevent human and livestock interference and to enhance the sustainable use and management of exclosures. This article analyses the contribution of village byelaws to strengthen the sustainable management of exclosures by addressing forest degradation, conflicts among users, and meeting the economic needs of users. We used qualitative research methods including in depth interviews and focus group discussions for data collection during July and November 2008 in two villages of Tigray that differ in distance from market and district town. Results revealed that the village byelaws mitigated the forest degradation by mobilising users towards common goals in the management of exclosures and resolved the conflicts among users by using monetary sanctions. In the village closer to market and district town, the enforcement of village byelaws was weak. This could arise from the high social capital among users which increased the negligence among users in exposing free riders that were their relatives and neighbours. Moreover, the village byelaws were not effective in meeting the higher expectations of users to get economic benefits from exclosures and improve their livelihoods. A possible reason for this could be the poor grass and wood production due to few years after establishment of the exclosures regardless of distance from market and district town. Recurrent drought, shortage of fuel wood, and the growing number of landless youths in the rural villages constrained the effectiveness of village byelaws and the further expansion of exclosures. In future, overcoming the poor rule enforcement by creating awareness among users on the need of strictly enforcing the village byelaws for equal benefit sharing will be very important. In addition, enrichment plantation of fast growing tree species that enhance wood and grass production will be crucial to enhance the contribution of exclosures to rural poverty reduction.

**Keywords:** Conflicts among users, exclosures, forest degradation, village bylaws

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## Is Agriculture a Good Shock Absorber for Economic Crisis? Evidence from a Rural Village in Thailand

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Rural villages in emerging market economies such as Thailand have undergone dramatic changes in the last decades. Periods of continued economic growth encouraged diversification out of agriculture for risk reduction. Thai villages are now characterised by a high dependence ratio as much of the labour force migrated to urban industrial centres. Hence, village families transform into multi-location households which rely on off-farm income and remittances while dependence on land and agriculture declines. However, during economic crises migrants may partly mitigate the effects of macroeconomic shocks through reverse migration to their natal households. This can pose a major challenge for rural villages, especially since many households may have de-intensified agricultural enterprises, which tend to reduce the demand for labour and employment opportunities in rural areas.

The paper analyses the role of agriculture in times of economic crises and is based on an in-depth case study of a poor rural village located some 350 km North of Bangkok. A unique panel data set including a complete village census of the 70 households in 2008 and 2009. In addition in 2009 all 225 village inhabitants including 80 family members who temporarily migrated to urban areas were interviewed. Major variables of the survey are household member characteristics, income sources, amount of borrowing and debt, shocks experienced, information exchange patterns and instrumental support structures.

Using an extended household model to incorporate the urban sub-locations as a theoretical framework we compare livelihood strategies and risk mitigation measures of different household types, namely traditional farm households and multi-location households.

Results show that migrants maintain strong social ties with their natal village and are often reluctant to develop new networks. Thus, the agricultural households perform in the short run an important safeguarding role since migrants rather return to the rural regions than relying on friends or colleagues in the urban centres. However, in the long run an intensification of agricultural production would require high initial investment costs in order to build irrigation systems for instance and could probably still not offer enough job opportunities and even out the decline in remittances and off-farm income.

**Keywords:** Agriculture, economic crisis, household models, migration, rural urban relations, Thailand

## **Global Price Changes and Local Livelihoods: The Impact of Agricultural Price Fluctuations on Rural Livelihoods in Cambodia**

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Since 2008, the high rise in agricultural prices and thereafter, prevailing volatility still are a major issue in the public, political and scientific debate in Cambodia. To analyse and understand their impact on peasant livelihoods, a field study was conducted in three villages from September until December 2009: in Ta Khoey, a rice-producing village south of Phnom Penh; in Kork Deu, which is situated near the Tonle Sap and is mainly shaped by rice farming and fishing; and in Bor Huy, a village at the border to Thailand, where farmers produce maize exclusively for export.

The Sustainable Livelihood Approach provided an appropriate conceptual framework to address the research question. The field data revealed that capital endowment was very low in all three villages. A malfunctioning institutional and political framework further increased vulnerability. Recent price developments thus hit an already very challenging livelihood setting and required the peasants to act. Their struggle to cope with these negative trends deteriorated their food security, increased dependency on external help and raised indebtedness. Adaptive strategies were mainly production and migration based. Changing agricultural prices played however merely a minor role within the decision making process for adaptation.

The study exhibited major drawbacks Cambodia has to face in order to reduce the overall vulnerability of peasant households towards agricultural price volatility. An adequate response to these challenges must not only deal with immediate symptoms but also with the root causes of vulnerability. Peasants are consumers and producers at the same time. Assuring food security in times of high food prices is therefore just as important as providing a basis which allows farmers either to profit from high farm gate prices or to diversify their livelihoods.

**Keywords:** Adaptation, Cambodia, coping, food prices, sustainable livelihood approach, vulnerability

## **Does Decentralisation Help to Fight Poverty? The Case of Community-based Pasture User Committees in Kyrgyzstan**

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The paper explores the introduction of community-based pasture management in post-socialist Central Asia. It looks at the implementation of a new law “On pasture” that was enacted in Kyrgyzstan in January 2009. The law shifts management authority for 9.2 million hectares of pastures to community-based Pasture User Committees. The paper studies how these Pasture User Committees are being established and which mechanisms of exclusion affect the participation of the poor and vulnerable in these groups.

The paper draws on a comparative case study conducted in three different municipalities in the northern parts of Kyrgyzstan. The analysis showed that three overlapping processes of Pasture User Committee establishment occurred during 2009. First, local level administrators had crafted rules based on their interpretation of the new pasture law, second, rules were being established by a government-mandated implementing agency. In addition also, NGOs worked on the establishment of the Committees. The analysis showed that in all study cases, regardless of the implementation procedure the poor were excluded from participation. Field data suggest that pro-poor effects of decentralisation do not come without substantial efforts for ensuring effective participation. Even if the participation of poor is forcefully supported, which was the case for the implementation strategy employed by the government mandated agency, local factors, such as perceptions of legitimacy and pressure for time-saving procedures led to exclusion of poor pasture users in community-based Pasture User Committees. The paper concludes with policy relevant recommendations for ensuring pro-poor effects of the current pasture management decentralisation strategy under way in Kyrgyzstan.

**Keywords:** Decentralised natural resource management, Kyrgyzstan, pasture, poverty

## **Linking Smallholder Farmers to High-value Markets – Impacts of Producer Group Participation in Rural Kenya**

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Improving market access for smallholder farmers is widely recognised as one of the key strategies to promote rural development and poverty reduction. However, high transactions costs have been identified as one of the major constraints for smallholder market participation. Today, changes in domestic and global supply chains associated with the rise of high-value agricultural markets introduce a new set of transaction costs. In particular, rising quality and procurement requirements further increase barriers of market entry for resource-poor farmers. Collective action in producer groups (PGs) is an institutional innovation to potentially reduce such barriers and increase smallholder competitiveness. The objective of this paper is to quantify production and marketing effects of PG participation, using the example of smallholder banana farmers in the central highlands of Kenya, where PGs are currently being established with NGO support. A probit model of PG participation shows that wealthier farmers are more likely to become members. Members have more land, as well as better access to investment capital and information technology. Employing a propensity score matching approach to control for self-selection bias, we find that members selling through the group benefit from 24 % higher banana prices than members selling outside the group and non-members. However, despite higher prices, no significant differences in banana gross margins are observed. This might be due to higher input costs and somewhat lower yields, since the majority of the PG members selling through the group have adopted improved, tissue culture planting material, which is higher yielding under favourable conditions but greatly suffered from the ongoing drought in 2007/2008. Overall, the findings suggest that PG participation improves access to input and output markets. Since many of the banana PGs investigated have just recently started to collectively sell bananas, positive effects on household welfare and food security may be expected in the future.

**Keywords:** Collective action, high value markets, smallholders

## **Is Honey Production an Alternative Pathway out of Poverty by Resource Poor Households in Marginal Lands of Kenya? Evidence from Baringo District**

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Using data from a cross-sectional survey, this study analysed the potential of honey production in Baringo District as an alternative pathway out of poverty and food security in agricultural marginal areas in Kenya with specific focus on value addition. The data were used to test the hypothesis that value addition in honey is effective in significantly improving the livelihoods of poor households where subsistence and pastoral agriculture is not sufficient to address the poverty and food security challenges in arid and semi-arid land (ASAL) areas. A Heckmann two stage and maximum likelihood logistic regression procedures were used to determine the extent of values addition contingent on the decision of a honey producer to participate in value addition activity, and to assess the link between honey value addition and household poverty status, respectively. The results from the study show that the decision to add value is positively and significantly influenced by the amount of honey harvested, group membership and amount of hours spent on off-farm activities, while it is negatively influenced the age of the farmers and the education level of the household head. The study further shows that although honey production and value addition are profitable, they are only activated within the farming system as an instrument to get out poverty and not as a long term productive activity for livelihood sustenance. It is the poor that continue engaging in the honey production and value addition. From the results it is concluded that existing institutional frameworks do not provide sufficient incentives necessary to for honey production to be beneficial in addressing poverty and food security problems and the policy challenge is to address institutional weaknesses that would making the contribution of honey production and value addition effective in mitigating poverty effects in agriculturally less favoured areas of Kenya.

**Keywords:** Honey, Kenya, poverty, value addition



# Communication and extension services

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## Webgis Meegahakivula

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Smallholder farmers in the Meegahakivula region of Sri Lanka were the subject of a conjoint research programme with international project partners. Degraded soils by accelerated soil erosion, decline in crop yields, thus income and non-favourable climate conditions were determined to be the main problems in the region. One goal of the project was to analyse the flows of goods and cash of the household farming systems over the year in an integral way. Furthermore, the project aimed at investigating the influence that incorporation of legume trees and leaves as green manure has in enhancing soil fertility and stability. Both agronomic and socioeconomic aspects were considered to evaluate the benefits of planting trees. The project involved the use of GIS-based technologies and photogrammetric issues. Photogrammetry was used to acquire spatial data such as the orthophoto or the terrain model, in order to obtain a differentiated view of soil fertility in different slopes. GPS field measurement, socioeconomic interviews as well as agronomic survey complemented the vast amount of basic data. The internet-based GIS platform (WebGIS) was implemented to store, administrate, analyse and visualise these spatial and non-spatial project data. The project participants can access the data easily over the internet, which simplifies the worldwide cooperation of the researchers. Apart from a web browser, no additional software is required. The platform allows advanced data queries and at the same time it is a tool that can be used for project data visualisation purposes. The system architecture of the platform is totally based on open source and free software components.

**Keywords:** Agronomy, Photogrammetry, smallholder farmers, Socio-Economy, WebGIS

## **What has Path Dependence got to do with Smallholder Farmers' Decision to Adopt Agricultural Technologies? Lessons from Côte d'Ivoire**

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The literature on farmers' choice of agricultural technologies is populated by studies that have focused almost exclusively on analysing contemporary observable variables but, little attention is paid to understanding the historical context and policy antecedents that may have influence farmers' technological choices. This paper identifies path dependence as a historic phenomenon that exerts important influence on the contemporary adoption decisions on agricultural technologies by smallholder farmers. This paper begins with a discussion on path dependence and its relevance in shaping farmers' choice of farm technological options. Using a case study of the cotton sector of Côte d'Ivoire, it then examines how various policy and institutional interventions have created structural changes that have led to the emergence of dominant farming enterprise and exerting notable influence on farmers' choice of farm technologies in contemporary times. It emphasis how historical and external interventions have led to the emergence and contemporary dominance of chemical pesticides in crop protection technology at the expense of environmentally sound and stable technologies in the cotton sub-sector of the country. In the paper, we particularly highlight how farmers' choice of production technologies and the dominant farming system that emerged over time are determined not by geography and soil characteristics alone, but also by historical interventions and policies. It is recommended that efforts to promote sustainable natural resource management among farming communities should recognise and analyse any path dependent patterns that exist in the targeted communities with a view to understand farmers' responses to different agricultural technologies. The study concludes that agricultural policy interventions should be assessed not only in terms of their short time effects on farm production but, also their potential long term effects (intended and non-intended) on biological and other natural resources.

**Keywords:** Cotton, natural resource management, pesticides, sustainable agriculture, West Africa

## Learning through Moving Pictures: Farmer-to-Farmer Video to Stimulate Farmers' Innovations about Botanical and Alternative Pest Management Practices in Bangladesh

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Managing pests is crucial for quality crop and seed production in agrarian tropical countries, but has often led to excessive and indiscriminate use of pesticides, threatening environmental and human health and increasing production costs. For years, farmer field schools (FFS) have promoted integrated pest management (IPM), often including local alternatives to managing pests. Although impacts on target communities have been significant, challenges to extend the impact beyond those directly involved in FFS have become more pressing. Farmer to farmer learning plays an important role and must be strengthened in future. We therefore assessed whether and how video-mediated group learning could contribute to farmer-to-farmer extension of local pest management innovation. We developed a video based on results of participatory research on a botanical pesticide prepared from the local plants to control field pests of vegetables and storage pests of crop seeds (vegetables and grains) in northwestern Bangladesh. Six men and six women farmers groups were organised in twelve villages in Bogra district. In both men and women groups we compared the effectiveness of conventional one-day community training workshops with facilitated and non-facilitated farmer-to-farmer video shows as ways to share results of participatory research. Workshops and video shows were organised at the beginning of vegetable (*e.g.* bean) cultivation season. All participants were interviewed before and after (*i.e.* at the end of bean and rice season) each exposure. In this presentation we report the findings of the women groups. Video proved more powerful than conventional training to convey new ideas derived from farmers' participatory research and improve fellow farmers' knowledge, attitude and practices about complex issues like pest management. Video allows better explanation of underlying biological and physical process and stimulates learning about local innovative pest management practices. Although effective as a stand-alone method to trigger further knowledge seeking and experimentation, video shows followed by facilitated group discussions helped to further explain scientific principles and build confidence of the rural women about knowledge intensive innovations like botanical pesticides. The study creates a better understanding of how farmer field schools can benefit from video-mediated learning to enhance farmers' innovation capacity in managing pests.

**Keywords:** Bangladesh, botanical pesticide, local innovation, participatory research, video

## **“Aid-infoservice Germany”: A Success Modell for the Development Cooperation**

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In view of the high numbers of malnourished people worldwide it is evident that agricultural production and productivity together with the nutrition situation have to be improved. Knowledge transfer is one of the key issues for improved agricultural productivity, food security and nutrition. The evaluation of the potential applicability of the - in Germany - successful operating knowledge transfer system “aid-Infoservice Germany” as a model for developing countries is matter of the study. The analysis confirmed that “aid-Infoservice” can be considered as a success model for the knowledge transfer in the field of agriculture, food and nutrition - in Germany. In an effective and efficient way the organisation has had a sustainable development impact by providing and implementing the relevant knowledge and information, and by contributing to education and problem solution of the target groups. The systematic screening of organisations together with the personal interviews confirmed that an organisation or a service with the characteristics of “aid-Infoservice Germany” does not exist in the same or a similar set-up. Critical characteristics, such as the systematic integration and participation, the combined media- and technical expertise, the multi-disciplinary focus are not provided for by one institution in the same combination. The widely missing interface between science and practice is one of the root causes for the difficulties in the transfer of knowledge to local target groups. Didactical information material and media - designed according to the specific requirements of the country and the local target groups - can improve the knowledge transfer in developing countries. The value-added by potential “aid”-country offices in developing countries was overwhelmingly endorsed by the expert interviews and the focus group. The issue of sustainability remained as a major constraint for the potential implementation of the “aid”-model in developing countries. These concerns are relevant and can only be addressed and evaluated through further examination in the context of a pilot project that tests the model and its benefits/added value for both governments and stakeholders in the development context. Both FAO and BMELV have agreed to develop and support a project proposal for such a pilot project.

**Keywords:** Agricultural productivity, aid-infoservice Germany, food security, knowledge transfer, media, nutrition, success-model, target groups

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## Living off Uncertainty

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In this paper we argue that specialist dryland pastoralists produce by exploiting non-uniform distribution, in the form of what we call the ‘intelligent’ harvesting of unstable concentrations of nutrients on the range. Recent research in complex dynamics questions the utility of analytical tools based on average values when dealing with conditions of unpredictable variability. On the other hand, average values and models of standard statistics are fundamental to all dimensions of pastoral development, from natural resource management to service provision and conventional models of animal production. Production in drylands pastoralism might therefore be at odds with the most basic items in the tool bags of both pastoral development planners and policy makers.

In spite of decisive advances made by the ‘new range ecology’, drylands pastoralism is still looked upon as a coping strategy that allows herders to get along with an ‘inadequate’ resource base. This stance can be traced to a long-established approach in the disciplines that inform pastoral development planning (natural resource management, range ecology, animal science) to rely on analytical tools based on standard statistics and average measures. However, pastoralism is better understood as a *sui generis* production system exploiting unstable concentrations of nutrients (asymmetric distribution: the most reliable feature of drylands environments); a system geared at maximising economic value, while stabilising its performance in environments where ‘uncertainty’ is harnessed for production. Since average values and standard statistics fail to capture asymmetric distribution (precisely what is relied upon for production in drylands pastoralism) they should not uniquely or uncritically inform pastoral development planning.

We are not suggesting that pastoral development planners and policy makers should (or could) stop using average values and standard statistics. However, the risk of misrepresentation following from the use of such inappropriate tools is potentially very costly. For once, because they build into any pastoral development analysis the implication that agricultural production systems must rely upon stability and uniformity. To the extent to which pastoralism does not (because instead it exploits asymmetric distribution), pastoralists are implicitly excluded from the category of producers by the analytical framework that supposedly targets them for development interventions.

**Keywords:** Asymmetric distribution, complex dynamics, feeding selectivity, high reliability, new range ecology, non-equilibrium, pastoral development, woDaaBe

## **Food Ethics: A New and Necessary Academic Approach to Improve Food and Nutrition Security**

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Interdisciplinary approaches for addressing complex social, environmental and economic issues surrounding the world food systems are now at the core of international agricultural research and development. Such approaches involve interaction between different academic cultures and frequently require intensive interaction between researchers and indigenous rural communities. Such communication and participation processes can pose limitations and difficulties if the roles of agricultural scientists, practitioners and the subjects and objects under research are not clearly defined and enjoy a common understanding by the involved stakeholders.

Despite the important role agricultural researchers play in this process, academic modules on the ethics of international food and nutrition systems are still missing from the study plans of agricultural Faculties. In response to this, University of Hohenheim students, Faculty and staff are collecting inputs and analytic expertise from different sources -including non-university and partly also from non-scientific institutions- for the formulation of a teaching concept to create a new module on the “Ethics of Food and Nutrition Security”.

This new course module will not only provide knowledge on philosophical and ethical basics and concepts, but will also entice independent and critical thinking. It aims to enable an active discussion on the necessary values and the social responsibility of those involved in the future design and management of the world food systems. This

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is the first example where university students in close collaboration with professors and external experts develop an academic module through a participatory process that involves a series of conferences, symposia and workshops. This initiative may have implications for European agricultural universities seeking to develop curricula and appropriate research in the field of ethics of the world food system.

**Keywords:** Applied ethics, social responsibility, student initiative, sustainable agriculture

## **Simulating the Decision-making of the Local Farmers in Provisioning Ecosystem Services — the Case of Bungo District, Sumatra Island, Indonesia**

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Ecosystem services (ES) trade-offs occur when the provision of the ES is reduced as a consequence of increased use of another ES. The growing demand to meet the human needs particularly for food causes the decline in other ecosystem services such as agro-biodiversity which are both crucial to human wellbeing. This research presents the decision-making and negotiation process of the farmers in three villages of Bungo District (in Jambi Province, Sumatra) in provisioning ecosystem services i.e. rice and rubber latex productions through land use dynamics role-playing games. Participants of the game assumed roles such as palm oil companies and pulp wood and paper industries as agents of land use change in the area that influence the decision-making processes of the villagers. The role playing game tried to capture the social interactions of the main actors in relation to land use change and provision of ecosystem services. Among the main results of the land use dynamic role playing game showed the strong “non-economic motivations” of the farmers and were verified using the focus group discussion. The results of this activity will be incorporated in the on-going development of an agent based modelling (ABM) to simulate and visualise the temporal and spatial scale effects on the tradeoffs between goods and services from the landscape of Bungo District while integrating the values and perceptions of the key actors. This research aims to assess between upland agricultural production (as provisioning service) and measureable ES such as (agro)biodiversity and carbon stocks for the present and future uses and provides experience for other regions.

**Keywords:** Decision making, ecosystem services, land use cover change, land use dynamic role-playing game, oil palm, rice, rubber latex production



## Potential of Posters as Visual Pictorial Aids in the Process of Health and Nutrition Counselling in Cameroon

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A fundamental requirement within the international development cooperation is to communicate interculturally. Nevertheless projects aimed at nutrition counselling fail due to ambiguous communication. Therefore pictorial aids are suggested as a language-independent way of understanding. The aim of this study was to produce posters about nutrition related sicknesses affecting infants (0 to 36 months) in urban Cameroon. Their use and comprehensibility as a health counselling instrument should be measured. The study, conducted from May to August 2008, used a triangulation of methods related to qualitative social research. The methodology of the qualitative approach included participant observations and focus group discussions. Within the quantitative part, face-to-face interviews (n = 117 mothers) were conducted in order to gain the following information: the nutritional and health status of infants, the most common sicknesses in that age group, and the usage and comprehensibility of posters as counselling instruments. The results of the qualitative and quantitative data were transferred into visual pictorial aid by a local Cameroonian artist. Looking at the media use, the survey showed that verbal counselling by nurses was declared to be the most trustful source of information (64 %). Furthermore 94 % of the women have already used posters to get information about optimal child feeding practices, and 87 % judged them to be easily or very easily comprehensible. As a result 97 % wished to be counselled with the help of posters in future times. Consequently 10 posters about the resulting consequences of poor feeding practices and unhygienic feeding environments as well as their prevention were designed. For instance the storage of food under the bed and its contamination by insects, rodents, and other vermin; their resulting consequences such as stomach ache, diarrhoea, and worm infections; as well as their avoidance by covering the pot with a lid were visualised. The study showed that the implementation of pictorial embodiments is reasonable and could support verbal communication in order to facilitate intercultural communication and therefore increase the success of nutrition counselling programmes.

**Keywords:** Africa, Cameroon, counselling, intercultural communication, nutrition, posters, visual pictorial aids

## Capacity Development as a Bridge to Transform Scientific Knowledge into Action for the World Food System

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The world food-price crisis and the over-all reverse trend of the world food system to supply the world population with adequate food has shown that generating scientific knowledge alone is not enough to support policy-makers and society in implementing strategies to solve the development problems. Capacity development (CD) is one of the bridges to bring across scientific knowledge to individuals, organisations and to political systems to enable them to assess, analyze, and solve the persisting old and up-coming new challenges in an appropriate manner.

Meanwhile a whole industry has developed around the issue of “capacity development”, which is strong in the development aspect, however weak in systematizing capacity and defining which capacities are actually needed and have to be developed at which level by whom. It seems that there are as many capacity assessment frameworks on the market as organisations working in capacity development and most of these frameworks are organisation-specific and often difficult to understand and utilise by others.

A group of capacity development experts from various organisations have formed a working group and developed a tool to systematize needed competences to build up the appropriate capacity at different levels and to be able to assess missing capacities related to certain challenges. This framework is focusing on capacity rather than the common approach of capacity development. It looks at capacity in a variety of different ways: capacity in time (past to future), capacity of different skills (“soft” and “hard”), capacity as system (complex and simple), and capacity of people (individuals to groups).

The framework is developed in such a way that it can be used by professionals as well as laypersons, from international organisations as well as local civil society groups. The underlying objective of this tool is to encourage people to think of capacity development as a critical development activity in its own right, enabling individuals and groups to develop their ability to manage the food system at the local up to the global level and thereby improving its major task to supply the world population with enough and adequate food.

**Keywords:** Capacity development, empowerment, food security

## **Role of Agricultural Extension Agents (AEAs) in Syrian Drylands**

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In Syria, extension is an important agency and depending on its research studies farmers can run their own farm in an efficient way. Majority of the farmers are influenced by their knowledge and access to the extension in the area and therefore, any deficiencies in the present system of agriculture extension would largely affect farmers' productivity of agriculture and hence their income leading to negative impacts on livelihoods. In this direction, the agricultural extension agents are potentially important links between the farmers and other more distant sources of information. Accordingly, this paper aims to explore level of attending for training courses by Agricultural Extension Agents (AEAs) and presents the perceptions of AEAs about the roles undertaken by them and factors affecting the performance of extension service in Syrian Drylands (Salamieh District). Primary data were collected from 20 AEAs by means of structural questionnaire during January 2010. The results reveal that 35 % of AEAs did not attend any courses in the last year. AEAs' perceptions of their roles indicated that they were satisfied with the roles: Conduct on-farm demonstration plots, and implementing the agricultural production plan. While the AEAs were neutral to the roles of programme planning and dissatisfied with the roles: Cooperation with agricultural scientific stations and assisting farmers to define their problems. Moreover, the results showed that lack of transportation facilities, low salary and lack of rewards and concentrating on controlling agricultural legislation were major hindering factors for extension agents in implementing the extension programmes. It is recommended that emphasis on education, training and skill building of extension staff should be increase. Additionally, there is need to coordinate work between research activities and extension service with the objective of adopting extension programmes dedicated to tackle farmers' problems. Increasing transportation facilities for the AEAs will improve their abilities to reach farmers' sites in time as well as they could bring farmers' technical problems to the extension unit.

**Keywords:** Extension agents, hindering factors, Syria, training

## **Influence of Public and Private Agents in the Use of New Knowledge and Technology among Small-scale Producers: The Case of the Honduran Coffee Chain**

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Various providers of knowledge and technology can influence the way small-scale coffee producers innovate. In the paper we present results from a study in which we define five different innovation trajectories in which public and private agents influence the producers' decision to adopt new knowledge and technologies. These include: a) innovation through local buyers b) innovation through international buyers and exporters c) innovation through input suppliers d) innovation from government and development cooperation and e) innovation through farmers' initiatives. In order to test which of those trajectories had most influence on coffee producers in Honduras we rated levels of innovativeness among coffee producers in three communities in major coffee producing areas. We also collected data on the type of relationships these producers maintain with other members of the community and with public and private agents in coffee development. Depicting the internal and outbound connectedness of producers in the three communities studied, tools of social network analysis were applied to find out how interactions with certain agents, separately and cumulatively, have influenced the use of improved methods in coffee production and marketing. According to the results, there are significant differences in the way that various providers of knowledge and technology, especially private buyers and development agencies, but also input providers and farmers organisations and unions influence the farmers' behaviour towards innovation. Buyers exert an influence particularly on certification and quality aspects, whereas development agents have a greater influence on improved agronomic practices. Farmers who communicate with the extension branch of input providers tend to be more innovative. These results suggest that development programs should take more seriously into account the role of private actors in innovation among agricultural producers and, hence, design development programs in such a way to allow for collaboration with these agents.

**Keywords:** Coffee production, Honduras, innovation, social networks

## Impact of Dissemination Pathways on the Probability and Intensity of “Push-Pull” Technology Uptake in Western Kenya

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In Kenya, food security is linked to households having sufficient maize supply. However maize production has significantly been challenged by stemborers (*Chilo partellus* and *Busseola fusca*) and *striga* weeds (*Striga hermonthica* and *S. asiatica*). The recommended conventional control methods (e.g. crop rotation, chemicals) have not been effective despite some of them being prohibitive and unaffordable to small resource poor farmers. Push-Pull Technology (PPT) developed by International Centre for Insect Physiology and Ecology (ICIPE) together with its partners has successfully been promoted as a control measure for the two vices in western Kenya. It comprises intercropping between rows of maize with plants (*Desmodium*) that repel stemborers, and which also reduce the level of *striga* infestation, combined with a surrounding crop of plants (Napier grass) that trap out stemborer pests. Since PPT is a new and relatively knowledge-intensive technology, the provision of information about it is critical for its adoption, use and retention. By examining the relationship between the adoption of PPT (probability and intensity) and the dissemination pathways, this study aims at isolating the pathway(s) that have greatest impact on adoption. This information will help in coming up with an effective dissemination strategy. A Macdonald and Moffit decomposition of two limit tobit was used to analyse data from 491 respondents selected from 4 districts in western Kenya. The results indicate that field days (FD), farmer field school (FFS) and farmer teacher (FT) chronologically, had the greatest impact on the probability that a farmer in the study area would adopt PPT and also on the intensity of adoption. The PPT adoption intensity was higher on small farms than on large farms and on farms close to the tarmac roads than those far away from the tarmac roads. The impact of location dummies varied across the districts. Also, the impact of dissemination pathways on both adoption decision and intensity of adoption was higher than the impact of socio-economic factors (e.g., age, education). Efforts to disseminate PPT should therefore target the use of demonstrations and field days to intensify adoption. FT and FFS can be used as alternative pathways.

**Keywords:** Adoption, dissemination pathways, push-pull technology, Tobit

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## Research Spillover: Quantification Methods and Recent Experiences in ICRISAT Groundnut Research

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Sustained, well-targeted, and effectively used investments in R&D have improved agricultural productivity worldwide and thereby contributed to food security. In this context, research spillover effects refer to a situation in which a technology that is generated for a specific target region or product is also applicable to other locations or products that are not targeted during the research process. They are generally categorised in three groups: across location spillovers, across commodity spillovers and price spillover effects. The focus here will be the across-location spillovers which occur when a technology designed for a specific region is also applied in other regions. Efforts to quantify these effects have shown that their contribution to the overall impact can be substantial at times.

The consideration of these effects is especially important for international research institutions like the Consultative Group of Agricultural Research (CGIAR) centres. Against the background of their global mandate one has to carefully assess where to invest research funds in order to reach maximum impact. The thorough understanding and quantification of the spillover effects that emerged from past research is one important tool in this priority setting process.

Based on the methodology developed *e.g.* by Davis *et al.* (1987), this paper will enhance the measurement of potential agroclimatic homogenous spillover domains using example of the International Crops Research for the Semi-Arid Tropics (ICRISAT) groundnut research and variety release. Due to the regionalised structure of ICRISAT and other CGIAR centres, a special focus is set on the interlinkages among the African and Asian locations. Results show that the spillover potential is rather high based on agroclimatic similarities across the locations. Nevertheless, the actual spillover realisation is by far lower due to differences in market structure, governance factors and other socioeconomic factors. To overcome these bottlenecks through new innovations along the research continuum as well as along the commodity value chain is crucial in order to achieve higher impact from the funds invested and therefore increase the poverty reduction impact from ICRISAT research.

**Keywords:** Africa, agricultural research, Asia, budget allocation, international trade model, priority setting, spillover effects

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## Resource-productivity of Smallholder Croppers using an Endogenous Switching Regression: A Study of Farmers within and outside the National Program for Food Security (NPFS) in Nigeria

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The National Program for Food Security (NPFS) is designed to contribute to a sustainable improvement in national food security. The main implementation strategy of the programme is to empower small farmer communities with a timely provision of credit, agricultural input, and technical support services to increase farmers' output and income on a sustainable basis. The present study was designed to examine factors influencing a farmer's participation in the NPFS as well as the resource productivity of farmers within and outside the NPFS activities in Nigeria. We employed an endogenous switching regression with a sample selection model on a total of 176 farmers (89 within and 87 outside) for the econometrics analysis. The empirical evidence from the Probit model indicates that variables such as education, age, extension, farm size and hired labour significantly increased the probability of a farmer's participation in the NPFS. The estimates of the endogenous switching regression model shows that sample selection bias would have resulted if the net returns equations had been estimated without taking into account the decision to participate in the program. The coefficients of the considered conventional production inputs in the net-returns equations (*e.g.*, cost of materials, family labour, hired labour, and farm size) significantly increased the net-returns for both participating and non-participating farmers. The returns-to-scale (RTS) value was computed from the sum of the output elasticities of the inputs; the value shows that an average farmer within the programme exhibits increasing RTS (1.187) while the same number of farmers outside the programme exhibit decreasing RTS (0.861). The implication of this is that, farmers within the programme received higher net-returns from the joint use of inputs compared to the farmers outside the program. Further analyses show that NPFS farmers obtained higher average net-returns as a result of their participation in the programme while those who choose not to participate in the programme have average net-returns. The policy implication from these findings suggests that the NPFS has tremendous benefits in ameliorating household food security and increasing the income generation potential by improving agricultural productivity in the country.

**Keywords:** Endogenous switching, food security, Nigeria, resources-use, sample selection

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## Constraints of Eco-friendly Pest Management Practices in Bangladesh

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Bangladesh has achieved food self sufficiency with the impact of the “Green revolution”. But the technologies have resulted in farmers’ dependence upon pesticides, which are causing serious environmental problems. In Bangladesh, at present, 79 % of imported pesticides are used for rice, 10 % for vegetables.

Mindless spraying of chemical pesticides has adverse residual effects on the whole environment. The pests are becoming resistant as the frequency of spraying is increasing. The increasing cost of farming put pressure on farmers who are starting to leave farming as an occupation. To control pests, a collaborative IPM project was started in 1980. The project received the majority of its funding from DANIDA while it is administered by the DAE.

The main goal of this study was to find the obstacles to ecofriendly pest management practices in Bangladesh. Information was collected through direct observation and 12 key informant interviews at government and NGO levels.

Farmers consider that all insects are bad and therefore insecticides should be sprayed to ensure a healthy crop. They use pesticides as preventive rather than curative measure. Mono-cropping and the poor soil fertility are the major causes of pest attacks. Not only lack of farmers’ knowledge, but also unconsciousness, commercial mentality and lack of knowledge of sellers are the main causes of increasing pesticide use. Most farmers are using pesticides recommended by dealers. The latter sometimes recommend highly toxic pesticides which are available to them.

It was found that farmers increased their production by 8-10 % after IPM training through increased knowledge, better management, use of balanced fertilizers, good healthy seeds etc. However, only 4 % of farmers have been trained out of the 11.8 million farmers in Bangladesh.

The present Pesticide act dating from 1985 that allows any buyer to purchase any amount of pesticide needs to be amended. The supply of organic pesticides is so low compared to farmers’ demand that they face problems in controlling pests in an environmentally friendly, safe and secured way. The government needs permit the production and importation of bio-pesticides.

**Keywords:** Environmental safety, Integrated Pest Management, pesticide dealers, IPM training, pesticide act

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## **An Inquiry into Causes of Corruption: Instrumental Variable (IV) Approach**

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Corruption as a research topic is relatively new. Most of the literature on corruption is at macro level and deals with cross country analysis. This gives little insight about the relationship between corruption and individual agents. The present work is an attempt to reduce this gap by analysing experiences of 210 farm households belonging to six villages of Bangladesh. Instrumental variable (IVPROBIT and IVTOBIT) approaches are employed to identify farmer's socio-economic determinants for corruption and bribe experiences. This study focuses on two questions: which farm households are more likely to experience corruption; and why amount of bribe varies among households for the same service. In the IVPROBIT model the dependent variable is the dummy of corruption experience(s), whereas it is amount of bribe in the IVTOBIT model.

Among service recipients, 70.4 % experienced corruption during the period July 08-June 09 while interacting with different service delivery organisations. Bribery is most the common (64.7 %) form of corruption; followed by negligence of duties (19.3 %) and nepotism (9.2 %). In the IVPROBIT model, household's relation with sub-district executive officer's office (UNO office) and location dummy has significant impact. The associated signs explain that households having relation with UNO office and living in urban areas are more likely not to experience corruption than their counterparts. The UNO office has immense influence by being the prime authority for implementing and monitoring different government programmes and projects in respective locality. These influences are helpful while facing corruption. Several factors are responsible behind notable difference in rural and urban experiences. Compared to urban areas services in rural areas are limited. Besides media, civil society organisations, and people's awareness are relatively less in number and, thus, maybe less effective in rural areas. The IVTOBIT model shows that household's living expenditure (per head) has positive significant impact on bribe amount. This suggests that service recipients' socio-economic status except economic capability to pay bribe does not get consideration whenever they fall on bribery. The rent seekers only discriminate service recipients depending on their economic status; as they find rich households more suitable to devour higher sum of bribe.

**Keywords:** Bribe, corruption, instrumental variable, Probit, Tobit

## **The Role of Cooperative Societies of Gum Arabic Producers in Promoting Gum Arabic Production and Marketing in North Kordofan State, Sudan**

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This study was conducted in Sheikan and Om Rowaba Localities in North Kordofan State. It focused on role of cooperative societies of gum Arabic producers in gum arabic production and marketing. It also aimed to investigate production, marketing and general services provided by these societies. Primary data were obtained from personal observations and questionnaires using simple random sampling technique. Secondary data were obtained from respective sources, references and related institutions. Data were analysed using simple descriptive statistics and partial budget analysis for determination of net returns to producers by comparing three groups: one benefiting from Gum Arabic Cooperative Societies (GACS), the second benefiting from Gum Arabic Company (GAC) and the third group not benefiting at all (NBG). Analysis of marginal gross returns and costs per hectare was carried out for the three groups. Results showed that 79.3 % are benefiting from GAC, 66.1 % for the group benefiting from GACS and 49.9 % for NBG. The highest cost of production and marketing occurred for NBG, followed by GACS, with lowest cost of production and marketing for GAC. Analysis of variance showed no significant differences between the three groups as far as average costs and returns were concerned. The discriminate analysis of some items of production and marketing of gum arabic showed no significant differences between the three producers groups except in case of transport costs from production areas to marketing points. Problems in the study area include misunderstanding of producers and administrators of the role and work of GACS, in addition to inadequate finance. The GACS in the study area are not efficient. Services provided by GACS did not result in significant differences between members of societies compared to others with respect to production and marketing of gum arabic as well as increase of returns from sales of gum. The study recommends raising awareness and training on administration of GACS that need to be linked with related institutions as well as improvement of infrastructure and provision of adequate financial support for gum producers and societies in the area.

**Keywords:** Analysis of variance, discriminate analysis, gum Arabic company, gum Arabic cooperative, infrastructure improvement, marginal gross returns, Sudan

## Assessing the Impact of Land Use Policy on Urban-rural Sustainability Using the Fopia Approach in Yogyakarta, Indonesia

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This study presents the results of a sustainability impact assessment (SIA) of policy induced land use changes in Yogyakarta, Indonesia. The regional problems at place are mainly the rapid expansions of urban areas due to high population pressure and the conversion of paddy fields and forests into settlements. The objective of this study was to assess, in an integrated way, the impacts of two alternative land use policies on social, economic and environmental Land Use Functions (LUFs) in Yogyakarta. For this purpose, the following scenarios were developed for the SIA: a forest protection scenario (S1), a paddy field conservation scenario (S2) and a counterfactual (no policy) scenario of ‘Business as Usual’ (BAU). The framework for Participatory Impact Assessment (FoPIA) was applied to conduct an expert-based impact assessment. For the specification of the regional sustainability context, a set of nine regional LUFs and associated indicators were identified and developed including three social (provision of work, food security, quality of life), three economic (land-based production, non-land-based production, infrastructure), and three environmental (provision of biotic resources, provision of abiotic resources, maintenance of ecosystem processes) sustainability criteria. The resulting scenario impacts of the assessment differed considerably with mainly positive impacts of the S1 and S2 scenarios on seven of nine LUFs and negative impacts of the BAU scenario on six LUFs. The overall perception of the participation-based FoPIA method by the regional stakeholders was positive. We therefore conclude that this method contributes to an enhanced regional understanding of policy effects and sustainability, particularly in datapoor environments.

**Keywords:** Land use change, land use functions, stakeholder participation, sustainability impact assessment



# Transdisciplinary research

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## **Conservation and Use of Wild Populations of *Coffea arabica* in the Montane Rainforests of Ethiopia: From Research to Action**

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*Coffea arabica* originates from Southwest Ethiopia, where its wild populations naturally occur in the understory of the montane rainforests at altitudes between 1,000 and 2,100 m. Wild Arabica coffee is not only consumed by local people, but it is also a cash crop for the local as well as the international speciality market. Above all, it is a unique gene pool for national and international coffee breeding due to its high genetic diversity. As forest land is increasingly converted to agricultural land, the wild coffee populations and their habitat, the montane rainforest, are highly threatened.

To bridge the gap between research during 2002 to 2008 and practice, the NGO “Environment and Coffee Forest Forum (ECFF)” was founded. Based on the research findings, ECFF and its German partners work on (1) the establishment of a protected area for wild coffee and its forest habitat, (2) the development of guidelines for the use of wild coffee and the coffee forests, (3) the establishment of an in-situ gene bank for the conservation of wild coffee genetic resources, and (4) concepts for environmental and conservation education and raising public awareness. The way from basic research to implementation-oriented and participatory activities will be described and discussed with the aim of establishing an UNESCO-MAB biosphere reserve at Yayu/Southwest Ethiopia.

**Keywords:** Coffee forest forum, Ethiopia, NGOs, wild coffee

## **Impact Monitoring and Evaluation Systems for Farmer Field Schools in Kyrgyzstan: Optimising Resource Allocation for Higher Impact**

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With the collapse of the Soviet Union Kyrgyz agriculture went through deep structural changes and the new small subsistence farmers were ill-prepared, lacking technical knowledge and entrepreneurship. Pilot activities demonstrated that Integrated Pest Management (IPM) as topic for Farmer Field Schools (FFS) could effectively fill the gap in extension services and enable farmers to become more efficient and self-reliant managers of their scarce agricultural resources, not so much in the sense of reducing the use of pesticides, but to improve the management of their crops. The objective of this study was to develop an Impact Monitoring and Evaluation System (IMES) to measure the effectiveness of FFS in terms of resources allocation, participation, outcome and impact that could be useful for donors, partner organisations and potential FFS-participants, taking into account the Kyrgyz context and the particular framework of IPM FFS. In the period of 2003 to 2006, 174 Farmer Field Schools were conducted in Kyrgyzstan and altogether approximately 2600 farmers were trained. Since 2006, the IPM Farmer Field School approach in Kyrgyzstan is no longer in the pilot phase. There was a need to prove its effectiveness in improving farmers' livelihoods and conduct an outcome monitoring of the FFS. The existing monitoring system of the IPM programme in Kyrgyzstan focused mainly on results and outputs. However, farmers can best define indicators reflecting their livelihood situation and rating scales realistic to their specific condition, a participatory Monitoring and Evaluation within the FFS-group and a longitudinal (before/after) comparison was proposed. A spider diagram was used as a framework to visualise quantitative, rated core indicators, which were the basis of the qualitative questioning on reasons for changes, making it possible to attribute certain impacts to FFS-trainings. The generated feedback and self-reflection additionally motivates and empowers participants, an effect highly appreciated by the FFS approach.

**Keywords:** Farmer field schools, IPM, Kyrgyzstan, outcome and impact monitoring evaluation

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## **BioDIVA – The Challenge of Inter- and Transdisciplinary Research for Equitable and Sustainable Use of Agrobiodiversity in Wayanad District, India**

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The trans- and interdisciplinary research project BioDIVA aims to generate transformation knowledge towards a gender-equitable and sustainable use of agrobiodiversity. Approaching agrobiodiversity from the disciplinary perspectives of land use change, institutions, sociology, economy and ecology establishes per se a ground for an interdisciplinary analysis of the boundary spanning complexities. At the case of rice-diversity in Kerala, South India, the paper outlines the initial steps to establish a research design for a transdisciplinary understanding of the dynamics associated with agrobiodiversity loss.

Setting out for a four-year expedition to create a development perspective for farming communities and other actors involved in the upland rice farming system, we firstly present the results of integrating disciplinary theoretical assumptions of natural and social sciences on a conceptual level. Thereby we reflect on the process and tools to identify the specific perspectives and interdisciplinary intersections. This step prepares for the confrontation with the field in an explorative case study as a means to build a common ground at the very beginning of BioDIVA research process. Secondly, we discuss the BioDIVA research design after encountering with the field.

To create a development perspective for farming communities and other actors involved in the upland rice farming system of Kerala, South India, we reflect on the predefined key terms, which guide our research, met transdisciplinarity in the field, explore the knowledge domains of farmers, scientists and development practitioners and incorporate these different kinds of knowledge and interests into a common research design. The paper is structured as follows: 1) We introduce to the key terms, which guide our research, 2) reflect on transdisciplinarity as a research paradigm, 3) explore the knowledge domains while presenting tools for generating disciplinary perspectives by merging them into intersections, 4) reflecting on the process, we proceed to build an interdisciplinary framework to prepare the transdisciplinary integration, 5) present our first findings in the field and conclude with a first critical discourse on transdisciplinary research from our perspective of South India.

**Keywords:** Agrobiodiversity, gender equity, interdisciplinarity, methods, rice, sustainability, transdisciplinarity

## Self-organisation in Building Resilience to Climate Change in Smallholder African Agriculture

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Building resilience seems to be an effective response to addressing increasing rainfall variability due to climate change and the uncertainties in the temporal and spatial manifestations of other climate change impacts in sub-Saharan Africa. Such an approach would contribute to reducing the vulnerability and increasing the adaptive capacities of smallholder farmers and their farming systems to climate change, and equally secure agricultural production. These goals become even more crucial, considering the net deficit production of African agriculture and the recurrent food crises in some sub-Saharan Africa regions.

In the discourse on social-ecological systems, resilience is conceptualised as having three characteristics, namely, buffer capacity, self-organisation and the capacity for learning. This paper explores how self-organisation contributes to these goals by using it as a conceptual and analytical lens. Self-organisation is based on the understanding that the degree to which farmers are connected and have control over their various resources determines the degree to which they can reduce their vulnerability and build their resilience to climate change. The criteria and indicators for self-organisation are elaborated. The paper shows how self-initiative, cooperation and networks, and reliance on own farm resources and farmer's own knowledge contribute to resilience.

Data was collected through interviews and focus group discussions in Kenya as well as through literature review. The case study is illustrative of smallholder agriculture in sub-humid and semi-arid areas of sub-Saharan Africa. The results provide insights for improving adaptive capacities in smallholder agriculture and also contribute knowledge on the usefulness of self-organisation as a concept in resilience research.

**Keywords:** Adaptation, Africa, agriculture, climate change, resilience, self-organisation, smallholder farmers

## Socio-economic Profile, Resource Use Efficiency and Constraints Study in the Tank Commands of North Eastern Karnataka, India

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Tank irrigation is an age old established practice in most of the semi-arid tropical parts of India and particularly in South India for providing life saving irrigation to the crops. Tank commands has a special significance to marginal and small farmers who depend on the tank irrigation hence can be effectively used for development of backward areas. The study was conducted in three districts like Bidar, Bellary and Raichur districts of North eastern Karnataka in the selected tank commands rejuvenated by Jala Samvardhane Yojana Sangha, Government of Karnataka with an objective of studying the resource use efficiency in the tank commands and to identify the constraints faced by farmers in farming activities. Majority of the farmers in the study area were practicing only animal husbandry as subsidiary enterprise, field crops were the major crops. In order to maximise the profits, the optimum use of resources is imperative. The C-D production function was used to measure the resource use efficiency and allocative efficiency in the study area. Results revealed that, there are seven important variables influencing the dependent variables. The inputs like feeds + concentrates was over utilised and number of cows and seeds were under utilised in Bidar district. The resources like land, number of cows, fertiliser + FYM were over utilised and labour, PPC + veterinary charges were under utilised in Bellary districts. In Raichur, fertiliser + FYM and labour were underutilised. Indicating the scope for reorganisation of resources to optimise their use to enhance returns. In all the districts, the use of resources which are showing negative production elasticity should be decreased to achieve the optimality in the resource use and the use of resources showing more than one elasticity should be encouraged to enhance the profitability condition. The analysis of constraints encountered by the farmers in the study area revealed that there are several problems associated in the study area are grouped under two heads namely production constraints and marketing constraints. For safeguarding the farmer's interest to enhance farm efficiency, arrangements should be made to avail timely and adequately the credit, inputs and market information.

**Keywords:** Elasticity, JSYS, resource use efficiency

## **Women Empowerment by Self Help Groups: A Way-in for Education and Nutrition**

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At the Millennium Summit in September 2000, the international community gathered and adopted UN Millennium Declarations, which popularly are called the Millennium Development Goals (MDGs). Setting out a series of targets with a deadline of 2015, they have become the heart of the global development agenda. Girls' education and overall improvement in women's status contribute significantly in improving the nutritional status of the family. Failing to reach MDG on gender equality and women's empowerment will lead to heavy economic costs. Missing the target for gender parity in primary and secondary education could lower a country's annual per capita growth rate by 0.1-0.3 %, which emphasises the degree of its importance for a country. All this clearly emphasises the need for women empowerment to facilitate education and nutrition within the MDGs by a Self Help Groups (SHG) concept. This is presently in boom in developing countries like India, Bangladesh and in Africa with the SHG concept of savings and income generating activities. In India, since two decades women were empowered by SHG microfinance programme, which is renowned as the world's biggest microfinance programme reaching millions of women clients. However, it still has a tremendous potential for a way out to empower rural women. The poster will attempt to picturise the impact and influence of these SHGs on rural women participating in savings and income generating activities and changes in their life after their empowerment.

**Keywords:** Income generating activities, MDGs, savings, women empowerment

## Participatory Soil Quality Indicators Survey: Experience of Indigenous Community in Mai-Negus Catchment, Northern Ethiopia

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Degradation in soil quality (SQ) is often associated with the type of land use, soil management and local knowledge involved in agricultural production, besides to the other soil forming and erosion influencing factors. Local SQ knowledge is complex, multifaceted, and often quite subtle in its expression as it involves much experiential trial and error, but also includes scientific processes. Despite of this fact, little or nil information is documented on the issue of participatory SQ indicator diagnosis from the experience of local community view to Ethiopia condition. This poster is therefore reports the experience of local community in diagnosis of SQ indicators using participatory approach in the year 2009 at Mai-Negus catchment, northern Ethiopia. Transect-walk field observation was used to acquire SQ indicator data during the survey. This was supported by presented to the household heads to discuss, review and reach in consensus in the points collected during the walk. Indicators of SQ in the form of crop yield, soil depth, erosion and sedimentation processes were easy to identify by the farmers during the transect-walk and these are the commonly used once as farmers reached in consensus. The process of achieving a community consensus on ranking SQ indicator in the form of erosion, soil depth and colour raised a lot of arguments among farmers in the meeting, sometimes requiring that some dissatisfied farmers visit the actual eroding sites where they can verify the differences in indicator severity. Participatory diagnosis of SQ indicators promoted cooperation between local and external participants and formed the basis for an agreed land management planning, implementation and evaluation that can be part of the approaches for sustainable management of soil resources.

**Keywords:** Local community, Mai-Negus catchment, North Ethiopia, participatory, SQ indicators

## **Skills-based and Practice-oriented Curriculum Development for Sustainable Upland Agriculture in Northern Laos – Reaching Ethnic Groups and Women**

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The Ministry of Agriculture and Forestry (MAF) of the Lao People's Democratic Republic had set up a working group that analysed the situation of agricultural education in 5 specialised colleges since 2006. This working group came to the conclusion that the existing agricultural education was not enough practice-oriented and that the graduates did not have the skills required on the labour market. Therefore a project was planned in 2008 and its implementation started in early 2009. Within this project (SURAFCO) funded by SDC a method for participatory curriculum development was developed with the aim to make it skills-based and practice-oriented, and also to reach ethnic groups and women. The present paper describes the steps that were implemented to achieve a skills-based and practice oriented curriculum.

The method developed started with a framework analysis and an analysis of professional profiles: possible professions and positions that the graduates might work in after graduation were identified, and professionals in the public and private sectors interviewed. This step resulted in an overview of professions and related professional skills and competences. Then a first tentative structure of the curriculum was developed, with three majors (crop production in the uplands, livestock production in the uplands, and agribusiness). The professional skills were reformulated in a way that they could be included in the revised curriculum, while a modular structure was elaborated. Different module types for theoretical, mixed or practical topics were shaped, and the skills allocated. The next step consisted in the elaboration of the modules, with description of the main elements required to achieve the expected skills and competencies. Finding the right mix between theory, applied theory and practice is a major challenge. Finally, the detailed planning of modules (including lesson planning, preparation of teaching aids, teaching methods, etc.) was elaborated. The inclusion of ethnic groups and women in the reform process are discussed.

**Keywords:** Agriculture education, skills-based curriculum, student centred teaching, upland farming systems

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## Application of Mobile Learning in Agricultural Education: Case Study of Khuzestan, Iran

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Nowadays, rapid development of information and communication technologies leads to introducing new forms of communication and learning, including e-learning and mobile learning. Mobile learning and mobile tools as new phenomenon in rural communities have key potential capacity to present electronic services and training in agricultural sector. Considering this feature it is essential to understanding the advantages and disadvantages of mobile tools, feasibility and how to use these technologies in rural sector. The purpose of the study was assessing feasibility and applications of these technologies in agricultural education in Khuzestan Province, Iran. A descriptive correlation survey approach was used in this study. Responds filled in closed questions questionnaire. Reliability and validity of instrument were determined by investigating the attitudes of m-learning and extension specialists. The study population consists of managers and experts in Agricultural organisation of Khuzestan province. A sample of 255 managers and experts was selected by using the stratified random sampling method. Results showed that respondents have positive perception to application of m-learning in agricultural education and e-services. The results also indicated that most important areas of the mobile tools applications for villagers are: Informed when making various educational courses, to send information about the climate zone, Send warnings to the prevalence of specific agricultural diseases, send information about different kinds of agricultural inputs, agricultural products price information, warning and information about natural disasters (flood, ...) in the region through SMS and MMS. Results also determined that attention to cultural situation before starting mobile learning and service for rural communities, development of mobile services telecommunications infrastructure, reducing costs to access information through various mobile tools for rural people and training courses about using mobile tools and related services are the main solutions for development of mobile e-government and learning in Khuzestan province. Based on factor analysis, five most highly ranked items on appropriate e-government services for rural sector were identified as: garden and crops, livestock, administrative and credit, marketing and foreign.

**Keywords:** Agriculture, farmers, m-learning, rural development

## **Improving Livelihood Opportunities of Protected Area Support Zone Communities in Nigeria: Lesson Learnt through Beekeeping Training**

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Biodiversity most especially in the third world countries are of enormous socio-economic benefit to man irrespective of their geographical locations. However, anthropogenic actions of man have continued to erode tropical genetic diversity. To tackle this menace, diverse programmes at different level in the third world countries aimed at improving the qualities of life of the rural poor living close to natural resources and which safeguard the ecosystem have also continued to evolve. Majority of these programmes were aimed towards switching the attention of rural people off haphazard environmental resources usage. One of such ecological investments fast growing among the rural poor in some parts of Africa contributing immensely to food security, livelihood improvement, and development of small and medium scale industries of concern is beekeeping. This study reports the intervention of Global Environment Facility (GEF) through Nigerian National Park Service in support zone communities of Kainji Lake National Park, Nigeria to reduce impact of human attention and activities on the park biodiversity and natural heritage. Training of identified traditional honey-bee harvesting group was initiated and financed by GEF operating in the study area while technical support of subject matter on modern beekeeping techniques was provided by specialists from the Federal College of Wildlife Management, Niger State, Nigeria. The learning process formulated for the implementation of this project was in two stages; building the capacity and confidants of the beneficiaries on sustainable means of farming, managing, harvesting and the processing of honey and its by-products rather than traditional method of no-ecological benefit. During monitoring and evaluation stage to assess performance, it was revealed that eagerness of the beneficiaries to improve and sustain the initiative was paramount. However, they are still facing some limitations.

**Keywords:** Agribusiness, beekeeping, biodiversity, ecological friendly, technical-known-how

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## **Processes of Change: Climate Variability and Agro-pastoralists' Livelihood Strategies in Gaza Province, Mozambique**

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The livelihood of agro-pastoralists in Mozambique's semi-arid areas is becoming progressively more vulnerable. Increased frequency and duration of droughts turns food insecurity into an almost constant threat. The system's resilience is further affected by pressures such as population growth, resource degradation and lack of basic services. Promoting social learning is a promising approach to develop and improve coping mechanisms to climate variability. In addition, through building human and social capital, it can lead to empowerment of agro-pastoralists. To achieve such results a first step is the comprehension of the local "socially based spatiality" a concept that characterises "organisation, use[s], and meaning of space as product of social translation, transformation and experience" (Soja, 1980:210). Therefore this first phase of the research grasps two main issues related to household's livelihood activities: 1. Socio-spatial organisation; and 2. Pluriactivity. The last stands here for the customary diverse livelihood strategy of rural populations. This analysis, which shall be expanded during a second phase of field research, is done by collaboratively assessing and reflecting on life-world through the use of tools of applied anthropology.

Due to frequent crop failures in the past decade, agro-pastoralists reinforce off-farm livelihood practices. Among these are, for example, the increase of charcoal production and the extraction of wood. The first has become an important livelihood strategy, which offers casual employment opportunities for women and young men, in the face of threatened food security. Due to its buffering capacity against extended dry spells, the role of livestock becomes crucial to the household. Yet, with the effects of climate change the livestock vulnerability also increases. With a background on the local life-worlds, our next step will be on Action Research, whereby we will focus on increasing adaptive capacity through collaborative learning strategies.

**Keywords:** Agro-pastoralists, climate variability, livelihood strategies, pluriactivity



# Value chains - Poster session I

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## **Risk Perception and Adaptation to Climate Risk in the Coffee Sector of Chiapas, Mexico**

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Investigations of climate adaptation have largely focused on technological interventions and geographic and socio-economic characteristics of adaptive capacity. Much less research has examined how risk perception motivates individuals to take adaptive actions. Less research still has examined farmers who produce for export but persist at a subsistence level. While we cannot measure climate change effects in se, we can and do measure proxies of climate change through frequency and severity of drought and precipitation, and associated infestations. We use logistic and linear regression analyses to predict risk perception and perceived sources of risk based on a survey of coffee producers in Chiapas, Mexico. While coffee is not a subsistence crop, the farmers in the survey derive virtually all of their modest income from coffee production. Sales of coffee are invested in purchasing food, basic household products and other necessities. Farmers are risk-averse to climate change as dramatic alterations in coffee production threaten household survival.

We model the statistical significance of several hypothesised socio-economic, demographic, and risk perception variables. Regression results suggest higher socio-economic and education status, migrant history, and household dependency burden of minors are inversely predictive of number of sources of climate-related risk perceived while high climate risk perception is predicted by history of torrential rains and coffee pests, household age structure, and level of household assets. The demographic findings point towards the importance of household life cycles in assessing perceptions of risk, vulnerability, and adaptive capacity, and resulting adaptive motivation. These findings have rich policy implications for adaptation management and small-holder production security. They merit further investigation to identify how, where and why climate risk perception plays a role in adaptation in other geographic areas of vulnerability worldwide.

**Keywords:** Adaptation, agriculture, Chiapas, coffee, food security, land use/cover change (LUCC), Mexico, risk perception

## Resource-use Efficiency in Tomato Production in the Dangme West District, Ghana

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Tomato forms a very important component of food consumed in Ghana and this is evident in the fact that many Ghanaian dishes have tomatoes as a component ingredient. Tomato production in Ghana is mainly a smallholder activity. In a bid to help farmers increase productivity, the focus is usually on whether farmers are using better and improved technologies. It is however necessary to investigate whether these farmers are even making maximum use of what is available to them in terms of inputs so that the stakeholders involved in agriculture will be convinced that the new technologies they intend to introduce to farmers will be used efficiently and cost – effectively to boost output. Farmers might use resources rationally but not at the economic optimal level. As the aim of every agribusiness firm is to maximise profit while minimising cost, it is pertinent to determine the efficiency of resource-use.

This study was carried out in the Dangme West District of Ghana where tomato production is prevalent and highly consumed. The study focused on the socio-economic characteristics of tomato farmers, the farm production function and the efficiency of resource use in tomato production. Data was collected using multi-stage sampling technique from 60 tomato farmers in the study area with the aid of questionnaires. Data collected was for the 2007 farming season. It was analysed using descriptive statistics and least square regression technique. The results showed that 88 % of the farmers were males and 12 % were females. 87 % of the farmers had extension contact. Also, the average farm size was 2.5 acres. The Cobb-Douglas production function gave the best fit for the sample with adjusted  $R^2$  of 70.8 % and it indicated that land, pesticide and hired labour significantly influenced tomato output. For the efficiency analysis; seed, land, hired labour, fertiliser and pesticide were the inputs being underutilised. The study concludes that profit could be improved by using more of seed, land and hired labour and the right quantity of pesticides and fertiliser.

**Keywords:** Dangme West District, efficiency, production function, resource use, tomato

## Policy Implementation and Impact in Kenyan Agricultural Sector: A Case of Potato Marketing Regulations

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Potato (*Solanum tuberosum* L.) is the second most important food crop in Kenya after maize, both in terms of production and consumption. However, the crop value chain is known to be imperfect and complex, resulting to low income gained by farmers. To streamline the value chain for the benefit of farmers, the Government of Kenya established a legal notice no. 44 of 2005, which preceded legal notice no. 113 of 2008 (ware potato packaging size and weight regulations). This study was carried out to monitor the implementation, enforcement and economic impact of this 2008 legal notice using formal questionnaires administered to traders and farmers in selected seven markets and regions, use of focussed group discussion as well as stakeholder participation in a workshop. The study was conducted between December 2009 and February 2010. The findings show that both traders and farmers are aware of the regulations but none are implementing them except very few traders. Farmers had higher (97 %) knowledge of regulations compared with traders (92 %). Farmers were unable to implement the regulations due to cartels (broker/trader), lack of storage facilities as well as lack of information about the potato production costs and the prevailing market prices at any given time. The study shows that the contribution of potatoes to the Kenyan economy is 300 % higher than what is recorded in government reports. Lack of transparency in the value chain has reduced the benefit of potato production to farmers. The amount lost to brokers is valued at USD 13.9 million while corruption on the way to the market is estimated at USD 6.5 million. This study outlines several policy recommendations to ensure enforcement of the regulations and streamline the potato value chain in Kenya.

**Keywords:** Extended bags, farmers, potato policy, standard bags, ware potato

## **Primary Co-operative Agriculture and Rural Development Bank (PCARDBS) Credit Impact on Income and Employment of Borrowers and Participation of Weaker Section**

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An effective research in the field of co-operatives can help to identify strength and weaknesses in their working and performance. Hence, an attempt on credit impact of primary co-operative agriculture and rural development banks (PCARDBs) on borrowers was undertaken. In the present, ever changing economic environment, the role of co-operative institutions in meeting the necessities of the weaker section (SC/ST members) being increasingly recognised from last few decades. Present study has also focused on to insight the extent of participation and credit disbursement to the weaker section of the society.

The study was conducted in the year 2004 in Tumkur, Tiptur, Gubbi, Koratagere and Sira PCARDBs of Tumkur District in Karnataka state. Time series data for 7 years on various performance indicators were collected, besides information from randomly selected sample of 75 borrowers for the study. The techniques like tabular analysis were used to analyse the data.

Findings of the study revealed that, the income generation was more in farm mechanisation, and employment generation was more in non-farm sector of loan for all the PCARDBs and the variation in magnitude of employment generation was observed among the banks as well as among the purposes. The study on extent of participation of weaker section inferred that, the coverage of SC/ST farming communities and percent loan advanced for them are not reaching the expected level. Hence, there is a need to enroll more number of members from weaker sections particularly SC/ST so that they can avail the services from PCARDBs to enhance their socio-economic conditions. The study suggested new venturing into the scheduled banking activity, extensive training to the members for better use of productive loans and need more programmes for reaching and also creating awareness to the weaker section of the society to use the existing opportunities within PCARDBs.

**Keywords:** Income and employment impact, PCARDBs, weaker section



## **Agricultural Intensification: Determinants and Impacts in the Mae Ram Watershed of Northern Thailand**

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Northern Thailand has undergone rapid agricultural transformation during the last few decades with agricultural intensification as one of the main results of this rural transformation. Farmers in this region adopt land, capital or labour intensive strategies to meet the growing needs for food and income. These intensification activities however have impacts ranging from socio-economic to environmental. The study aims to find out the main agricultural intensification strategies, their driving forces and their implications on socio-economic, environmental and conflict issues in the region.

The study was carried out in 2009 in the Mae Ram watershed located in the province of Chiang Mai in northern Thailand. Data was collected by carrying out 25 key informant interviews, 3 focus group discussions, 42 household surveys, soil and water sampling and use of Participatory Rural Appraisal methods.

The major findings from the study indicate that land, labour and capital intensification strategies are used by farmers to grow mainly vegetables for commercial purpose throughout the year. The main strategies include multiple cropping, short fallows; wide use of agro-chemicals, irrigation systems, soil conservation techniques such as terracing and intensive use of labour. The proximate driver of agricultural intensification in the region is the promotion by the Royal Project which facilitates easy access to micro-credit, inputs and market. Restriction on land expansion by national park policy and increased household size are also key drivers. The wealth status and living standard of households have generally improved after engaging in agricultural intensification but it was found to be associated with the increased frequency of erosion, flooding and siltation as well as increased soil concentration in pesticide residues in the watershed. Water availability and contamination resulting from intensification activities are the main conflict issues between the upper zone farmers and lower zone villagers in the watershed. The findings of the study suggest a need for more environmentally sustainable intensification strategies to avoid the negative impacts.

**Keywords:** Agricultural intensification, conflicts, determinants, impacts, Mae Ram watershed, northern Thailand, Strategies

## Collective Action Problems in Quality Control of Palm Oil

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The oil palm sector in Thailand suffers from a low oil extraction rate which is the result of poor quality fresh fruit bunches that are harvested and delivered to crude palm oil mills. This paper is based on interviews conducted in Thailand with oil palm producers, mill managers as well as members of oil palm associations and Thailand's Office of Agricultural Economics. Underlying reasons for why the fresh fruit bunch quality is inferior include a lack of price discrimination for different qualities of fresh fruit bunches, a paltry incentive structure within mills for quality control, an overcapacity of mills, an intense competition between mills and the current labor structure for harvesting fresh fruit bunches. Unfortunately, these reasons formulate a collective action problem at both the producer and mill levels. Thus, third party intervention is required. Solutions include increasing producer incentives, subsidizing mills, and/or mandating that mills must have quality control. If the quality of fresh fruit bunches were improved the oil extraction rate would increase, which would increase fresh fruit bunch prices and crude palm oil production.

Although by no means an easy task, the quality of fresh fruit bunches can be improved, given the right steps.

**Keywords:** Collective action problems, palm oil, quality control

## Supply Chain Differentiation, Contract Agriculture, and Farmers' Marketing Preferences: The Case of Sweet Pepper in Thailand

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In many developing countries, agricultural and food systems are undergoing a major transformation towards high-value and modern supply chains. In export markets, standards and certification systems are gaining in importance, while domestically, the role of supermarkets and hypermarkets is growing. Transformation of retail structures comes along with a modernisation of procurement systems. Super- and hypermarkets in particular increasingly switch from buying through spot-market transactions to contractual agreements with farmers, often through specialised intermediaries.

There is an emerging body of literature analysing how smallholder farmers in developing countries can be linked to modern supply chains. However, most of the available studies concentrate on farm and farmer characteristics, failing to capture details of institutional arrangements between farmers and traders. Moreover, farmers' preferences have rarely been considered.

The present study addresses these research gaps by analysing marketing channels of sweet pepper producers in Thailand. Sweet pepper was introduced in Thailand some 10 years ago, mainly for exports and upscale domestic supermarkets. Over time, it gained wider popularity among domestic consumers, so that sweet pepper is nowadays also traded in more traditional wholesale and retail markets. Moreover, different contractual arrangements between farmers and traders can be observed.

Building on primary survey data, we analyse three main aspects. First, we describe institutional details of coexisting marketing channels and highlight differences between traditional and modern supply chains. Second, we examine farmers' subjective motivations to participate in particular marketing channels. And third, a choice experiment is used to analyse farmers' attitudes towards contracts in general and different contract designs.

Our findings reveal a general preference of farmers for marketing options that do not involve a contract. Additionally, provision of inputs and credit can increase the attractiveness of contracts. Yet, the most important factor for farmers is a personal relationship with the buyer, which is probably related to issues of trust. Some policy implications are discussed.

**Keywords:** Choice experiment, contract design, farmers' stated preferences, modern agricultural supply chains, Thailand

## The Importance of Networking for Smallholder Swine Farmers in Colombia: A Social Network Analysis

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Social networks are an important strategy in helping people to cope with difficult conditions like e.g. a lack of basic services or inputs. The worse the conditions and the poorer the people, the more they will protect themselves by forming social networks. In many cases social networks replace formal providers of services and inputs and operate in an informal way, e.g. as providers of financial services, informal extension or problem solving assistance. Smallholder swine farmers in Colombia are challenging difficult conditions as well, and so is for example the access to credit and cheap feeds very limited and therefore a constraint for an increase in production.

To evaluate the effect of social networks in the smallholder swine production in Colombia (Popayán region), a Social Network Analysis was conducted in March 2010, using semi-quantitative interviews for all participants of the smallholder swine value chain in this region (whole network analysis). First results indicate that smallholder producers with a high degree of centrality, a high in-/out-degree, and an adequate balance of strong and weak ties in social networks have better access to resources and services. Moreover they tend to be better established with new information about markets, financing, and extension. Therefore they know more about input/output prices, discounts, consumer demand/preferences, market requirements, how to get a credit, or where to ask in case problems in production occur or innovations want to be tried. This surplus in information increases their competitiveness in comparison with other stakeholders in the value chain and due to this they are more able to increase their production and to reach more developed markets. This makes them being opinion leaders and influential persons for other actors in the networks and so they are likely to play an important role in the development of the smallholder swine value chain in this region. The final analysis will be performed within the coming months.

**Keywords:** Colombia, smallholder swine production, social Network Analysis, value chain

## Efficiency of Bt Cotton over non-Bt Cotton Production: An Econometric Analysis

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Cotton is the major commercial crop amongst all cash crops in India and provides livelihood to more than 60 million people in its cultivation, processing and textile industry. Cotton crop is infested by various pests causing significant yield losses, therefore Bt cotton was introduced in India during 2001 to reduce pesticide consumption and also increase productivity. With this background the Present paper analyses the resource use efficiency of Bt cotton over non-Bt cotton in Karnataka state, India by using decomposition analysis technique. The data was collected randomly from 45 farmers cultivating Bt and non-Bt cotton from Haveri district of Karnataka. The results of the regression analysis indicated that the independent variables considered in the model explained a large part of the variability in the gross returns from cost of cultivation (96.8 % and 97.5 % in Bt and non-Bt cotton cultivation). Whereas the result from decomposition analysis show that efficient use of labour (200.8 %), fertilisers (184.8 %) and seeds (65.8 %) had contributed the most to the difference in returns between Bt cotton and non-Bt cotton cultivation. The measured difference through decomposition analysis of gross returns between Bt cotton and non-Bt cotton was 55.0 %. In that non-neutral technology between Bt cotton and non-Bt cotton cultivation comprises -25.4 %. Contribution of differences in the quantity of inputs used to higher returns from Bt cotton to the measured difference in gross returns between Bt and non-Bt cotton was 56.6 %. While that of the efficiency in the use of inputs was 23.8 % in Bt cotton. Hence, Bt cotton cultivation is recommended over non-Bt cotton in that area.

**Keywords:** Bt cotton, decomposition analysis, non-Bt cotton

## **Export Performance, Comparative Advantage and Competitiveness: The Case of Moroccan Citrus Sector**

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A competitive supply chain needs not only to rely on its natural endowments, but it needs to be able to enhance and maintain global market shares. It also needs to be able to assure required investments, co-ordinate activities of chain actors and fulfil product requirements posed by various destination markets.

By observing the case of Moroccan citrus sector, this research determined competitiveness and strategies used to attain competitiveness in international business environment. Performance of Moroccan citrus sector in the period from 1993 to 2008 was analysed by determining its export revealed comparative advantage and by measuring its competitiveness in terms of relative unit value index and constant market share analysis. Such quantitative assessment was accompanied by qualitative study that aimed to explore how the sector responds to requirements of its business environment. Interviews with key stakeholders were the main part of the qualitative study. The first round of interviews involved informants from government institutions and professional associations of fruit producers and exporters. In the second round, interviews were conducted with key stakeholders of the citrus value chain: export groups, producer co-operatives, packing houses and producers.

Results showed that Moroccan citrus export chain is partly able to fulfil the global performance requirements. The export of citrus fruit builds upon the comparative advantage, while the main competitiveness strategy includes competition in terms of price. This strategy, however, did not manage to be maintained in several destination markets, where the loss of competitiveness has been observed. Furthermore, the constant market share analysis revealed the emergence of new export strategy that is based on redirection of lower-value products to non-EU markets. Moroccan citrus sector is currently strengthening its competitiveness through structural modifications and investments in infrastructure, quality and safety management systems.

**Keywords:** Comparative advantage, constant market share analysis, Moroccan citrus sector, unit value

## Enhancement of Possibilities for Farmers in the Coffee Region of Colombia Supported on Bamboo Forest Managing

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The *Guadua* (*Guadua angustifolia* Kunth) is the most important woody bamboo species of tropical countries in South America. In the coffee region of Colombia, forests are highly fragmented and dominated by this bamboo species; however these forests represent an important alternative for farmers as a complement of agriculture or live-stock. During several decades, bamboo forests have provided raw material for different application such as structures, handicrafts and fences. In addition, these forests fulfil relevant ecological functions because of high biodiversity, habitat for fauna, soil protection, CO<sub>2</sub> fixed and water regulation. Currently, demand of *guadua* culms has increased due to some initiatives of rural enterprises aimed to develop bamboo products for local and international market. Therefore, high quality of bamboo culms is demanded by these enterprises. Quality depends on different factors which include silvicultural practices, the selection of mature culms, standardisation of culms and organisation of farmers. Silvicultural practices are being optimised by proper inventory and planning. Maturity of culms which is the base of the quality definition is being estimated by different ways including physical and mechanical properties, lignin and starch content and developing a device which relates maturity and the transmission of sound waves. After defining the quality and also including information on dendrometrics features, culms are standardised according to range of values previously established. Farmer organising has included training and technical support as well as engages them with forest certification process. Improvement in each one of the factors contributes to consolidate an alternative for rural farmers based on bamboo managing.

**Keywords:** Bamboo quality, maturity, physical and mechanical properties

## Regulated Markets and Rural Development in India

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The increased production and heavily arrivals of marketed surplus especially food grains forced to set up new modern markets to maintain buffer stock at national level. Further to increase in income of market committees and to incur expenditure on various development works in rural areas, there is need of incentives for producers to bring maximum production of their farm surpluses in regulated markets. Therefore, the investigation was carried out with the objective to examine the availability of amenities in regulated markets, incentives for producers and contribution of regulated markets in rural development in Haryana state of Indian Union.

The study reveals that total market arrivals of agricultural commodities increased up to 12.26 million tonnes during the year 2006–07 due to vast network of 105 principal yards, 178 sub-yards and 142 purchasing centres in the state. The capacity of storages, cold storages and coversheds also registered significant increase and it reached up to 4.9 lakh tonnes. While number of villages and area served per regulated market declined as result of increase in number of regulated markets. The number of regulated markets and sub-yards, capacity of storages and coversheds exhibited positive growth rate indicating health sign of market infrastructure development. Most of markets possessed all types of amenities as per norms of Bureau of Indian Standards, except parking place, medical facilities and sundry shops. The Marketing Board has made investment on various development activities like establishment of grain and vegetable markets, renovation of old markets, construction of rural roads, repair of rural and municipal roads for easy accessibility for transport of farm produce. Apni Mandis were also set up for fruits and vegetables to benefit both producers and consumers through elimination of market intermediaries. The Board has also introduced various schemes like compensation to victims hurt during agricultural operation, awards for innovative farmers, Krishak Uphar Yojana, bonus of sale of produce through cooperating marketing society and agri-business information. The producers can enhance their farm income through disposal of surplus farm produce in regulated markets. Ultimately the income generated to marketing board will be spent on various development projects in rural areas

**Keywords:** Farm produce, market arrivals, regulated market



## **Analysis of Organic Products Marketing Channels in Kenya: A Transaction Costs Approach**

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The nature of marketing of high value agricultural products such as Organic products has evolved over time, resulting into well coordinated physical, exchange and facilitating functions. However, the degree of market efficiency and effectiveness of these functions is highly influenced by the nature of interactions between the actors and their attributes. The current study aimed at offering policy options for improving marketing of organic products in Kenya through an analysis of the marketing channels. First, the study identified the actors and activities involved in marketing of organic products in Nairobi urban area. Secondly, the commodity (organic fruits and vegetables) attributes, the actors and the activities were analysed with view of determining how they influence two key outcomes: transaction costs and profitability. Primary data for the study was collected through a survey among 31 traders dealing in organic fruits and vegetables within Nairobi city. The data were analysed within the Institutions Analysis and Development (IAD) Framework.

Results indicate that although transaction costs exist in the three channels identified, the nature and magnitude of such costs greatly varies across the channels depending on the number of players and their attributes. Traders incur transaction costs while searching and screening for reliable suppliers and customers, transporting the product and enforcing contracts. Furthermore, the type of transaction costs incurred within each marketing channel highly depends on the level of information asymmetry between actors, the actors' attributes and existing institutional arrangements that are necessary to maintain transactions and counter opportunistic behaviour. The nature of activities and actors within each channel was also found to influence the transaction costs. The study draws imperative policy implications that can be used to reduce the transaction costs incurred in the business of marketing organic products. Some suggested policy options include: improving market information transmission, reforms in legal framework to facilitate contract farming and improved transport infrastructure.

**Keywords:** Organic food products, organic marketing channels, transaction costs

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## Designing a Socio-economic Development Model for Arab Farmers in Israel

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Israel's agricultural sector is characterised by a very modern and intensive system of production, backed by advanced organisational structure which based on close cooperation between the Ministry of Agriculture, the Settlement Department of the Jewish Agency for Israel and the Farmers' Organisations. However, the political and socio economic environment of the Arab Farmers, tackled them to share their colleagues to the job in the Jewish sector the "development cake". It's expressed by unfair land ownership policy, lack of agricultural subsidies and development funds, tangled with absence of any representative body in the decision makers table, that leave them out from national and regional development plans. This study-paper suggests grouping farmers through Farmers' Organisation and Producers' Cooperatives that have a viable potential, both socially and economically, which expresses one of its principal comparative advantages as a socio-economic model for the family farms holders - men and women - of the land, interested in consolidating their position as producers of goods and services within the agricultural business activity. Unfortunately, the Arab agricultural cooperatives and "their representative associations" failed to play any significant role on building marketing of agriculture produce, which is presumably should be their major area of operation, nothing has been done to open new markets, improve auxiliary marketing services, or stabilise prices. In spite of that, it should be noted that, no one can deny the efforts made by Arab farmers for improving their production and retaining their agricultural life style. Some have achieved high production records when granted the opportunities and should be entitled due esteem and appreciation. In brief, development of agriculture in the Arab sector requires institution of a policy that will increase profitability, encourage initiatives and excellence, and allocate resources to achieve advancements in the farming economy. Agricultural development that is efficient and productive as well as sustainable in its use of resources, competitive in terms of external orientation, and providing adequate incomes to a large number of farmers with equitable distribution of incomes and benefits.

**Keywords:** Agricultural cooperatives, Agro-food chains management, arab agriculture, economic advantage, Farmers' Organisations, socio-economic development

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## Exploring Factors Critical to Innovation of Urban Cabbage Production in Cotonou (Benin), Accra (Ghana) and Ouagadougou (Burkina Faso)

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Urban vegetable production is an important economic activity in metropolises of developing countries, including the West African cities of Cotonou (Benin), Accra (Ghana) and Ouagadougou (Burkina Faso). In these cities, growing local demand for fresh produce stimulates the commercial production of high value vegetables. Farmers respond by establishing commercial crops and, facing increasing pest pressure, apply synthetic pesticides as a standard strategy to reduce the risk of harvest losses. Scientists and local experts have expressed concern about abuse, misuse and overuse of pesticides that put both farmers and consumers at risk. Consequently, a need for innovation towards risk-reduced vegetable production and marketing was identified.

We define innovation as a creative process of varying, selecting and incorporating knowledge by a multitude of stakeholders. This process can yield a diversity of changes (outcomes of the innovation process). We hypothesised that innovation will occur only if farmers perceive a need for change. This study investigates which changes in general have occurred in the past several years, how farmers obtained the necessary knowledge and why certain technologies and processes were innovated.

In each city, we implemented research question-led PRA workshops at two urban production sites. For that purpose, we drew a purposive sample of 15 cabbage growers at each site; five of the participants of each workshop were later interviewed using a semi-structured questionnaire, which was informed by the workshop results. These results included innovation histories and innovation system maps.

We analyse the dataset applying qualitative content analysis, employing a hypothesis coding strategy. Preliminary results suggest that farmers readily select and integrate new varieties and new pesticides in the production process. Principal factors positively influencing innovation were found to be directly observable benefits and adaptability of a technology to the local environment. By comparing the country cases, the lessons of this study will contribute to the understanding of urban cabbage production systems, and of factors critical to innovation in such systems in West Africa.

**Keywords:** Innovation systems, pesticide contamination, urban farming, West Africa

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## Can Small-scale Farmers Sustain Household Energy Requirements from On-farm Produce? A Case from the Uluguru Mountains of Tanzania

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Uluguru Mountains are part of the Eastern Arc Mountains of Tanzania (EAM) an ecosystem of global importance among the 25 most important “biodiversity hotspots in the world”. The EAM and its watersheds cover an area of 343,229 km<sup>2</sup>, carrying most of the national forest nature reserves, which according to the Tanzania Forest Act of 2002 is covered by the highest level of habitat protection. These conservation measures have major impact on the livelihoods of surrounding communities who are dependent on forest services such as fuel-wood, timber, thatching grass, or forages. Excluding rural communities from these forest resources without alternative income and energy sources is a major challenge to livelihoods and sustainability of conservation programs, because for years such communities have accrued up to 70 % of income and over 90 % of the household energy requirement for cooking from forests resources.

Tandai, a village within the Uluguru Nature Reserve (UNR) and Kitumbatu forests margins represents the case described above where the surrounding forests are under high protection. The two forests reserve areas are characterised by high biodiversity with UNR carrying more than 135 endemic species of plants. Formation of the Uluguru Nature Reserve (24,115 ha) in November 2008 has huge implications on the livelihoods of the village population as they are not allowed to extract any kind of forest products from the forest reserves.

Tandai village household energy demand in terms of fuel wood is estimated at 5 Mt per year, which has to be obtained through on-farm production or from the forest reserve. Some farmers own small woodlots serving as sources of firewood for cooking, timber for construction purposes or for selling. The alternative is to buy wood from outside and/or switching to alternative biomass energy sources such as locally produced liquid biofuel. To analyse the energy demand and supply patterns and its constraints a sample of 350 households (37 % of total households) from Tandai village is used to undertake wood value chain analysis and assess the bio-energy production potential of existing on-farm agroforestry systems as part of a project studying bio-fuel energy technological efficiencies in Tanzania.

**Keywords:** Agroforestry, bio-energy, conservation, forest degradation, fuel-wood, small-scale farmers

## **Economic Analysis of Tube Well Driven Sprinkler Irrigation and Furrow Irrigation for Agriculture in Haryana, India**

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India is facing water scarcity and micro irrigation techniques are considered to mitigate the water scarcity through water saving, reduction in irrigation costs and increase in the irrigated area. Haryana and Punjab are the most progressive states in agriculture and considered as innovators and early adopters of any kind of technology. For instance these states had made a great contribution towards green revolution for achieving food security. The sprinkler irrigation system is one such technology introduced in Haryana in late seventies and considered as suitable for region because of mainly water scarcity problem and favourable soil type. The study mainly focuses on the looking at the economic feasibility of the tube well driven sprinkler irrigation and furrow irrigation using discounted and undiscounted cash flow techniques such as Net Present Value (NPV), Benefit-Cost ratio (BC), Internal Rate of Return (IRR) and Pay Back period. The data was collected from 90 farmers using sprinkler irrigation from the multistage sampling technique and simple random techniques. Results indicate that, there is incremental increase in irrigated area to about three folds and decline in labour use per hectare by 78 %. The average net returns per hectare from sprinkler irrigation was found to be 19.5 % higher than tube well irrigation. The economic feasibility criterion showed that the investment on sprinkler was economically viable. The NPV of sprinkler irrigation was found to be Rupies 7970, BC ratio was 1.97, IRR was found as high as 17 % and the pay back period was 7 years. Considering the benefits of sprinkler irrigation, Indian government should facilitate use of micro irrigation techniques through subsidies and incentive schemes.

**Keywords:** Agriculture, furrow irrigation, India, sprinkler irrigation

## An Economic Analysis of Production and Marketing of Medicinal Plants in Northern India

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India is one of the hot spots in Medicinal and Aromatic Plants (MAPs) in the world. The wide diversity of MAPs potential is under explored with respect to few species and over exploited in case of few other species. India with its diverse resource base of medicinal plants on one hand and its ancient knowledge on Ayurveda medicine on the other hand has a great potential in the field of MAPs. In this regard, the paper mainly focuses on the economic profitability, marketing and resource use efficiency in relation to producing medicinal plants such as Safed Musli (*Chlorophytum borivillianum*), Mulhathi (*Cassia angustifolia*) and Sonamukhi (*Glycyrrhiza glabra*). The data was collected from farmers using purposive sampling and analysed using un-discounted cash flow techniques and Cobb-Douglas production function.

Mulhathi was found to be the most lucrative option among medicinal plants grown since gross returns over variable cost and net return from Mulathi was estimated to be Rupies (Rs.) 113 714 and Rs. 88 581, respectively, which is higher than for Safed Musli and Sonamukhi. The regression results demand use of one or the other inputs for maximisation of gross returns. However, the scope for increase is higher for Safed Musli than compared with Mulathi and Sonamukhi. In case of Safed Musli, the Marginal Variable Product (MVP) to Marginal Fixed Cost (MFC) ratio of land preparation, manure and fertilisers, interculture and hoeing and irrigation charges was more than unity, indicating scope for higher input use for enhancing gross returns. Similarly, Sonamukhi can increase manure and fertilisers and interculture and hoeing, and Mulhathi growers can increase manure and fertilisers for improving production levels.

Finally the market channel analysis proved that the higher the market players in a particular channel lower will be the producer's price. The study will give useful insights to the policy makers to generate the untapped potential of medicinal plants, prevent over exploitation and promote sustainable use of medicinal plants.

**Keywords:** Marketing, medicinal plants, northern India, production



## Exploring the Diversity of Urban and Peri-urban Agricultural Systems in West Africa: An Attempt Towards a Regional Typology

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Developing appropriate and innovative technologies and policies to respond to the challenges that urban and peri-urban agriculture (UPA) is facing in West Africa requires a better understanding of the existing production systems. Although there is an increasing recognition of the importance of UPA in the region, its extent, forms and related practices may vary across countries and cities because of different socio-economic conditions and urbanisation patterns. A systematic classification of the regional UPA systems is still lacking but is necessary to allow for meaningful comparisons between cities and avoid misleading generalisations. The purpose of this study was to determine the proportion of households involved in UPA activities in three West African cities and to classify them into homogenous groups. 700 randomly selected households (250 in Kano, Nigeria, 250 in Bobo-Dioulasso, Burkina-Faso, 200 in Sikasso, Mali) were surveyed using a structured questionnaire. With significant ( $p < 0.001$ ) differences across cities, more households in Bobo-Dioulasso (87.6 %) and Sikasso (62.5 %) than in Kano (41.6 %) were involved in UPA. Subsequently, survey data from 318 households (Kano: 99, Bobo-Dioulasso 111, Sikasso: 108) were submitted to principal components analysis for categorical variables (CATPCA) to reduce the original set of variables (26) to a smaller number. It allowed a mix of variables with different measurement levels to be included in the analysis. Next, the TwoStepCluster method, that handled both the selected continuous (5) and categorical variables (5) was used to classify the households using object scores obtained from the CATPCA. Diversification of farm activities, farm resource endowment and production orientation were observed to be the major discriminating variables. In each city, four distinct UPA systems were identified, of which three were common to Kano, Bobo-Dioulasso and Sikasso: commercial gardening plus field crop-livestock (cGCL; 59 %, 18 %, and 37 %), commercial livestock plus subsistence field cropping (cLsC; 14 %, 41 %, and 7 %), and commercial gardening plus semi-commercial field cropping (cGscC; 14 %, 28 %, and 30 %). The fourth system was location-specific and could be characterised as follows: semi-commercial livestock plus commercial gardening in Kano (scLcG; 13 %), commercial field cropping in Bobo-Dioulasso (cC; 13 %) and commercial gardening in Sikasso (cG, 26 %).

**Keywords:** Multivariate analysis, typology, urban and peri-urban agriculture, West Africa

## **A Value Chain Approach: Integrating Costa Rican Small-scale Banana and Plantain Producers into the Tourism Sector**

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Agricultural growth and development of staple crop sectors like bananas and plantains help to alleviate poverty through employment and income generation. For Costa Rica being one of the biggest producers and exporter of bananas and plantains worldwide, the banana trade has an important influence on the economy. However, mainly multinational companies benefit from the export, while small-scale producers who mainly produce native banana and plantains species, lack access to these international markets. Local markets for bananas and plantains from small-holder production are small and provide low profits for farmers. By using the value chain analysis this article shows how the tourism sector can offer new market opportunities for the native species to local small-scale farmers. It further identifies the obstacles small-scale producers face when wishing to participate in the tourism sector.

The results of a survey of about 50 questionnaires conducted in the tourism sector in Costa Rica in 2010 show that whether the hotels and restaurants purchase their bananas and plantains from a salesperson or a marketplace differ regionally. This leaves different options for small-scale producers to participate in the local markets. However, the buyer's preference for a frequent supply with small amounts of bananas and high transport costs represent a major challenge for small-scale farmers which the hotels are unwilling to pay for. To lower this transaction costs on the producers side a more efficient organisation of quality production and of the supply logistics are required.

The main barrier for participating in the tourism sector is, however, the missing demand from hotels and restaurants for diverse native species of bananas and plantains which are mainly supplied by small-scale farmers. However, much of the traditional banana and plantain diversity enjoyed by local farmer communities is unknown to the buyers in the touristic sector as well as for tourists themselves and therefore not demanded. Supportive policies from private and public sector such as awareness campaigns for traditional production and the diversity of products can increase demand.

**Keywords:** Banana, Costa Rica, tourism, value chain

## Resource Constraints in Urban Food Production: A Survey of Red Bricks Kilns in Khartoum State, Sudan

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Some parts of the Blue and River Nile banks, the most fertile land in Sudan, are used for traditional red brick production which heavily competes with vegetable cultivation for land. The rapid urbanisation leads to the expansion of this industry and encourages land owners to rent land for both purposes. Red bricks are mainly produced by traditional techniques, whereby biomass fuels (fuelwood and cow dung) are used for burning. Modern brick production where fossil fuel is used as an energy source makes up for less than 2 % of the total annual brick production.

The main objectives of this study are to ascertain the profitability of this industry compared to agricultural land use and to quantify the carbon dioxide emission used in traditional red brick making. A number of 50 kiln owners around Blue and River Niles were interviewed during July 2009 and relevant secondary sources were reviewed. Descriptive analysis was used to analyse information and data collected.

Red bricks production is the only source of income for about 85 % of the interviewees and landowners constitute about 15 % of them. Land rent value for kilns can be more than 5 times the value from shared crop cultivation. The rainy season is considered the “off season” for red bricks production, and work is continued in most kilns from September to June. At the same time prices of both inputs and outputs are highly unstable throughout the season. Red brick making uses an average of about 0.017 t per 1000 bricks of fuel wood. Labor constitutes with 58 % the greatest share of the total production costs. The average yield of a kiln per season is about 1.7 million bricks. The Benefit/Cost ratio for each thousand bricks is about 123 %. Overall, these brick making industries destroye and erode clay soil, cause serious deforestation and likely are an important source of greenhouse gas emission as they use huge amounts of fuelwood from unsustainably managed forests and dung cakes for brick burning, with the brick kilns being of low combustion efficiency.

**Keywords:** Khartoum, land use, red bricks production, urban agriculture

## Assessing the Competitiveness of Syrian Cotton Production: A Policy Analysis Matrix Approach

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The ongoing opening of the Syrian economy to the world markets after it was predominantly state-controlled and the scarcity of natural resources, in particular water, require a reallocation of domestic resources. State policy in Syria has a noticeable influence on the agricultural and particularly on the strategic crops sector. Cotton is important crop from this sector and generates 20-30 percent of the total foreign agricultural exchange earning in the country. Under these conditions, the study employs the concept of comparative advantage of international trade theory to analyse competitiveness of Syrian Cotton Production. The mechanism of comparative advantage can explain much of the competitive performance both in the recent past and in the near future, given the technological and structural characteristics of the production as well as the properties of the macroeconomic environment associated with the recent market reforms. This paper examines the efficiency of lint cotton production in one of the major producing provinces in Syria considering the different irrigation systems that are used to produce cotton and using a modified policy analysis matrix (PAM) approach. The PAM data was collected firstly at farm level, where farms were classified into four groups according to water resource and irrigation systems. The collected data at this level were related to the cost of agricultural operations. Secondly, data of the post harvest operations and off-farm processing were gathered from the National Agricultural Policy Centre and the Cotton Market Organisation. The results of the analysis indicate that lint cotton is not efficiently produced in the river region; while it has comparative advantage only in the drip irrigation system in wells region. Without government interventions, it is likely that acreage in areas which used conventional methods of irrigation will move away from cotton to more profitable crops. This study suggests reconsidering the currently applied policies concerning prices and subsidies especially in public river irrigation systems und using of drip irrigation technologies.

**Keywords:** Comparative advantage, cotton irrigation system, policy analysis matrix approach, Syrian agricultural policy

## Land Use Change in Southern China: Reconciliation Between Household Consumption Demand and Market Supply

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Rural poverty alleviation remains a vital goal of development policy worldwide. Nevertheless, conventional ways of improving rural livelihoods such as augmented investments in agricultural intensification measures can have negative impacts on natural habitats such as forests by extensively increasing motivations for clearing. Over the past two decades, rapid land use change in Yunnan province south of China has been characterised by increasing monoculture rubber plantations in the Nature Reserve, which heavily affects the floral and faunal diversity and further deteriorates fragile mountainous ecology. Rubber has become the main cash crop for many farm households and changed the landscape as well as land culture rapidly. Meanwhile, over-dependent on one income source puts farm households in greater risk. The study focuses on construction of a linear programming model and simulation of policy scenarios compliant with local conditions to analyse local economy and suggest rational policy options. A village-household linear programming model was developed to identify factors driving landscape and land-use change for three different farming systems in the Southern China and to provide policy makers with potential strategic intervention options for land use. The main assumption is that farmers maximise expected income subject to annual subsistence requirements in adverse conditions. The effect of net returns of alternative land uses by village farm households was quantified. The analysis provides evidence to the relative importance of markets and provincial agricultural or rural development policies on land-use changes nationally. Simulations from different policy scenarios indicate that demographic pressure and higher natural rubber price were found to intensify agricultural production processes, whereas introduction of increased rural wages, and reduced food crops prices were found to impede the process of forest degradation. In conclusion, some feasible to manage measures such as incentive-based compensation policies were suggested.

**Keywords:** Driving forces, land use change, South China, village-household

## **Constraints and Opportunities in Paddy Value Chain in Andhra Pradesh, India – Linking Small Rural Producers to Urban Consumers**

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Rice is one of the most important food crops grown in India. During last 4 years there has been an abrupt increase in the price of paddy affecting the purchasing power of middle and lower middle class consumers. Rice being the staple food of Andhra Pradesh, it is of utmost importance to analyze the way it is produced, marketed and the role of different actors in this chain. This study mainly focuses on the trends and issues from farmer to consumer throwing light on the price margins of different actors involved in the total paddy value chain. Levy systems, role of millers, government agencies, civil supplies and other alternative systems of procurement of paddy are studied. Along with these issues, a major area of concern is the problems and issues involved with production of paddy with respect to power supply, irrigation, and increase in cost of cultivation, fall in net incomes, mechanization, irrigation, labour issues, input usage, credit and marketing. This paper clearly brings an understanding on the whole dynamics involved in the production process without compromising the food security aspect. The study also researches on the sustainability of the paddy production by small farmers when the net income accounting to a meager amount of INR 1000 per acre. The study also researches for alternative system of marketing and compares the farmer share in traditional marketing of paddy and in the alternative system.

**Keywords:** Food security, marketing, paddy, sustainability

## **The Influence of Grades and Standards on Governance Relations: the Cases of Asian Vegetables Produced in Honduras and Northeast Brazil's Grapes and Mangoes**

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The effect of grades and standards is positively linked to addressing concerns on consumers' side. It reflects the absorption of stressed social values such as the importance of social and environmental sustainability. Actors in the chain are forced into interdependence either through lead buyers or through governments' demands for conformity to various standards. Also, it is argued that intra-firm transfer of knowledge and information may be facilitated through standards implementation. Standards have become, however, a way to understand the configuration of power relationships along value chains. The two studies presented here provide insights about aspects constituting the latter issue. The Asian vegetables sector in Honduras portrays how domestic lead players structure the requirements for export through a set of parameters on crop management and produce characteristics demanded to producers. This situation provides them the ability to handle the uncertainty involved in the exchange of Asian vegetables, whereas economizing on the main transaction costs. However, the retaining of information's strategic content on issues such as market demands from actors further downstream in the chain to a great extent enables them to preserve their position as lead players. On the other side the outlines of a research line conducted in the fruit production region of the São Francisco Valley in Pernambuco, Brazil, by the Globalisation of Agriculture Research Group in the Federal University of Pernambuco, illustrate the case of a productive region which for some years has lived the process of overarching productive restructuration to comply to global corporate retailers in the main consumer market of USA and Europe for mangoes and table grapes. Actors involved in the value chain for the region's products have seen an increasing pressure for compliance with main international standards of production quality and, with that, the 'externalisation' of the skills needed for defining quality assessment parameters of a great number of production aspects. Both studies illuminate on the dilemma of the vulnerability of local farmers in the producing regions of the south hemisphere, connecting them in a relation of captivity and strongly binding their means of livelihood to international markets of the developed nations.

**Keywords:** Quality, standards, value chains

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## **Characterisation and Vulnerability Analysis of the Fish Value Chain in Face of Climate Changes in the Lower Amazon Region, Pará - Brazil**

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Some characteristics of the climate dynamics in the Amazon include extreme events as the case of drought and flood in the lower Amazon region occurred in 2005 and 2009, respectively. This region presents a very peculiar water dynamics, characterised by strong seasonality, with six months in flood and drought, alternately. Traditional fishing is the main economic activity for communities that occupy such areas located in the Alenquer municipality in the state of Pará, Brazilian Amazon. Because it is an activity intimately connected with the seasonal river flows, which in turn is governed by the weather, fishing activity results vulnerable to climate extremes, with particular consequences to the fishermen, which plays the most important role in the value chain. Thus, this work aims at better understanding the role of agents in the fish value chain, assessing the contribution of the traditional fishermen and the climate, economic and social risks which interfere in the local economy. Moreover, results of this study provide a scenario analysis on the fishery activities that could be useful to draw specific adaptation strategies on climate changes as well as policies to improve local economy. As the fishing industry requires a complex evaluation given the lacking of temporal and quantitative data, the data collection procedures were carried out through literature review, semi-structured interviews with representatives of the strategic sector, questionnaires and participatory methodologies. Despite being composed of simple agents, such as fishermen, middlemen, marketer and refrigerators, the fish value chain presents a great variability in their trade relations depending on its location, presence or absence of land and proximity to the main municipalities. Another aspect is related with the economic losses suffered by the fishermen caused by their vulnerability to the identified risks. Finally, extreme events in the local climate strongly affect the local economy, demonstrating the need of political measures to address such problems.

**Keywords:** Amazon, rural economy, value chain



## **Incorporating Value Chain Research into Horticultural and Agricultural Study Programmes in Developing Countries**

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At Humboldt-Universität zu Berlin two EU-projects within EuropeAid's Edulink and Asia-Link programmes are coordinated which focus on incorporating Value Chain research into horticultural and agricultural curricula at universities in partner countries in East Africa and Asia.

The project ValueLEad aims at enabling student education at two African universities in sustainable and quality-oriented fresh-food chain management (FFCM) with a focus on poverty alleviation and meeting the needs of the agri-food sector, in particular the vegetables and fruit as well as dairy sectors.

The project DOCUMAP focuses on education and training in the fields of supply chain management and postharvest handling of vegetables and fruit at three Asian universities.

These projects are based on three assumptions:

a) graduates of horticultural (and agricultural) study programmes require analytical and problem-solving skills, an interdisciplinary thinking style, team work and communication skills and — centrally — aptitude and attitude of self-directed learning in order to master the challenges of their future jobs in rapidly changing horticultural and food sectors.

b) Problem-Based Learning (PBL)-type student research projects and multiple collaboration with actors of the agri-food sector are central elements of study programmes with these competence-based learning objectives.

c) Curricula, institutions and human resources need to be simultaneously developed on different levels in order to adapt study programmes to this end.

The projects thus address lecturers at the African and Asian partner universities within various complementary project activities for development of student-centred PBL and interdisciplinary research as well as other Value-Chain related curriculum elements.

Furthermore, the cooperation between the universities offers a basis for North-South and South-South academic partnership networks for continuous development of the food value chain analysis concept and its adaptation to African and Asian realities.

The concepts of and experiences with the two projects will be described, successes and challenges analysed and conclusions for refinement of the approach presented.

**Keywords:** Curriculum development, problem-based learning, university-industry cooperation



# Market development - Poster session I

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## Market Orientation, Diversification and Market Participation of Smallholders: Evidence from Ethiopia

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Commercial transformation of subsistence agriculture is an indispensable pathway towards economic growth and development for many agriculture dependent developing countries. Commercialisation entails market orientation (agricultural production destined for market based on market signals) and market participation (amount or proportion of agricultural surplus offered for sale). However, the literature on commercialisation of smallholders makes little differentiation between market orientation and market participation of smallholders. Moreover, the literature on commercialisation of smallholders focuses on the output side of commercialisation, giving little attention to the input side. This paper is aimed at empirically testing (1) whether the determinants of market orientation and market participation are consistent, and (2) whether higher market orientation is translated into higher market participation. The paper is also aimed at analysing the determinants of the intensity of use of purchased inputs for annual crop production, as a measure of household commercialisation from the input side; analysing the effect of land fragmentation on crop diversification and market orientation, and analysing the effect of crop diversification on household participation in crop output and input markets as seller. Results show that the determinants of market orientation and market participation are not necessarily the same, although they are not inconsistent. Market orientation strongly translates into market participation. Land fragmentation is the most important determinant of crop diversification. There appears to be a U-shaped relationship between crop diversification and crop input market participation of household as buyer. Results imply that policy and institutional strategies to enhance smallholder commercialisation need to target enhancing market orientation at the production planning level, and market participation at the post-harvest level, and these strategies may be different. Reducing land fragmentation has potential to enhance smallholder commercialisation in Ethiopia. Improving productivity and production is an important determinant of market participation of households. The extension service, although effective in enhancing market orientation, failed to have significant effect on market participation, suggesting that the marketing extension component of the extension service needs to be strengthened.

**Keywords:** Commercialisation, diversification , market orientation, market participation

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## Effect of Improved Technology and Substitution of Traditional Transport Containers on Food Safety and Milk Marketing in Somalia

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Camel milk plays an important socio-economic role in Somalia not only because of its high nutritional value but also as an important source of income. Hygiene and marketing of milk also influences not only the human health but income and food basket. An evaluation was carried out assessing data of a EU-funded project implemented in Somalia that recorded the transformation from the prevalence of the use of plastic milk containers towards aluminium milk cans, and its effect on food safety and marketing.

Large volumes of raw milk were handled by the informal market and supplied daily to urban consumers. However, milk transporters and milk traders lacked the technical skills and basic understanding of milk hygiene to be able to provide quality fresh milk to the markets. Milk that has gone sour fetched a lower price by between 25 % and 40 % compared to fresh milk, thus reducing the incomes of both traders and producers. Findings indicated that raw milk collection and marketing is characterised by absence of hygiene and cooling, the use of plastic containers for transport that cannot be sanitised and poor retail practice by street vendors. The influence of pooling of different camel milk batches along the collection and marketing chain is illustrated by the increase in prevalence of *Streptococcus agalactiae*, a mastitis pathogen that originates from the udder. The pathogen was found in 50 % of transport containers coming from producing herds, in 62 % of milk containers sampled at primary collection sites and in 70 % of milk containers sampled from an urban market of the same region. The constraining factors for the milk production sector are listed as 1) loss in milk quality due to rapid spoilage during transport and marketing, 2) reduced profit on milk sales, 3) milk production areas often become inaccessible during the rain, 4) low milk prices during rains and lack of milk processing leaves producers unable to utilise seasonally increased yields to build food and cash reserves, 5) periods of milk surplus are rapidly followed by periods of food scarcity.

**Keywords:** Camel milk, contamination, critical control points, food safety, quality assurance system

## **Preference Modelling of Urban Consumers Towards Organic Vegetables at Kathmandu Metropolis, Nepal**

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Organic production and marketing in Nepal is relative a new venture. Some super markets have started selling organic vegetables and many restaurants are serving organic foods to the consumers. Recently, there has been growing interest from different stakeholders at different levels for the promotion of organic production and marketing. Demand of organic vegetables is going up in the urban areas due to growing affluence and education, increasing awareness about health and quality of food products and transformation of food systems towards healthy and safe consumption. However, the crucial questions to be addressed before making production and marketing decision are how consumers react with such newly introduced vegetables in the market and what factors of the commodity make consumption appealing to consumers? Therefore, the present study, conducted in the densely populated Kathmandu valley, aims at contributing market information that permits implementing an efficient and effective strategic marketing plan for organic vegetables in the urban market centres of Nepal. Consumers' willingness to buy organic vegetables, in general, was studied using binomial regression model and the value they place to the set of attributes of tomato, in particular, was studied using conjoint modelling.

Most of the consumers would be willing to buy organic vegetables; however, higher price and the lack of certification are the key deterrents. Family size, knowledge of health risk of inorganic vegetable consumption and education are significantly influencing consumer's willingness to buy organic vegetables. The most preferred combination of tomato would be organic with high quality and low price (NRs 40 kg<sup>-1</sup>) and the least preferred combination would be organic with poor quality and high price (NRs 80 kg<sup>-1</sup>). Price has higher relative importance with discernible differences at different market segments.

Conjoint modelling with market segmentation refers the preferential differences of different attributes of tomato. The study thus envisages that niche organic vegetable markets should be developed targeting certain segments of the consumers who would be willing to pay more for organic vegetables and certification should be initiated to give credence to the vegetables thereby appealing the consumers and provide benefit to the producers.

**Keywords:** Conjoint analysis, Nepal, organic vegetables, part worth, tomato

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## **Farmers' Risk Management in Maize Production in Northern Viet Nam: Determinants of Variety Choice and Area Allocation**

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In Viet Nam, maize has become the second most important crop after rice due to its importance as feed for the country's rapidly growing livestock industry. In the mountainous district of Yen Chau in northwestern Viet Nam, maize is grown by almost all farmers and accounts for 65 % of their total cash income, on the average. Given the price fluctuations and adverse ecological effects observed, this concentration on maize production must be viewed as a relatively risky livelihood strategy. Hereby, the level of risk depends - among others - on the yield potential, yield variability, and input requirements of the maize varieties used. Understanding farmers' decision-making with respect to maize production is a crucial prerequisite to enhancing both its economic and ecological sustainability. Hence, based on data collected in a random sample of 300 households in Yen Chau district, the objectives of this study are to investigate (1) the maize varieties used and their characteristics, (2) determinants of farmers' choice between riskier and less risky varieties, and (3) determinants of the area share allocated to maize. A probit regression model identifies determinants of variety choice, and a subsequent OLS regression identifies factors influencing area allocation, accounting for possible unobserved differences between farmers who grow riskier and less risky maize varieties. Regarding the level of risk involved two maize variety groups can be identified, LVN (less risky) and NK (riskier). The probit model correctly classifies 67 % of NK growers and 95 % of LVN growers, indicating a relatively high level of predictive power. Amongst others, the maize price received in the previous season, literacy of the household head, and access to credit positively influence the choice of the riskier NK varieties, while the recent experience of food shortages and a remote location work towards opting for LVN. The area share allocated to maize is positively influenced mainly by per-capita land availability and the share of upland area, and negatively by the price of urea. Overall, we find that the riskier NK varieties are also attractive to the poorest, presumably risk-averse, tercile of farmers but they are not able to exploit their yield potential.

**Keywords:** Maize variety choice, probit regression, risk aversion, Viet Nam

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## **Improving Livelihood of Small-scale Farmers through Market Led Irrigated Crops Development: Case Study from Tigray, Northern Ethiopia**

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Rainfed crop production in the semi-arid areas of northern Ethiopia is associated with high risks of rainfall variability which occasionally lead to partial or complete crop failure and consequently, most of the farmers were considered as food insecure. To improve the livelihood of farmers in such areas, interventions targeted at resource conservation and the development of irrigated agriculture have been promoted. One such intervention area is the Atsbi-Womberta district of Tigray region. This paper analyzes the experiences and lessons in the district. The intervention has three interconnected components: increased crop water availability, enhanced crop water uptake, and increased productivity to improve income of small-scale farmers, all linked to market oriented diversification into high value crops, based on value chain approach, and demand driven, participatory and knowledge based extension. The changes associated with the interventions and uses of conserved resources were systematically captured using household level surveys, specialized studies and key informant interviews. Results show that farmers initially used the irrigation water to grow cereals, achieving yield increase of about 81% relative to rainfed. Later on, farmers shifted to non-cereal more market oriented irrigated crops, in which case the share of market oriented irrigated crops increased from 27 % of the total irrigated land in 2004 to 88 % in 2008. Moreover, crop diversification of households increased, including garlic cultivation during frost period, and pulses to break pest problems and improve soil fertility, and raise income from beans during the dry season market niche. Besides, annual cropping intensity shifted from one cereal harvest to 2-3 high value crop harvests. Average household income of beneficiaries increased by about nine fold compared to non-beneficiaries. The total irrigated area also increased eight fold and the number of beneficiaries by about three fold. The lessons imply that investment in resources conservation could be enhanced if linked with short-term income generating activities through linkages with markets.

**Keywords:** Market oriented diversification, production risk, resource conservation

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## Market Integration and Deforestation in the Peruvian Amazon

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While deforestation in general is the result of the complex interaction of a variety of factors, land use change for the purpose of agricultural expansion is considered to be a main cause for deforestation in the Peruvian Amazon. Market growth, commercialization and in particular increased market integration in turn constitute important economic factors underlying and promoting agricultural expansion. As an initial step towards a more comprehensive analysis, we investigate the integration of the Department of Ucayali, located at the Western margin of the Amazon basin, into the agricultural markets of Peru's coastal areas which are the main consumption markets as well as the gateway to international markets. Cointegration analyses are carried out and, where indicated, vector error correction models (VECM) are estimated using wholesale price data for rice, cassava and papaya from different market places from the coastal capital of Lima along the trading route crossing the Andes to Pucallpa, the capital of the Department of Ucayali. In case of rice and cassava, there is cointegration between markets in the Andean highlands and Lima but markets in Ucayali are not found to be cointegrated with the coast, reflecting the fact that both staples are produced primarily for self-consumption. In case of papaya, markets of the department are found to be cointegrated with the coast. However, VECM analyses yield a low price transmission elasticity of 0.37, as compared to a price transmission elasticity of 0.64 between the highlands and the coast. This result highlights the importance of the mountain passage for the market integration of the Peruvian Amazon. The conclusion of this initial analysis is that, although the Peruvian Amazon already is integrated with national markets, efforts in infrastructure improvement and the strengthening of market institutions will have the potential to substantially increase market integration and, hence, commercial opportunities and the pressure for deforestation. We propose to extend the analysis to include palm oil, which accounts for a large share of the increase in agricultural area over the past years. We suggest to further explore the relative importance of market integration and other factors for deforestation.

**Keywords:** Amazon, cointegration analysis, deforestation, market integration, Peru, price transmission, vector error correction model

## **A Village Social Accounting Matrix for Mountainous Southwest China: A Case Study in Xishuangbanna, Yunnan, China**

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Xishuangbanna is known for its biological diversity and included in the Indo-Burma biodiversity hotspot. Besides, it is enriched by diverse ethnic groups and culture. However, rapid modernisation such as large infrastructure and investment projects and great dependence on rubber plantation significantly challenges the local socio-economy, inherited landscapes, environment with all consequences for mankind and nature. This study focuses on a presentation of a village economy and society, and aims to detect sustainable modes of exchanges in the community which reduce the need for more rubber as means of development, since rubber has increasingly negative effects on the environment. The idea is to implement village social accounting matrix (SAM) in China in order to lay the foundation for further analysis. The village SAM is a model that comprehensively describes national and regional economic structures in a certain period. It combines input-output tables with macro-economic accounts into a balanced and closed structure to provide a data base for economy-wide analysis. An aggregated SAM includes six accounts, such as activities, factors, households, village government, investment and rest of world (ROW). Furthermore, the SAM will be disaggregated into a detailed model to reflect interactions among various farm-household groups within villages as well as external relationships. Activities which take place in the village will be divided into eleven sub-accounts covering on-farm, off-farm and public activities. Factors are divided into eight production factors referring to three kinds of labour and land as well as two types of credit. Three groups of households and government's two fiscal separate flows are used to disaggregate the account. The ROW is specified as three different institutions interacting with villagers inside the community. The model emphasises the mutual impacts of farming activities and construction of public infrastructure on the village socio-economy.

**Keywords:** Farming activities, public infrastructure, SAM, Southwest China

## Assessing the Market Potential of Local Agrobiodiversity Products in the Tajik Pamirs

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The Tajik Pamir Mountains is a very harsh environment and its agriculture is characterised by a tremendous diversity of unique fruit varieties, at the basis of local food culture and food security. Fruits like mulberry, apricot, and apple, are important for their adaptability to sloping surfaces. Particular traits give local varieties advantage over introduced ones. However, soviet agricultural reform and recent efforts by development organisations to create markets introducing exotic varieties, are having a profound effect on the loss of agrobiodiversity, increasing the vulnerability of households.

This pilot study carried out in 2009 aims to investigate the market potential of local products derived from apple, apricot, mulberry and how to exploit it to benefit the community livelihoods and the agrobiodiversity maintenance.

An household-level survey was conducted in 3 valleys of the Tajik Pamir, on 78 households cultivating apple, mulberry and apricot varieties. A participatory multi-stakeholder workshop attended by market chain actors working with these fruit species - and with local researchers and developers - was organised to identify and discuss opportunities and bottleneck of the market chains of these crops.

The results show that farmers cultivating these species own very little land (ca. 0.3 ha). These crops represent their main cultivation, used for food and income generation. They cultivate a great number of different varieties (33 apple, 40 apricot and 37 mulberry). Apart from a number of introduced apple varieties, cultivated because of their market appeal, a great number of local mulberry and apricot, but also apple, varieties are maintained for different reasons (early-ripening, good taste and quality, easy to store and to dry).

Most promising products derived by this local agrobiodiversity were identified. Looking at the market chains, a number of problems and opportunities have been classified (such as trainings for pest management, processing and packaging; farmers' cooperatives for marketing).

Exploiting the identified opportunities and, at the same time, raising public awareness about the nutritional qualities of local crop varieties among the producers and consumers is a way to proceed to enhance the market potential of these local species and maintain the local agrobiodiversity.

**Keywords:** Agrobiodiversity, livelihoods, market chain, market potential, mountainous areas, Pamir mountains, participatory market approach

## Export Competitiveness of Pomegranate in India

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Indian agriculture is vested with the herculean responsibility of feeding more than one billion people. 72 % of India's population live in rural areas, and three quarters of the rural population depend on agriculture for their livelihoods. Agricultural growth in India slowed down to 2.1 % between 1998–99 and 2004–05, largely due to a decline in the food grain sector. Given the high dependence of the poor on agriculture, the stagnation in this sector is currently threatening to stall poverty reduction in India. The immediate question to be addressed is how agricultural growth can be accelerated. The question can be answered by diversifying the consumption pattern towards high value agricultural commodities in general and high value horticultural products in particular.

Horticulture is an important component of agriculture accounting for a very significant share in the Indian economy. Rising consumer income and changing lifestyles are creating bigger markets for high-value horticultural products in India as well as throughout the world. The most important high-value export products are fruits and vegetables. The present paper analyses the comparative advantage and competitiveness of pomegranate, which is the important foreign exchange earner among major fruit crops exported from India.

The primary data was collected from Bijapur district of Karnataka, India and secondary data was collected from concerned government institutions (as APEDA) and also from exporters of fruits and vegetables. The Policy Analysis Matrix (PAM) was selected as the analytical tool to analyse the export competitiveness, comparative advantage, and the degree of government interventions in the production and export of pomegranate. The policy distortions were measured through indicators of PAM.

The effective protection coefficient (EPC) of pomegranate (0.45) values were found to be less than the value that indicate that producers are not protected through policy interventions. Whereas the domestic resource cost (DRC of 0.28) and the private cost ratio (PCR of 0.59) values show positive social as well as private profit which indicates that India has a competitive and comparative advantage in their production. The overall result shows that the cultivation as well as export of pomegranate is economically profitable and efficient.

**Keywords:** EPC and DRC, PAM, pomegranate

## **Agricultural Imports from Developing Countries and the Socio-economic Effects of Emerging Carbon Label Initiatives: What can be Learned from the European Label Initiatives of Food Products?**

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Climate change caused by global warming poses a challenge for the current and future generations. Temperature stabilisation is necessary to avoid major changes of ecosystems; the success will depend on the degree of emissions in the next decades. One strategy to reduce CO<sub>2</sub> emissions is the introduction of a so-called carbon label related to climate change relevant gas emissions of a product. Several countries, supported by private industry, have already started to introduce labels (UK, Switzerland, Japan), other countries are still in the planning process (Germany). Different strategies exist on what is measured, how, if the label is linked to a comparative advantage over other products or if it obliges also to a reduction of emissions. The proposed labels are adding to the abundance of existing standards and labels. Quality (e.g. GlobalGap), environmental (e.g. organic, water/energy efficiency) and social (e.g. fairtrade) standards and labels are especially predominant in agricultural-based products but become increasingly important in all economic sectors. Until now, all labelling initiatives are developed in industrialised countries. Due to international trade, these standards and labels affect also developing countries, their emerging industries as well as their agricultural sector.

Based on intense literature analysis, the study identifies the historical development of environmental and social labels used for European food products. We look at the effects on the agricultural sector in developing countries and ask which lessons can be learnt for the design of a carbon label? What kind of strategy could reduce the confusing complexity of too many different labels aiming at the same output of reducing CO<sub>2</sub> emissions? What might be potential socio-economic impacts of a carbon label on farmers and their agricultural products from developing countries?

Current existing standards show a development from private initiatives on a country level to Europe-wide regulations. Debates regarding the regulations and initiatives for carbon labels focus mainly on measurement issues. Trade-offs between social development and environmental protection are expected to increase over time and impacts may range from better market integration to market exclusion of (small-scale) farmers in developing countries. The effects will also depend on the respective carbon label regulation.

**Keywords:** Carbon label, climate change, market integration, social development

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## **Cotton Farming as a Livelihood Strategy in Arid and Semi-arid Dry Regions of Kenya: What Influences the Adoption of Improved Management Practices?**

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Cotton (*Gossypium hirsutum*) is grown in over 80 countries, providing a significant source of livelihoods to millions of people. In Kenya the crop is mostly grown as a cash crop in the Arid and Semi arid regions under rain fed conditions. Due to its drought tolerance, the crop provides an ideal food security strategy for smallholder farmers. After independence small-scale cotton farming was introduced by the government. It was a success story until the collapse of the sector in the early 1990's. In the late 1990's the government embarked on the promotion of cotton farming among smallholders mainly through provision of seeds and improved farming practices. In 2009 a survey was carried out to determine the current level of adoption of improved Cotton production practices in Eastern and Coastal regions of Kenya. Questionnaires were administered to 54 randomly selected farmers. A Tobit analysis was used to determine socio-economic, and technology factors that influence adoption of improved cotton management by smallholder farmers. All households used compost farm yard manure, and in the wealthier households, inorganic fertilisers as part of their soil fertility management strategies. Based on the Tobit analysis, land area, ethnic group, years of farming, off-farm income, contact with extension officers significantly and positively affected adoption for cotton farming. Farmers in coastal region reported lack of seed to be the major constraint to the adoption of cotton farming, while lack of knowledge of new varieties was the major constraint for farmers in the Eastern region. The results from this survey suggest that the strategy for improving the adoption of cotton farming will differ depending on infrastructure and the socio-economic niches of farmers in a given area. This study proposes enhancing these strategies with Bt cotton farming and Farmers Participatory Training and Research (FPTR).

**Keywords:** Bt cotton, farmer field school, food security, information access, input access, Technology adoption

## Determinants of Participation in Payments for Ecosystem Service Schemes

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Landholders are generally assumed to be willing to participate in payments for ecosystem service (PES) schemes if the offered payment exceeds the opportunity cost of participation. The calculation of opportunity costs (and thus the determination of payment levels) is often based on historic financial data such as net returns of the formerly practised land use. Reliable estimates of opportunity costs are required especially in flexible, cost-aligned payment schemes with differentiated payments at the farm scale. We question here whether opportunity cost estimates that do not consider personal land holder characteristics such as personal risk considerations, information access and non-monetary values such as personal preferences (*e.g.* for traditional land use practices) are sufficient to explain a land holder's decision to enrol land in PES. To test these assumptions, a PES adoption model was developed for hypothetical adoption decisions by 178 landholders on the Nicoya Peninsula, Costa Rica. The model explained up to 73.5 % (Nagelkerkes pseudo  $R^2$ ) of adoption variance. The results confirm that adoption is not determined by financial opportunity costs alone. In fact, net per hectare returns turned out to be insignificant in explaining adoption. The model stresses the importance of risk and information issues in explaining PES adoption. Trust in state institutions, for example, played a highly significant role in the model. Proxies for non-monetary preferences, however, could not be shown to significantly explain decision making. The results call for more integrated methods of opportunity cost estimation on the farm scale. Inverse auction systems are proposed here as an alternative approach for the determination of farm level opportunity costs. Their strength lies, among others, in that all adoption determinants (including risk, information and personal preferences) are potentially expressed in the land holder's bid.

**Keywords:** Adoption, auction, Costa Rica, opportunity cost, payments for ecosystem services



## Performance Payments: A New Strategy to Conserve Large Carnivores in the Tropics?

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Biodiversity, including wildlife, is globally decreasing at alarming rates. Many large carnivores are endangered due to habitat loss, poaching for trophies, and deliberate persecution as consequence of depredation on livestock. Wildlife-livestock conflicts are estimated to be especially severe in the tropics since the soaring demand for land and resources in these countries is in direct competition with wildlife's conservation needs. This development has evoked calls for innovative conservation policies.

In the present paper we explore the novel conservation performance payment approach which for wildlife-livestock conflicts, so far, has only been implemented in Sweden. Conservation performance payments provide incentives for conservation by issuing payments based on indicators of conservation outcomes. Performance payments are a type of payment for environmental services (PES).

The contribution of the paper is twofold. A structural framework of performance payments' design is developed and an empirical assessment of the approach to tiger-livestock conflicts at Bandhavgarh National Park in India, an example where conservation needs compete with humans' increasing demand for land and resources, is presented. The framework focuses on issues of scheme design such as identifying performance indicators, targeting, payment amount and timing, considerations on making payments to groups vs. individuals, scheme duration, and inadvertent side effects. The assessment of the applicability of the performance payment approach to tiger (*Panthera tigris*) conservation is based on a high-profile policy workshop, an interview with the park management, and 305 household-level interviews conducted in 20 villages in the buffer zone of the park. Our assessment of the transferability to India suggests that there is no general restriction on implementing this type of policy in a developing country context.

**Keywords:** Conservation performance payment, India, Payments for environmental services, Sweden, Wildlife-livestock conflicts

## **Rising Food Prices in Benin: Changes in Market Interactions of Small Scale Farmers in Atacora-Donga**

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The global rise in food prices in 2007 and more intensively in 2008 affected consumers' worldwide, developing countries however, were even affected to a higher extent. In fact Benin's citizens – especially the urban poor consumers – had to accept rising prices of 70 % (local rice) to over 200 % (maize). This prompted the Benin government to several reactions (reduction of import tariffs, establishment of buffer storage), in hope to ensure national food security. Although prices have fallen again during the global economic crisis from mid-2008 on, they remained in 2009 on a higher level. But however the question arises how producers were affected by higher prices of agricultural commodities?

This case study was developed under a broader frame of student GTZ studies among small scale famers in developing countries (*e.g.* Mali, Cambodia and Peru), which aimed to examine economic impacts of risen food prices. It focused on qualitative surveys among rice and maize – two of the most important staple foods in Benin – farmers in the northwestern region Atacora-Donga. The study considered in particular farmers' market participation, as well as their interactions with traders, millers and other persons, who have been involved in local value chains of rice and maize. Did the farmers benefit in the past or the present from the rising food prices or did increasing prices for agricultural input factors offset possible advantages? And to which extent have producers' cultivation behaviour and market interactions been influenced?

The study portrays a detailed picture of different economic reactions and adoption strategies of small scale farmers, which were not only determined by previous market participations, but also influence prospective agricultural investments.

**Keywords:** Benin, market participation, rising food prices

## **Food Price Crisis and Rural Livelihoods: Analysis of Livelihoods of Small-scale Farmers in the Republic of Mali**

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In 2008, the Global Food Price Crisis turned agriculture and food security back into the public, political and scientific debate. Especially the population in Low-Income-Food-Deficit Countries (LIFDC) was threatened by increasing hunger and poverty. In order to analyse and understand the impact on small-scale farmers livelihoods in the Republic of Mali, a field study was conducted in the Office du Niger, the major irrigation and rice production zone of the country. Major regarded crops are rice and vegetables. Additional the survey considered millet and sorghum farmers who depend on precipitation. Aiming to point out the impacts of rising prices in a bottom-up perspective, the Sustainable Livelihoods Approach provided the conceptual framework for an holistic point of view. A great variety of appropriate tool kits and participatory methods has been applied.

The collected data reveals an negative impact of the rising prices among the population. The institutional and political framework show malfunctions and the organisation of the peasants must be called disadvantageous. The drying trend in the region, introducing Climate Change, worsens already insufficient harvesting. The adaptive strategies among the Interviewees mainly consisted of quantitative and qualitative changes in daily nutrition besides sale of livestock and other possessions.

The challenge to reduce vulnerability and strengthen the resilience of small-scale farmers lies in education and formation. Key issues are the improvement of the peasants-organisation and an amelioration in land use. Furthermore innovations and the implementation of further processing ways in order to enhance existing value chains should help to reduce the existing vulnerability.

**Keywords:** Food Price Crisis, land-use, peasants-organisation, republic of Mali, Small-Scale Farmers, value chains, Vulnerability



# Market development - Poster session II

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## **The Impact of High World Food Prices on the Sudanese Agricultural Crop Sector**

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The recent dramatic increase of world food prices has been attributed to many factors; among them on the supply side are weather-related production shortfalls, changes in stock levels and increasing fuel costs. While on the demand side, the changing structures of demand and biofuels production from agricultural commodities are considered as the main factors. Sudan as one of the developing countries and a price taker in the world market of food has been affected greatly by the price increase. This paper aims at studying the impact of the increasing food price on the agricultural crop sector of the Sudan. In this paper a multi-market model is used as the main tool to assess the increase of the world food prices on the cereal sector. Multi-market analysis is a tool for simulating the effects of agricultural price policies on outcomes considered of interest to policy makers. The model under consideration takes the normal specification of a standard partial equilibrium model; it is static and consists of a set of demand and supply equations for each commodity with the level of production and demand determined by factors including prices, income, demand and supply-shift variables and various other assumptions about policies. Price transmission equations in the model establish links between the domestic price, the producer price (for producers of exportable products and of import-substitute products), the consumer price and the world market price. The model has been extended to calculate the impact of high food prices on the main economy variables which include supply and demand of cereal; in addition it estimates major national food security indicators. Different scenarios of the high food prices showed an increase in farmers incentives resulting in higher levels of production of agricultural crops, on the other hand, consumers demand has decreased significantly, and the national food indicators reflect a positive effect on the food self sufficiency ratio and a significant decrease in per capita consumption.

**Keywords:** Food security, multi-market model, Sudan

## Attitudes in Consumption of Organic Products in Kenya: A Comparative Analysis of Local and Foreign Consumers in Nairobi

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Though facing many challenges the Kenya's organic subsector has grown steadily since the early 1980's attaining over 200,000 ha of certified organic area and total production standing at approximately 3,500 Mt in 2009. However, it has been established that the demand for organic products is mainly drawn from foreign consumers, with over 75 % of the total organic production destined for the export market. Nonetheless, if the growth in organic production has to be sustained, our argument is that local and regional markets are to establish. To create such a market, it would be imperative to understand the bottlenecks that exist within the organic value chain, and also understand the drivers of specific consumption trends.

The current study was an attempt to understand the drivers of consumption of organic products among the tourists and also drivers against the consumption of organic products by local consumers. Comparisons were made along psychological factors (health concerns), Socio-demographic factors (cultural, religion, education and ethno-cultural background) and economic factors (income). Data were collected from potential and current domestic (100) and foreign (100) organic product consumers. Both quantitative and qualitative approaches were used, with theoretical framing given by theories drawn from Social Psychology. From the study, it emerged that there were disparities between the local and foreign consumers on specific consumer attributes, believed to be the key drivers of organic consumption. Tourists who consumed organic food products in their home countries were also more likely to consciously seek for organic products while in Kenya. This implies that the drive to consume organic products is an intrinsic aspect, driven by personal believes, trust and psychological influences. These points out the importance of consumer education and awareness creation, building trust within the local organic food certification systems and creating a culture of environmental friendliness.

**Keywords:** Foreign tourists, local consumers, organic food products, psychological factors



## **Economic Profitability and Adoption of Bt Cotton and non-Bt Cotton in North India**

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Cotton is one of the major cash crop in India accounting an area of 9.4 Million hectares and 4.39 Million tonnes to production. In India, Bt cotton is the first genetically modified crop introduced in 2002 and currently it covers more than 75 % of the area under cotton. The adoption of Bt cotton is high in India in comparison of other countries. There is a phenomenal change in area, cotton yields and input use for Bt cotton compared to non-Bt cotton over years. There exist strong favour and strong protest in the adoption of Bt cotton. The current paper clarifies the debate by analysing Bt cotton and non-Bt cotton farmers profitability and adoption in Haryana and Punjab states of India considering primary data from 160 Bt cotton farmers and 40 non-Bt farmers using simple random sampling. Results are analysed using partial budgeting and logistic regression. Results indicate that Bt farmers are getting three times more returns than non-Bt farmers reflecting economic profitability of Bt cotton. In econometric analysis for adoption, it was found that farmers can benefit significantly from technology. Farmers are adopting Bt cotton due to higher yields and reduction of insecticide use even though seed cost is high in comparison of non-Bt cotton. Education and farmer's network played an important role in adoption. But the adoption factors varied from state to state. Punjab state farmers are earlier adopter than Haryana Farmers. In Haryana state, cotton experienced farmers are adopting more this technology. The results will give crucial information for the policy makers for promoting production of Bt cotton aiming at improving farmers socio-economic status.

**Keywords:** Adoption, Bt cotton, India, profitability

## Bilateral CDM-flows: Stand-alone, or Substitute for FDI and Aid?

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In 2005, the Kyoto protocol entered into force to combat climate change. With it, requests for and registration of projects under the so-called Flexible Mechanisms, the Clean Development Mechanism (CDM) and Joint Implementation, started. These mechanisms are meant to give developing and transition countries a contributing role in the combat against climate change. They construct an incentive scheme to engage in environmental projects without limiting the countries in their industrial growth. Under the Flexible Mechanism, each abated ton of CO<sub>2</sub> equivalent in such a project is rewarded with Certified Emission Reductions (CERs). Those CERs can be sold to firms in countries that underlie a cap in the Cap and Trade scheme of the Kyoto protocol, so it can be counted against their emission limit.

The UNFCCC actively facilitates projects, bringing together entrepreneurs in the respective host countries with entrepreneurs in the partner countries. Hosts benefit from easy financing and technology transfer and financiers gain CERs from the projects.

This paper analyses the determinants of partnerships and the amount of CERs generated between an industrialised financier country and a developing host country. The focus is on factors that facilitate partnership through pre-existing channels, like foreign direct investment and official development aid. In particular, light is shed on the determining factors for the small amount of CDM projects in Africa. So far, only 24 of the 2120 registered projects were hosted in Africa (excluding South Africa).

The analysis is conducted using a gravity model with bilateral panel data from the years 2005 until 2007 to control for period specific effects. Within this framework, multilateral resistance terms and spatial autocorrelation are accounted for by employing techniques by Anderson and van Wincoop (2003) and Porojan (2001), respectively.

Results suggest that African states lack properties attracting CDM project investments similar to a lack of properties attracting Foreign Direct Investment (FDI). Moreover, contrary to previous findings, the model does not yield a significant relationship between a host's CO<sub>2</sub> emissions and the number of CERs transferred from that country to partners.

**Keywords:** Aid, climate change, CO<sub>2</sub>, gravity model, Kyoto protocol

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## Assessing the Market Integration of Locally Produced Groundnut in Ghana

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The raising global food prices and food insecurity of many poor rural households in developing countries can partly be attributed to the failure of the existing market structures. The study specifically examines the trends in the monthly prices of groundnut, ascertains whether the groundnut markets in the North and the South markets is integrated. It further identifies the distribution channel used in the groundnut market and the constraints facing the groundnut market. The study used the Ravallion Model concept to analyse monthly time series real retail prices data, and the Kendal's coefficient of concordance to test the agreement between rankings of constraints. Results from the graphical trends and the growth rate estimates show that prices of groundnut generally tend to fluctuate throughout the year with an annual growth rate of 1.9 to 2.9 % from 2004 to 2006 marketing year. The econometric analysis of data testing for market integration shows that the local groundnut market was not integrated neither in the short nor the long run. This means that prices are not immediately transmitted between the markets. The channel of distribution followed the orthodox type were the main participants in the market where producers, wholesalers, retailers and consumers. Transportation difficulty, lack of standardisation for the local market and inadequate credit were ranked as the top three major constraints facing the groundnut sub-sector. This also accounts for the constant instability in the prices and low returns to farmers. The study concludes that for groundnut market integration, consideration should be given to providing timely appropriate transportation services and low cost credit to traders who facilitate movement of the product from the North to the South. It is also recommended that appropriate standardisation and market price control mechanism should be carefully implemented to adequately compensate groundnut farmers.

**Keywords:** Distribution channel, Ghana, groundnut, integration, market, rural farmers

## **ILRI/BMZ Safe Food Fair Food: Building Capacity to Improve the Safety of Animal-Source Foods and Ensure Continued Market Access for Poor Farmers in sub-Saharan Africa**

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In developing countries, food-borne diseases are one of the most important public health problems and animal-source foods cause a large proportion of such diseases. In sub-Saharan Africa where many people live in poverty, the level of food hygiene is very low. This is not only because living environment is generally unhygienic but also most of marketed foods are distributed through informal value chains which are not regulated by the governments.

The Safe Food, Fair Food (SFFF) project, funded by BMZ, is building capacity in risk analysis, which has greatly improved food safety in developed countries, to resource-poor sub Saharan Africa. Adaption of risk analysis involves participatory methods to assess risks of animal source food borne diseases and explore feasible measures for improvement of food safety driven by consumers and market participants themselves.

The SFFF project has several steps. Firstly a food safety situational analysis is carried out by stakeholders of food safety in the participating countries and problems are identified. Tailored training is given with the collaboration of German institutes (Federal Institute for Risk Analysis: BfR and Free University of Berlin: FUB). The important problems identified are investigated by graduate students using participatory risk analysis. This involves developing solutions for improving food safety while ensuring continued access to markets for smallholder producers and participants in informal marketing. At the same time, capacity to carry out such studies is developed. The results gained from risk assessments are shared among food safety stakeholders in the National Workshops to enhance the use of such results for decision making and to make participatory risk analysis familiar to them.

The 8 participating countries are Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mali, Mozambique, Republic of South Africa and Tanzania, and in total 18 students are involved in the research project. A wide variety of studies is being carried out: human and animal brucellosis, *E. coli* O157 and *Salmonella* in beef, *Staphylococcus aureus* in milk, polycyclic aromatic hydrocarbons in smoked fish, *Salmonella* in chicken, game meat from National Parks, dried beef and slaughtering and consumption of meat in tribal rituals. Initial findings from these are presented.

**Keywords:** Food safety, participatory risk analysis, zoonosis

## **The Impact of Globally Fluctuating Food Prices on the Bolivian Price Level: Market Integration Analysis against the Background of the Food Crisis 2007/08**

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In the face of the food crisis 2007/08, the impact of globally fluctuating food prices on the Bolivian price level is examined via cointegration/error correction modelling techniques. The analysis focuses on the Bolivian wholesale prices of wheat flour imported from Argentina, ex-factory prices for sunflower oil/soy extraction cake (from Santa Cruz, Bolivia) and the corresponding international reference prices. Results from the Johansen Trace-tests reveal a strong comovement between the national prices and Argentinean export prices. The long-run price transmission elasticities obtained from vector error correction models (VECM) and Granger-causality tests confirm that shocks in the Argentinean markets are transmitted fully to the Bolivian price level. Despite of massive policy interventions in the wheat and edible oil sector on behalf of the new socialist Bolivian government during the food crisis, the common long-term equilibrium between the national and Argentinean price series persists. Given the results from price transmission analysis and the fact that only 20 to 30 % of Bolivia's soy and sunflower oil production is consumed domestically, a temporary export-ban in March/April 2008 seems to be an inappropriate trade intervention. Tariff-liberalisations, export-bans and state-imports in the Bolivian market of wheat/wheat flour have had little influence on the transmission of price signals from Argentina. Bolivia imports 60 to 70 % of its national wheat consumption, about 95 % of all wheat/wheat flour imports are from Argentina. Spatial distance also plays a role in the transmission of positive price shocks: in case of wheat flour those Bolivian wholesale markets with the largest distance to the Argentinean border are worse off.

**Keywords:** Bolivia, cointegration, error correction models, food crisis, price transmission

## Identifying Economically Efficient and Ecologically Sustainable Sectors for Structural Transformation in the Khorezm Region, Uzbekistan: Input-output Analysis Approach

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The worldwide increases in water demand due to population growth, industrial and urban development bring a need to increase the efficiency of water use, and increase the economic value of this scarce resource. In particular, as a result of ill water management and lack of good governance in the Aral Sea Basin, downstream areas such as the Khorezm region, where agriculture contributes 50 % of regional GDP and 70 % of population are rural, are suffering from frequent water stress during the irrigation period. In the aftermath of independence, in spite of liberalisation reforms in the agricultural sector, cotton production with its huge water requirement and low economic efficiency slightly decreased. Considering the need to identify key sectors that constitute the basis for the growth and development of the region, the main objective of this paper is to analyse economic and water use inter-linkages between economic sectors. To meet this goal, input-output model of the region are developed and virtual water flows between the sectors are estimated. The results show that Khorezm region is net exporter of virtual water since cotton fiber export provides 98 % of total hard currency revenues despite annually increased water stress. Moreover, aggregate direct and indirect water productivity analysis for each sector on the basis of input-output models indicates that the production of low-cash and high water consumptive crops are dominant in the economy of the region. While officially promoted crops such as cotton and wheat obtained high priority due to hard currency generation and food self-sufficiency policy, they are found to be less attractive in both economic and ecological terms. On the contrary, both water productivity and economic efficiency of fruit and vegetable production and processing industries are high. However, a suitable market infrastructure and an improved institutional framework are important prerequisites for succesful utilisation of the comparative advantages of the region in these crops.

**Keywords:** Agriculture, input-output analysis, key sectors, Khorezm region, virtual water

## The Performance of Ghana's Papaya in the Export Industry

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Papaya is an important non-traditional agricultural export commodity in Ghana. It is one of the commodities which is now gaining grounds in the Ghanaian export. It is a fruit which is in high demand in the export market due to its delicacy as a natural fruit and its other importance. Comparing the export volumes of papaya to other commodities in the non-traditional agricultural sector shows a very big difference since the contribution papaya makes to the sector is significantly low although it continues to increase per annum.

This study therefore examines the export of Ghana's papaya in the export market in terms of the volume that is exported per annum, the number of exporters engaged in this business and the contribution papaya makes to Agricultural Horticultural Export Earnings (AHEE). The study also examines the main determinants of export demand of Ghana's papaya and estimates quantitatively the magnitudes of these determinants as well as finding the logistic constraints to the industry.

The growth rate formula was used to determine the trends in the volume of export, number of exporters and the percentage contribution of papaya to Agricultural Horticultural Export Earnings (AHEE) after which the determinants of export demand were estimated quantitatively using the multiple linear regression model.

From the study, it was discovered that the demand for Ghana's papaya is highly price elastic meaning a decrease in real price of papaya results in an increase in quantity demanded. An average trade weighted income of major importing nations was also elastic but population as well as taste and preferences do not affect demand for Ghana's papaya. Pack house, trained staff and transporters are the major constraints to the papaya export industry.

It is therefore recommended from the study that the logistic constraints be provided to enable exporters meet Global-GAP standards as well as implementation of irrigation schemes to boost production. There is the need to put in place policies that will serve as inducement for more people to enter into production and export of papaya as well as reducing cost to bring down product prices.

**Keywords:** Determinants of export demand, export industry, global-GAP, horticultural export, non-traditional agricultural export, papaya, policies

## **Persistence of High Food Prices in Eastern and Southern Africa: What Role for Policy?**

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The high global food prices witnessed in 2007 and the first half of 2008 had large negative welfare impacts on the world's poor. Rising food prices and the current global financial crisis puts countries in Eastern and Southern Africa at risk of a reversal in gains made towards attainment of millennium development goals on hunger and poverty. The causes, effects and the policy implications of the food price crisis are not well understood. Paucity of data and information clouded the mechanisms and extent of food price transmission markets within ESA region. A study addressing the magnitude and implications of global food price changes in domestic markets in ESA correlated food price indices and several factors including landlockedness, tradability of food staples and level of import dependence. Results show that changes in global food prices are not fully transmitted to domestic markets in most countries in ESA. Countries with high import dependence for their key food staple which is also an internationally traded commodity face higher food prices. Policy responses advocated for by donors and country specific responses initiated by individual governments reflect a combination of short-term and long-term measures and can be broadly classified into in support to regional trade; agricultural productivity growth and social protection measures. Most responses involved imposition of export restrictions or outright bans that only led to regional market imbalances and caused the domestic prices of food commodities to rise. Although global food prices have embarked on a downward spiral since July 2008, prices in ESA countries continue to defy the global downward trend. Unlike in the past, the recent price surge affects most food commodities, including key cereals, oilseeds and livestock products. The global economic crisis may have shifted global attention away from food prices, but ESA countries have many reasons to worry. Domestic prices remain high and many of the factors that contribute to high and volatile prices remain unaddressed. Continuous analysis and updates of information on the food situation in ESA will keep the issue high on the agenda.

**Keywords:** Eastern and southern Africa, food prices, policies



## Modelling Decision-Making to Improve Livelihood of Smallholder Farming Systems

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Smallholder agriculture at large is a backbone for a majority of economies in developing countries and an important source for global food and fiber supply. Although the definition of smallholder agriculture is rather vague, these systems are generally characterised by small landholdings, low competitiveness and low market-orientation. A high variation of livelihood strategies of smallholder results in different prosperity and productivity levels. Smallholders have in common that their livelihood strategies are driven by interrelated decisions within an interacting framework of production, consumption and labour allocation.

This study seeks to analyse these interrelated decisions of smallholders by modelling the consequences within a framework characterised by scarcity of human and financial capital as well as limited access to land, capital and markets.

A System Dynamics simulation model, consisting of two modules, describes tradeoffs between labour allocation decisions on the one hand and production and consumption allocation decisions on the other. The model analyses the sensitivity of different types of farming systems to changes in the economic environment based on their resource endowment and preferences. The information to describe smallholder systems was gathered on 119 households in Meegahakivula, a region in the Sri Lankan hill country. A survey, interviews and agronomic field trials were conducted to analyse and model the flows of cash and goods within the household as well as between the households and their environment over time.

The analysis shows that flows of cash and goods are fluctuating over the course of a year around a steady state mainly influenced by the long lasting dry season. Changes in prices of products and production factors, salary-levels or off-farm employment opportunities influence consumption and labour allocation decisions. However, the model shows that strategies which are adapted to the available land and labour resources affecting livelihoods more than mechanisms of economic environment such as changes in prices and wages or economies of scale. To ensure a sustainable increase of income for all types of farming system and hence improve livelihoods in general, a beneficial policy framework and external investments in infrastructure and markets are needed.

**Keywords:** Consumption, labour allocation decisions, smallholder farming systems, Sri Lanka, system dynamics modelling

## Analysis of Biogas Innovations in Smallholder Farms in Kenya

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Wood fuel in Kenya constitutes 90 % of energy consumption in the rural areas with the demand growing at 3.6 % per annum. The use of such fuel has significantly contributed to deforestation through felling of trees. Forest cover in Kenya is now about 4 % of the total land area compared to the world requirement of 20 %. The energy poor in Africa spend about \$17b a year on fuel for lighting like kerosene which can be considerably reduced by replacing such fuels with biogas. Biogas is the most effective way of converting on-farm biological waste into fuel. Its use translates to increased incomes through reduction in energy costs, environmental conservation, and reduced labour demand on women, who often spend many hours searching for firewood. Biogas technology has been in Kenya since 1950's but is restricted to the highly productive areas of Kiambu, Nakuru and Kisii.

Our objective therefore was to study the factors influencing adoption of biogas technology in Kisii and Nyamira districts where land subdivision due to increasing populations has diminished forest cover thus limiting biomass fuel sources available to the people. Using multi-stage and random sampling, a total of 100 farms were selected for analysis. The study employed the double-hurdle model to analyse choice, rate and intensity of adoption. The main factor influencing adoption of biogas technology was the level of income. High cost of biogas installation was an impediment to the adoption by the poor and less endowed farmers tended to use plastic bag digesters as opposed to fixed dome and floating drum digesters which are more expensive but efficient. The other factor was the level of social capital, since farmers belonging to certain social groups tended to own biogas plants. Availability of technical support as well as donor subsidies also influenced adoption. Over 150 biogas plants have been installed by smallholder farmers in Kisii and Nyamira with help from GTZ. It was concluded that biogas promotion, development of appropriate technologies for different socio-economic groups, and forms of incentives or subsidies would enhance adoption especially in densely populated regions experiencing severe fuel wood shortage.

**Keywords:** Adoption, biogas, biogas technologies, digesters, income

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## **An Analysis of Different Marketing Channels on Greenhouse Vegetable Market in Uzbekistan: A Case Study on Tomato and Cucumber.**

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Given the current volume of vegetable production and the stratification of the population in Uzbekistan according to income level only high income earners consume fruits and vegetables. Because of low solvency, a large number of citizens cannot buy natural sources of vitamins, especially during off-season. According to the Ministry of Public Health of Uzbekistan, vegetable consumption should be 142 kg per capita annually, 28 kg thereof in the winter period. The average Uzbek has access to only 84 kg of vegetables, 5 kg thereof in winter. Additionally, many farmers producing greenhouse vegetables can not cover their production costs, which keep them from commercial farming and encourage subsistence farming.

Improvement of the marketing system in the greenhouse vegetable sector could initiate a sustainable development of this sector for two reasons: 1) if additional produce does not fetch additional revenue in the market, it may work as a disincentive to increased production. A shortage in the supply of a marketable surplus makes the development of an efficient marketing system extremely difficult; 2) if the market does not supply consumers with produce at reasonable prices and at the time and place needed, then increased production is not improving welfare in a society.

This paper attempts to understand the nature of the marketing channels, marketing costs, margins, price spread and producer's share in the consumers' price of vegetables produced in the off-season period in the Tashkent region of Uzbekistan. A field study was conducted during October 2009 - March 2010 in the Zangiota, Qibray, Chinov and Yangiyul districts of Tashkent, which account for about 47.2 % of the country's total greenhouse area cultivated with vegetables, supplying approximately 62 % of the nation-wide production. The study included 156 farmers selected randomly. Additionally, a survey on marketing strategies was conducted using a random sample of 63 retailers, 38 village level collectors, 8 export agents, 18 exporters and 27 wholesalers. The data were collected through personal interviews using a structured questionnaire.

**Keywords:** Greenhouse vegetables, marketing channels, marketing costs, marketing margin

## **Institutional Arrangements to Support Rural Livelihoods and Challenges to Access European Markets for Agricultural Products from Developing Countries**

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Agricultural intensification in Uzbekistan made poor communities in the rural areas depend greatly on surrounding nature for the majority of their activities and are influenced by the deterioration in the quality and quantity of the available natural resources. Uzbek agriculture has undergone a phenomenal transformation during the past two decades. Despite the fact the share of agriculture in the overall GDP is decreasing, it is still considered a pertinent sector in Uzbekistan. Taking into account the fact that around 78 % per cent of population live in rural areas, they will depend on agriculture and the related activities for their livelihoods. Recent agricultural policies towards growing high value crops do not fit to the overall picture where government dictates to grow cotton and wheat on the majority of available agricultural land. On the other hand, farm diversification towards cash crops requires financial reserves, quality inputs, improved technologies and also it has different marketing prerequisites. Some of these crops need immediate transportation to the market, require cooling storage or processing into a less perishable form. Even though commercialisation of these crops brings considerable profits, it does require adequate post-harvest infrastructure which is lacking in the region. Therefore transition from subsistence farming towards market driven production requires clearly set institutional arrangements in domestic and external markets. In the frequently observed absence of such institutional arrangements which is the case in most of the circumstances farmers prefer to grow just a small amount and sell it in nearby domestic markets. This paper follows a institutional economics approach to study the above mentioned issues. We recommend vertical coordination through contractual arrangements as a solution which might help to connect farmers to European markets for high value products. Abolishing currently existing market access barriers to European markets has the potential to contribute significantly to rural development in developing countries. In this context, contract farming could be employed as an institutional arrangement that opens new opportunities to the farmers and strengthens the rural economy by creating employment opportunities and increasing incomes while providing food security for the whole region.

**Keywords:** Contract farming, institutional arrangements, rural development

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## Understanding Livelihood Strategies of Different Generations of Plantain Farmers in Nicaragua – An Analysis of Investment in Agriculture and Demand of Technologies

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Plantain production for subsistence and cash income generation is a traditionally important part of small holders livelihoods in the South Pacific region of Nicaragua, both in the mainland of Rivas department and Ometepe island in the Lake of Nicaragua. Improved access to education and increasing integration of rural young people into nearby urban labour markets raise the question of the future role of plantain production in livelihood strategies and the demand for innovations in the medium and longer term. This study analyses the livelihood strategies and aspirations of different generations of plantain farmers and identifies their needs in terms of plantain production technologies and market strategies.

Data on livelihood strategies, plantain technology and demand for innovations was collected from 99 households of plantain farmers including young farmers (under 35 years), older farmers and their adolescent sons and daughters (the future generation). Results illustrate that plantain is the major component in livelihood strategies. A large majority of farmers wish their children to become farmers, and most of the young people consider plantain as a good option to make a living. Only slight differences were found in the asset base of older and younger farmers. However, compared to young and older farmers, the future generation reaches significantly higher education levels.

Major differences in assets and in the demand for innovations were found between the survey sites. In Rivas farmers have already intensified plantain production and are interested in improving irrigation systems. As major limitations, farmers in this area mentioned credit availability and high interest rates on capital. On Ometepe plantain productivity is much lower. Farmers feel constrained by a lack of knowledge about improved plantain production technologies. Under current poor infrastructure on the island, farmers perceive the use of modern inputs such as fertilisers as a first step for improving production. In general, there is only little awareness of possible marketing innovations among farmers of all ages in both survey sites, an option that might gain importance as the higher educated young people take over responsibilities on the farms.

**Keywords:** Different generations, innovation, livelihoods, Nicaragua, plantain

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## **Determinants of Integrated Pest Management Adoption: The Case of Mango and Citrus in Peru**

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Impacts of agricultural practices have been well documented by several studies. Dependency on chemical pest control has resulted in environmental contamination and detrimental effects on human health. In this context, Integrated Pest Management (IPM) appears as an option to reduce the negative impact of excessive pesticides use and to support the continuity of the agricultural system in the long term. Although IPM practices are considered as a friendly environmental management, the adoption is still poor by farmers. Previous empirical studies focused on identifying factors that affect adoption of IPM by farmers, explained that farmers' decision process of IPM adoption is influenced by technology, farmer characteristics, farm physical environment, farm institutional environment and historical conditions. In general, significant variables found in these studies are higher education levels and age of farmers, agronomic experience, higher household income, access to information sources, household size and size of landholding. Our main target is to explore attributes associated with farmers' decisions to adopt IPM practices in Peru. Using farmer level data from cross-sectional sample of 321 Peruvian farmers of mango and citrus (lemon, orange, and clementine), we propose a Logit model to analyse the impact of various variable categories (farmer and household characteristics, farm structure, plot characteristics, access to credit, markets and extension services, and institutional factors), on decision making process of IPM practices. Finally, from considering identified factors that affect IPM adoption, we aim to formulate policy recommendations about how to better promote adoption of IPM technologies to enhance livelihood in rural area as well as food safety for consumers.

**Keywords:** Adoption, chemical use, IPM, mango, rural development



## Biophysical and Socioeconomic Characteristics of Rural Homegardens in Gachsaran (Southwest of Iran)

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In order to infer biodiversity characteristics in sorely unknown Iranian homegardens, a multidisciplinary study was conducted in Gachsaran County (Southwest of Iran) during April to September 2008. Eleven villages including 5 villages inward Khamin mountainous protected area and 6 villages outside and around Basht town with a plain-hilly topography, were selected randomly and through interviewing 192 household heads and visiting homegardens, information on different biophysical and socioeconomic characteristics were gathered. Altogether 97 species were identified which only 33 species were found in protected area villages. Mean homegarden species richness varied between villages and was significantly less in protected area homegardens. Vegetables and summer crops were main components in protected areas homegardens, whereas fruit trees and shrubs were the main component in outside villages and ornamentals were developed more properly. Due to marginalisation of villages, lack of infrastructures and low linkages with urban centres, homegardens were less developed in protected area villages and vegetables were the main components for fulfilling necessary subsistence of households. Among social variables, age of household head and his/her education had not a significant relationship with homegarden species richness, whereas size to household had a significant positive correlation with species richness ( $Rp = 0.189$ ,  $p = 0.009$ ). Contribution of homegardening in rural household livelihoods was slight and varied averagely in villages from 0.71 % to 6.61 % of total livelihoods. Significant positive relationship between homegarden species richness and household income from homegardening ( $Rp = 0.414$ ,  $p = 0.000$ ) confirmed the role of diversification to improve economic and nutritional conditions of rural communities. Stepwise regression analysis showed that four variables including homegarden area, women decision making for ornamental plants, ratio of women activities in vegetable crops, and income from homegardening with explaining 66 % of variance, had the most relationships with homegarden diversity. Results revealed that along with more infrastructure facilities accessibility and more contiguity to urban centres, homegardens were developed more appropriately and increasing rural women activities in homegardening led to increase of homegarden biodiversity. More attentions should be paid to these vital components for developing sustainable and healthy livelihood of rural communities in Iran.

**Keywords:** Biodiversity, homegarden, Iran, rural livelihoods, sustainability

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## **Interrelationship Between Soil Conservation Decision and Farm Income: Evidence from Eastern Highlands of Ethiopia**

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Ethiopia is among developing countries that are reported to suffer severe land degradation problem. Land degradation is among the major problems creating a formidable threat to food security goals of the country. About 26 % of the land area in Ethiopia has been degrading over the years 1981–2003, directly affecting the livelihoods of 29 % of the population. It is estimated to reduce food production by at least 2 % and the national economy by about 1.0 billion US\$ per year.

Land conservation investments are necessary to increase crop yields, prevent degradation, and improve income. Conversely, improvement in income is believed to enhance investments on conservation activities indicating a reciprocal causation between the two. This causal link is related to the controversial notion of ‘downward spiral’ where poverty leads to degradation, and degradation to further poverty. Contrary to this notion, there is also an argument that the poor are not always to be blamed for land degradation.

This study uses data collected from a total of 211 households in Eastern highlands of Ethiopia and employed a Two-Stage Probit Least Squares to analyse how per capita income and adoption of stone terraces are interrelated. Whereas adoption of stone terraces positively affects per capita income, per capita income is not significant in affecting adoption of terraces. This means, there is no adequate evidence that the income reach is better in adopting land conservation practices as compared to the poor. Furthermore, per capita income is positively affected by fertility index of the plots, farm size, livestock holding, and proportion of perennial crops; and negatively by number of crops grown, age of the household head, dependency ratio, and involvement in off-/non-farm activities. Adoption of stone terraces, on the other hand, is affected positively by slope index, involvement in training, and level of education of the household head; and negatively by soil fertility index, land fragmentation, and proportion of female members of the household. Among important implications is that the issue of land conservation investment requires due attention in an effort to increase farm income and thereby ensure food security in the country.

**Keywords:** Ethiopian, land degradation, per capita income, terraces, two-stage probit least squares

## Herbaceous Multipurpose Forage Legumes in Central America – Status after 10 Years of CIAT Involvement

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For over a decade CIAT and partners have worked on the integration of herbaceous multipurpose forage legumes in smallholder mixed crop-livestock systems in the drought-prone regions of Central America. Chronic dry season feed shortages and declining soil fertility in the predominating maize-bean production systems with an increasing role of livestock have been targeted using participatory germplasm selection and development approaches. Due to their diversity and drought tolerance allowing farmers improved crop residue animal feeding and soil enhancement in time periods when land is not occupied with staple crops, herbaceous multipurpose legumes have emerged as the most promising options improving productivity as well as environmental and socio-economic sustainability. Symbiotic N<sub>2</sub> fixation improves soil fertility (replacing up to 60 % of fertiliser needs) and increases subsequent maize yields. Milk production increases by 20–30 % when supplemented to maize residues grazed by cows. Farmers recognise these positive effects. The focus for the coming years will be to scale results and to produce substantial amounts of seed with strong farmer involvement, and with a leading role of the national agricultural research and extension systems and other development partners.

While important progress has been made, there is still a lack of knowledge on how to manage the agronomy of these improved production systems at specific locations. More emphasis must be put on the generation of extension information to enable farmers to benefit from the full potential of these legumes, especially in the wake of the climate change impacts projected for Central America. There is also a continued need to identify and develop herbaceous legumes for grazing purposes, as well as for the recuperation of the large areas of highly degraded soils. Current available options are very limited.

In addition to their utilisation for ruminants, CIAT and partners engaged more recently also on research on the biophysical and socio-economic suitability of herbaceous forage legumes for monogastrics (especially pigs). This will offer new options - especially to small (female) farmers - to increase productivity and product quality while reducing costs.

**Keywords:** Animal feed, Central America, CIAT, drought-prone regions, green manure, herbaceous forage legumes

## Factors Influencing the Decision to Adapt to Climate Change: The Cases of two Wards in Rural Tanzania

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Tanzania is likely to suffer significant socio-economic and physical impacts from climate change. In Eastern Africa, climate change may reduce crop yields by 10-20 % to 2050, although in some zones losses are likely to be much more severe. People in the central eastern region of Tanzania already practice autonomous adaptation to climate variability, but this will be probably not enough to cope with the impacts of future climate change. Policy driven planned adaptation is necessary. Assessing effective adaptation practices, identifying obstacles for implementation of these practices and suggesting options to overcome them are prerequisites for planned adaptation.

The objective of this contribution is to assess factors influencing the decision of rural households in two Tanzanian administrative wards to adapt to climate change. One ward is disadvantaged in terms of food production and the other ward has a higher agricultural potential due to its biophysical characteristics. The assessment departs from identifying the socio-economic characteristics of the household in terms of land use, access to productive assets, education, training and income. The underlying hypothesis is that the adoption of micro-level measures for adaptation to climate change depends on households' perception of climate variability and change; household characteristics (*e.g.* access to credit, farming experience) and households' livelihood activities (the mix of crops and livestock *etc.*). The hypothesis is tested using quantitative data of 300 households in two wards of Tanzania. The household data is complemented by findings from focus group discussions with farmers in the two wards following the methodology of Rapid Rural Appraisal. Data was collected between May and October 2009 and in May 2010. The focus group discussions are analysed by means of a qualitative content analysis. The household data is analysed using descriptive statistics and statistic regression techniques.

The results show that households' vulnerability to climate variability and change is a function of demographic aspects, household assets, livelihood strategies and other factors. Effective adaptation policies need to take into account the heterogeneity of different household types.

**Keywords:** Adaptation, adoption, agriculture, climate change, household survey, livelihood strategies, micro-level practices, small-scale farmers, Tanzania, vulnerable groups

## **Migration Decisions of Rural Households in China: Do Household Demographics and Health Matter?**

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Given poverty, land scarcity and limited local off-farm opportunities, migration to coastal provinces plays an important role for the livelihood of rural households in South Western China. In this context, there is a likely interplay between household demographics and health which influence household's migration decisions. While people in the economically active age without dependents in principle can freely decide whether to migrate or not, those with children or parents in need of support are constrained in their choice. Migration of economically active household members, however, is facilitated by a division of labour within the household, with elder people taking care for children in order to allow young couples to migrate. In this regard, the health status of the grandparents' may affect their ability to participate in this kind of division of labour and determine whether they require support themselves, thus again being of crucial importance for the decisions on migration taken by the household. In order to explore the relationship between migration, household demographics and health a series of logistic regression models is applied to a household level dataset from Guizhou province, South Western China. Starting with a set of explanatory variables which capture, among others, numbers of children and elderly in the household as well as grandparents' health status, subsequent likelihood ratio tests are used to stepwise consolidate the model. It is shown that differentiating among children and elderly and taking into account the health status does not contribute to explaining the migration decisions. Rather, it is sufficient to capture the effect of household demographics on migration by the inclusion of the household dependency ratio as a single explanatory variable. It is suggested to check for robustness of the results reverting to the use of a panel dataset.

**Keywords:** China, Guizhou, health, household demographics, Logit model, migration

## **The Influence of Land Use and Credit Access on Rural to Urban Migration: A Case Study in Malang Regency, East Java, Indonesia**

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East Java as one of the national granaries has a very significant role to contribute to food security in Indonesia. Agricultural land in East Java is declining along with the increasing use of land for non-agricultural activities. Whereas the land ownership is a most important factor in increasing agricultural production, population growth led to polarisation of agricultural land, and to resulting inefficiencies of agricultural activities. Moreover, the structural transformation from agriculture to manufactures and service sectors entailed migration to urban centres and to abroad. Migration is a balancing process in which surplus labour gradually withdraws from the rural sector to meet the manpower needs in the urban sector. In East Java, it is a strategy for rural households to allocate their labour resources among different areas, to reduce the income risk and to increase total income. However, in the longer term, under the given conditions these strategies may cause a decline in agricultural production resulting from low investment in the farm sector. If this situation continues, food security in East Java will meet serious problems.

Agricultural sector performance may be enhanced by better credit access, as credit availability may increase investment in farm activities or related business in the rural areas. It can lead to higher productivity in the agricultural sector and thus increasing household income.

This study analyses the influence of access to land and credit on migration decisions. A survey among migrants or non migrants for primary data collection was carried out in Malang, East Java, Indonesia. For the data analysis a Probit model was used to investigate the factors that determine the probability of household head's decision to engage in migration depending on land ownership, credit access, indicator for social capital, physical capital and socioeconomic characteristics of households. The results suggest that land ownership and credit access have a negative and significant influence on the decision to migrate to urban areas. The results of the analysis are used to develop some policy recommendations with respect to the land use and credit access and reduction of out-migration from rural areas.

**Keywords:** Credit acces, food security, land use, migration

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## Rural Urban Migration and Agricultural Investment

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Out-migration of younger family members from remote rural areas to urban industrial centres in emerging South East Asian market economies is a process which has been going on for several decades already. This has led to changes in the resource endowment of agricultural households especially for labour. Generally the role of land as a source of wealth has decreased and livelihoods strategies have changed. This has resulted in the emergence of multi-location households where remittances have become an important source of rural income. While the role of remittances in supporting consumption of the rural poor has been subject of many studies it is less clear to what extent migrant purposively engage in agricultural investment in their natal villages. This paper is based on a representative panel data set on one of the poorest provinces in Northeast Thailand. Following a 3-stage cluster sampling design, a panel data set has been established with some 386 households in 2007 and 2008 from the province of Nakon Phanom, one of the poorest provinces in Thailand. The data were collected within the framework of the DFG FOR 756 at the University of Hannover. Expanding on rural household theory a model is developed that captures the role of the urban sub-locations of rural households. Applying a difference in difference model using matching techniques for establishing efficient counterfactuals, a household investment function is estimated with changes in agricultural asset endowments as a proxy variable. Results show that migrants' remittances are a major source of agricultural investments which suggests that livelihood strategies of household member who migrated to urban areas are still geared towards their natal base. A third panel wave is underway in 2010 with an investment module incorporated in the survey instrument. This will allow a more direct estimation of the investment function.

**Keywords:** Investment, migration, poverty, rural development

## **Rural Market Infrastructure and Impact on Rural Transformation: A Case Study in Northern Karnataka**

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Rural, periodic markets developed as a result of internal demand for exchange of goods and services among local communities are centres for exchange of common goods and services, in both cities and the countryside, all over the world. Held at a regular time and place, these markets link villages to small towns and their surroundings to create grassroots-level networking trade systems throughout the developing world. For impoverished and less-industrialised economies, periodic markets are the logical and appropriate places for peasant families to obtain goods and information. Though the development of rural markets plays an important role in improving socio-economic status of the rural community, it received least attention in many developing countries. In this context the present study was undertaken in northern Karnataka, India in order to analyse the impact of rural market infrastructure on rural livelihood, where rural market infrastructure was developed under various government schemes. The results indicated that the composition of the rural markets differs across the region and the participation of small farmers (60 %) is high. Majority of the traders participating in rural markets were from outside (82 %) and were found to move across different rural market, thus establishing strong linkage across the markets. The farmers who sold their produce in infrastructure developed markets were found to realise higher income compared to no infrastructure developed markets. The development of rural markets has also resulted in marginal change in cropping pattern in respect of fruits and vegetables. In majority of the markets, the farmers participation in planning of the rural markets development activity was found to be influenced by their income. Age and family size of the farmers had significant effect on farmers participation in rural market infrastructure development.

The results indicate that development of rural markets has certainly benefited rural community in general and farming community in particular. However, the infrastructure maintenance is very poor even though the local government authorities collect revenue from the markets. The policy makers need to focus on development of rural market and should consider the importance of stake holders involvement, periodicity, timing, location and maintenance of these markets.

**Keywords:** Periodic markets, rural infrastructure development, rural markets, rural transformation

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## **Taking Institutions Seriously: Interdisciplinary Perspectives on Rural Development in Kakamega District, Kenya**

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Despite being the backbone of the economy of most sub-Saharan African countries, rural regions are often peripheral not only in terms of space, but also in terms of inclusion into the realms of national economies and institutions. The development of a rural economy very much depends on growth in regional income and in the volume of goods and services produced, processed and traded. In case of Kakamega District, western Province, Kenya neither agriculture nor most non-farm activities were so far able to secure sustainable rural livelihoods, leaving over half the population living below the poverty line. Interdisciplinary research undertaken between 2004 and 2010 revealed several constraints inhibiting further rural development: restricted non-agricultural income opportunities; incongruence in spatial and economic planning; and weak sector linkages. One of the underlying reasons seems to be a neglect of institutions promoting economic development and governing rural livelihood activities; thereby wasting existing potentials of village communities. As quantitative as well as qualitative research has shown, participatory planning processes, a strong focus on training and capacity building (especially for non-agricultural activities), and strengthening the role of rural traders might provide necessary links to overcome some of the structural weaknesses. In line with this, economic analysis together with spatial planning methods paved the way for successfully introducing new livelihood activities in three selected villages; encompassing bee keeping and zero grazing. Our case studies provide useful insights into how application-oriented research in which local level initiatives is linked to government and non-government institutions prepare the ground for further discussions about reconciling the needs of rural households with sustainable resource management and other overarching development objectives.

**Keywords:** Institutions, Kenya, rural development



# Rural development - Poster session II

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## **Is Beekeeping a Viable Additional Income for the Rural Poor? Economic Analysis of Beekeeping and Honey Hunting as Income Alternative in the Philippine Cordillera**

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Modern beekeeping with the European honeybee (*Apis mellifera*) was introduced to the Philippine Cordillera as part of rural livelihoods supporting programs that aimed to substitute traditional honey hunting, a practice that is alleged to have a negative impact on the environment. Based on this premise, a capacity building framework that is exclusively dedicated to the apiculture of *A. mellifera* has been established in this region, and therefore the potentials that the native bee endowment offers for the reduction of rural poverty has been neglected. Moreover, the exoticness of the European honeybee has added prohibitive costs to the already expensive adoption of its apiculture, which has excluded the rural poor from adopting it.

This study aims to assess the viability of beekeeping and honey hunting practices, involving introduced and native bee species, as additional income alternatives for the rural poor in the Philippine Cordillera.

Five setups for the economic exploitation of bees were identified to potentially be adopted by rural smallholders in the study area, namely the apicultures of *A. mellifera* and *A. cerana*, honey hunting of *A. dorsata*, the meliponiculture of *Trigona* spp. and hive baiting for *A. cerana*. The former four were assessed and compared based on a cost-benefit analysis and a subsequent risk analysis, while the latter was subject to a qualitative analysis, due to the lack of sufficient data.

The results confirm that investing in the apiculture of *A. mellifera* involves relatively high costs, of which approximately 61 % are attributed by this study to the exoticness of this species to the Philippine Cordillera. An additional socio-economic appraisal that this study carried out on the honey hunters of this region suggests that these individuals would not be able to afford a substitution of this activity for modern beekeeping. On the other hand, the results show that the setups that involve the economic exploitation of native bee species have great potentials to be adopted as low-cost additional income sources, especially if they could participate in the infrastructure and other benefits that are offered by the organisations and institutions that currently support beekeeping of *A. mellifera*.

**Keywords:** Beekeeping, cost benefit bnanlysis, honey hunting, Philippine Cordillera, rural poverty alleviation

## **Interrelation of Intensification Processes and Externalities Within the Value Chain of French Bean Production: A Case Study of Nakuru District, Kenya**

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Since the 1960s, Kenya has been exporting high value crops like French bean to European markets. By the end of the 1990s European consumers started to ask for high quality produce and steady annual supply of fresh products. In order to meet these changes in demand actors along the value chain intensified their processes. In literature the development of French bean production in Kenya is widely discussed, however, intensification processes within the value chain, and resulting environmental and socio-economic externalities, here understood as unintended positive as well as negative side effects are missing in this debate.

Therefore, this study project analyses driving forces of intensification processes and relations and influences among the actors of the French bean value chain. The objective of this project is: to assess the complexity and organisation of the French bean value chain in the Nakuru district, Kenya, focusing on intensification processes and related externalities.

The value chain approach is applied, in order to get a comprehensive view on the organisation of the entire value chain within the case study area. All relevant actors of the chain have been identified by an in-depth literature review and a two-week field trip. Results of this study project are based on 14 semi-structured interviews with mainly open questions in the Nakuru district. The field results (1) give an insight in the actual value chain of the study area and (2) discover new interrelations concerning intensification and related externalities.

The French bean value chain in Nakuru is very complex in its relations and dependencies with tendency to vertical integration, despite the fact that fewer farmers are producers than expected. Direct causalities between intensified French bean cropping and environmental externalities such as decreasing soil fertility can hardly be identified. Socio-economic externalities are mainly positive, e.g. increase in living standards. On the one hand consequences for women are positive due to new employment possibilities while on the other hand due to cropping of French bean an increase in their workload is very likely. Finally, the export-rejected beans are available on local markets and therefore, are an additional ingredient in Kenyan dishes.

**Keywords:** Externalities, farmers, French bean, intensification process, rejections, value chain, women

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## Contribution of Endemic Ruminants to Farmers' Livelihoods in The Gambia

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Endemic ruminants in The Gambia, represented by the N'Dama cattle and Djallonké breeds of sheep and goats, are well adapted and productive in areas infected with trypanosomiasis. Despite these favourable attributes their contribution to farmers' livelihoods remains not well recognised. The present study characterises the specific functions they fulfil in smallholder crop-livestock production systems in the districts of Kiang West, Niamina East and Niani in The Gambia.

We collected data in nine randomly selected villages of the three purposefully selected districts. Following a Participatory Rural Appraisal (PRA) approach, two-day group discussions were held in each selected village, comprising between 25 and 30 participants, among which cattle, sheep and goat owners, livestock product processors and vendors, herders and non-livestock owners. PRA tools used were resource mapping, wealth ranking, matrix ranking and scoring.

The wealth ranking revealed that livestock ownership was distributed in a highly skewed manner across wealth categories in all districts, especially for cattle with rich households owning 20 times as many cattle as poor households. Cattle were ranked first as the species contributing the most to farmers' livelihoods, because of the multitude of their services, such as draught power, manure, milk, meat and transportation. Goats and sheep were considered very important regarding their contribution to cash income; small ruminants were more important to women than men. Cattle were scored the highest for savings and insurance. Sheep and goats were also kept mainly as a means of saving and insurance; income and ceremonial purpose were the next reasons for keeping these species. The importance of saving and insurance depict the role of endemic ruminants as a buffer to crop failure in these mixed farming systems, where the most important contribution to the farmer's livelihood was crop farming, followed by livestock rearing and forest product harvesting. Given the predominance of endemic breeds, no comparison could be made with the livelihood contribution from exotic breeds.

**Keywords:** Endemic ruminants, livelihoods, participatory rural appraisal

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## **Propensity-score Matching as Tool to Assess the Income Effect of Jatropha Plantation Work in Rural Madagascar: A Case Study**

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This study assesses the potential impact of wage work generated by a local Jatropha plantation on household income in rural Madagascar. The cooperating Jatropha plantation is located in central Madagascar at the district of Ambalavao, province Fianarantsoa. Since the plantation was installed it demands hired labour for plantation expansion and maintenance independent of the local growing seasons. The calculation for the average income effect is based on data derived by a socio-economic household survey undertaken by the authors in 2009. To assess the average income effect we apply a propensity score matching analysis, as working for the plantation is not randomly assigned and we therefore have to deal with bias generated due to self-selection into participation. In a first step we predict the participation of households into working for the Jatropha plantation using a logit model with the binary outcome participation or non-participation. Via introducing 32 independent variables covering household characteristics of 336 randomly selected household from three villages in the vicinity of the Jatropha plantation we reach to correctly predict participation or non-participation of overall households at 73.8 %. In a second step we compare the income per person for households which participate and for households which do not participate. This comparison uses the calculated propensity score as one-dimensional indicator for multidimensional household characteristics. Due to this we are able to match households which participate and households which do not participate with special regard on their household characteristics and therefore come to an unbiased estimate for the income effect. The results after applying Nearest Neighbour matching without replacement and caliper 0.13 show an average treatment effect for participating households of 93,008 Ariary per person (ca. € 33) and an average treatment effect across the whole sample of 37,950 Ariary per person (ca. € 14) during the last 12 months. The reduction of standardised bias reached 68.5 % with regard to applied matching method.

**Keywords:** Impact assessment, Jatropha, propensity score matching

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## **Factors Affecting Household Incomes among Integrated Agriculture Aquaculture Farmers in Malawi**

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Malawi is ranked as one of the poorest countries in the world with more than 50 % of the households living below the poverty line. In response to the poverty situation, the Malawi government in collaboration with non-governmental organisations (NGOs) have been implementing several poverty reduction programmes in an effort to arrest poverty and achieve the Millennium Development Goals (MDGs). Integrated Agriculture Aquaculture (IAA) is one of the poverty reduction strategies being promoted by developing countries where farming systems involve the cultivation of crops, fish and livestock by one farmer and usually on the same piece of land. While efforts to promote IAA date as far back as the 1980s in Malawi, the adoption by farmers remains low. Furthermore, there is limited published literature on the potential socio-economic and environmental sustainability and social acceptability of IAA.

Statistical analysis was done by using RESTORE (a research tool for natural resource management) and SPSS software packages and genstat. The result on the whole farm analysis showed that the average income per household was 102,000 Malawi Kwacha (MK) for non-IAs and MK 98,000 (when the exchange rate was MK 140.00 to \$1) for IAA which was not significantly different. The average total cost for fish production alone was calculated as MK 11,708.80 per household while the average total revenue was MK 5,254.86. This gives the gross margin of MK 2,589.86 from fish alone and hence a contribution of 5 % percent to total household incomes. This is not a good result because most of the adopters are still struggling. The study established that there market accessibility and price are the ones affecting revenues from fish sales. In addition, different areas experience different temperatures. This has a very big impact on the decomposition of pond inputs that are necessary for the survival of fish. Conflicts over water in some districts were reported where non-adopters claim that the diversions of water from the main channel to the ponds reduce water quantity and that the use of manure and other pond .

**Keywords:** Genstat, integrated aquaculture agriculture, monitoring evaluation, recycling

## **Economics of Different Farming Systems- Impact on Income, Nutrition and Health Security**

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Indian agriculture is dominated by large number of small holders with scattered fragmented holdings. Lack of adequate capital for investment has been the major constraint contributing to the decline in growth of agriculture. The consumption basket in India is changing towards high value agriculture due to rise in income, urbanisation, changing tastes and preferences of consumers. Thus, the move is towards diversification of agriculture with high value commodities such as milk, meat, fish, fruits and vegetables. In view of risk and uncertainty in agriculture especially of high value commodities, adoption of farming system approach integrating rising of crops, livestock and agro-forestry has become important and been an effective strategy for Indian farmers. This would internalise the complementarities of all the natural resources to realise high productivity, sustainability, profitability, better nutrition and low cost of production. With this backdrop, efforts were made to analyse the farmer's strategy to mitigate the predicament in south eastern dry zone of Karnataka. The main focus of the study was to analyse the economics of different farming systems and its importance in enhancing the nutrition of rural households and impact on income with an emphasis on finding out the gap in nutritional security and inequity in general. Personal interview method with farmers was followed to collect the primary data using pre- tested questionnaire. The data was analysed using measures of central tendency and regression analysis. Results have indicated that diversified farming system (agriculture+ horticulture+ sericulture+ livestock) was found to be one of the best alternative solutions in upliftment of rural economy in terms of income levels and nutritional status.

**Keywords:** Farming systems, health, income, Karnataka, nutrition, regression

## **Social Impacts of the Government Forest Protection Program on Local Households in Terms of Livelihood in Western China**

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Forest has been used as one of the important sources for local livelihood in China for generations. The utilisation is especially common in mountainous regions in Western China, where the areas are economically poor, large areas of forests are preserved, and local communities are isolated and solely relying on forests for livelihood. As implementation of the Natural Forest Protection Program (NFPP) since 1998, a large part of forests have been conserved with severe restrictions for commercial use. The impacts of the NFPP on local livelihood are unclear.

Research objectives are (1) to review the local forest-dependent livelihood (*i.e.* household income derivation, expenditure and labour time distribution) before the NFPP; (2) to observe current livelihood after the NFPP; (3) through comparison to understand impacts of the NFPP on local livelihood; (4) to suggest strategies for a better harmonisation between local livelihood and NFPP implementation.

Research is approached through a case study design. Four villages with a total number of 175 respondents were selected for field surveys where questionnaires, interviews and group discussions were employed. Quantitative and qualitative social research methods were used for data collection and analysis.

Research shows that the NFPP has directly impacted local household income and work structures, led households shifting from sole dependence on forests to new and better paying household income sources, such as migration work in towns or cities for alternative livelihood; the contribution of forestry incomes became less important to total household income and other income sources provided more lucrative. The NFPP negatively impacted households with increased costs for cooking and heating, while it positively affected households by freeing up time once used to collect fuel wood, allowing for better paying jobs that more than compensate for additional energy costs. The NFPP has also resulted in redistribution of household labour time, with less time spending on forest related activities and more freed up time on migration work. Attribution gap between the NFPP impacts and other possible influencing factors are discussed. Recommendations refer to a better implementation of NFPP to mitigate the negative impacts and for a sustainable forest management in different regional contexts.

**Keywords:** Forest protection program, livelihood, social impact assessment

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## **The Impact of Poverty Reduction Strategy Paper in Promoting the Agricultural Sector and Enhancing Farmers' Incomes in Rural Mozambique**

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Poverty reduction strategy papers (PRSP) are well known approaches adopted to help poor countries and their development partners strengthen the impact of their common efforts on poverty reduction. But what is the effect of PRSP in reducing poverty? Do PRSPs stimulate growth in the agricultural sector? Do they improve calorie availability from farmers' own production? Do they improve household incomes? On these questions, there is surprisingly little empirical evidence. In this paper, we look at the case of Mozambique, based on data from seven nationally representative household surveys between 1996 and 2008.

Mozambique has missed the overarching goal of reducing poverty in its PRSP II. In particular, it has failed to increase agricultural production and productivity through the promotion of agrarian services. The paper relies heavily on descriptive analysis, and some regression analysis. Many indicators set in PRSP II were not fulfilled, namely its irrigation target, access to price information and agricultural extension, availability and access to improved seeds and fertilisers. In addition, after significant improvements between 1996 and 2003, calorie availability from farmers' own production, used as a proxy of food security, deteriorated in the period to 2008. Income distribution has become more unequal, and poverty has worsened in the six years to 2008.

Rural poverty is intrinsically correlated with produced calories, and fluctuations on agricultural production due to vagaries of the weather raise additional questions. Was the remarkable reduction in rural poverty observed between 1996 and 2002 a permanent change in poverty, or just a transitory change? Will Mozambique achieve the MDG of reducing poverty if the cropping season of 2014/2015 is not favourable? If vagaries of the weather are driving most of the changes in rural poverty, then what are the farmers' prospects with the threats of global warming?

The next generation of PRSP should place higher priority on reducing household vulnerability to the weather, increasing irrigation where feasible and water harvesting/conservation technologies, expanding agricultural extension, and increasing the technological level of small farmers.

**Keywords:** Food security, poverty, Mozambique, trends on caloric availability

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## **The Impacts of Dairy Policy on Bangladesh and EU15 Dairy Farmers' Livelihoods**

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The milk price of the dairy enterprise is the single factor that plays a tremendous role in dairy farmers' income and livelihoods. The historic low price of milk in 2009 has significantly affected million's of dairy farmers' livelihoods all over the world. The dairy policy played a significant role in lowering the milk price. In responding to this issue, IFCN has conducted case study on how this policy affect milk price and affect the rural livelihoods both in Bangladesh and German Typical dairy farmers. Therefore, the aim of this paper is to describe the dynamics of the dairy markets. The impacts of reduction of national milk price on both Bangladesh and EU 'dairy farmers' livelihood is analyzed. A special focus is given on policy instruments like tariffs and export subsidies for dairy products. This project applies the methods developed by International Farm Comparison Network (IFCN). This method uses the concept of 'Typical' farms and utilises the TIPI-CAL model. The results shows that the re-introduction of EU export subsidy policy (5 € per 100 kg skimmed milk powder) in 2009 decrease world milk price by 2.5 € per 100 kg. The results also show that the dairy farm income in Bangladesh has decreased by 43 % and farm household income decreased by 7 %. Due to this, approximately 7 million people in Bangladesh and 0.45 million people in EU are suffering. From this study, it is concluded that the future dairy policy implications might focus on general welfare of both local and international perspectives to improve the dairy farmers' livelihoods.

**Keywords:** Bangladesh, dairy policy, EU15, livelihoods

## **Problems and Challenges in Attaining Millennium Development Goals towards Universal Primary Education, Gender Equity and Women Empowerment in Nepal**

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The eight Millennium Development Goals (MDGs) have been set to be achieved by 2015. Though Nepal has endorsed the Millennium Declaration to follow the global agendas of MDGs only five out of 75 districts have prepared their district level MDG progress reports. Nepal still remains one of the poorest countries with per capita income of US\$ 388 per annum, HDI 0.534, wide income disparities, large gender gap, and poor access to basic needs and social services by a large section of the population. The literacy rate was 53.7 % with high disparity between men (65.1 %) and women (42.5 %). Nevertheless, the primary school enrolment rate increased with an average annual growth rate of 3.5 % between 2003 and 2008, with increases especially marked in the district Hill by 6.2 % and in the district Terai by 4.3 %. About the empowerment of women, a visible but partly symbolic step has been forwarded that brought 33 % of women in the Constituent Assembly in 2008 but in grass-root level organisations women are still lagging behind.

The present study was conducted in two districts (Hill and Terai) of Nepal. The study aims to find out the problems and challenges in attaining MDGs 2 and 3 viz: universal primary education, gender equity and women empowerment. The primary data was collected by interviewing 400 respondents, focus group discussions and consultations with the key informants. Secondary data were obtained from relevant to the issues under consideration. Data were analysed with help of SPSS. The school drop out rate was as high as 82 % Hill as compared to that of 18 % in Terai. Major causes identified were lack of money, early marriage and family support by children. In general, women have no role in the social, cultural, and economic decision-making which varies from regions, culture and social settings. Major problems and challenges in achieving MDGs is the decade long political conflict that was coupled with people's inability to pay, linguistic differences, and caste and cultural differences. In addition, policy and implementation gaps and lack of monitoring were found to be other critical issues.

**Keywords:** Millennium Development Goals, primary education, women empowerment

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## **The Comprehensive Africa Agriculture Development Programme (CAADP): Hype or Real Chance to Push Africa's Agriculture Forward ?**

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The Comprehensive Africa Agriculture Development Programme (CAADP) has become the major economic initiative of the African Union (AU) and the New Partnership for Africa's Development (NEPAD) to combat poverty. It is the organisational implementation of the Maputo declaration by African Heads of States and Government in 2003 to devote 10 % of government budgets for agriculture. It has developed principles, instruments and processes to implement CAADP at the national and regional level. While CAADP has seen a very slow and difficult start, since 2009 it has gain tremendous impetus, particularly since the decision of the United States and some other donor countries to de facto link its support to African agriculture to the existence of country-owned, CAADP approved national programmes.

This presentation tries to find answers to the question whether CAADP can live up to the expectations it has raised. It does so by analysing its (still emerging) institutional set-up, the capacities of the actors involved, but also by understanding their expectations and interests. It is based on two studies. One analysed during 2007–2009 the implementation of the CAADP in selected countries (Kenya, Ghana, Uganda) and compared it with autochthonous national agricultural policy cycles. The other is ongoing and is based on document analysis and in-depth interviews with stakeholders and observers of CAADP at the trans-national level.

The studies finds huge differences between rhetoric and implementation, between aspiration and capacities, and between the expectations of different stakeholders. However, it also concedes that there is now a strong learning process in place, that capacities may accelerate with the implementation of the CAADP Multi-Donor Trust Fund if wisely applied, and that CAADP has a window of opportunity to make the difference in improving African agricultural policy processes and outcomes.

**Keywords:** Africa, agricultural policy, CAADP, political economy

## **Sub-catchment Management Plans – A Contribution to Sustainable Natural Resources Management**

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The relevance of Sustainable Natural Resources Management in rural areas of developing countries is increasing due to ongoing and non-reversible anthropogenic degradation and local as well as global induced climate change. The MDGs for poverty reduction request consequent change of natural resource management in order to meet the needs of rural populations. Moreover, sustainable natural resources management is closely linked to integrated watershed management (IWM) - as IWM emphasises a holistic approach with focus on catchment conservation and stakeholder participation. Thus IWM is also seen as one major basis for enhancing food security. Water Sector Reform Programmes in Eastern Africa are addressing the need for setting up institutional frameworks for the development of Catchment Management Strategies (CMSs) and Sub-catchment Management Plans (SCMPs). New laws, such as the Kenyan Water Act 2002, emphasise long-term sustainable utilisation of natural resources.

In Kenya, SCMPs were drafted in cooperation with German and East African Universities, the Water Resources Management Authority (WRMA) and Water Resources User Associations (WRUAs). Participatory approaches, practical field and seminar work as well as the interaction of human capacity at different educational levels, such as from universities, ministries and local stakeholders led to successful drafts of SCMPs in several sub-catchments in Kenya. SCMPs were developed within 'on-the-spot' seminars that incorporated all major aspects of IWM. Challenges of a changing environment, of population growth, biomass change, soil degradation, water pollution and increased water and energy scarcity were addressed in the SCMP. Focus was set on field mapping within the given watersheds (70 to 150 km<sup>2</sup>) and the perceptions of the local stakeholders.

Annual monitoring and evaluation reflected that the successful implementation of a SCMP is strongly linked to the active support and level of education of local stakeholders, financial means of the WRMA as well as the overall understanding of the relevance and benefits of IWM. Thus, the seminars for drafting the SCMPs not only addressed the management challenges of the institutional and local frameworks, but also emphasised a common understanding of sustainable integrated watershed management.

**Keywords:** East africa, integrated watershed management, natural resources management, sub-catchment management plan, water sector reform

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# **Sustainable management of natural resources under climate change (GTZ/DEZA session)**

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## Mongolia - Pasture Ecosystem Management Project (Green Gold)

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Mongolia's pastureland, which accounts for four-fifths of the country's 1.5 million square kilometre area and is the backbone of rural economy, is not in good shape. Experts estimate that 70–80 % of pastureland is degraded. While climate change is thought to be a contributing factor, overgrazing is the primary cause, and this has primarily been due to the opening up of access to pastureland after the 1990 transition which saw pasture go from being a state-controlled resource to a common resource.

The Green Gold Project focuses on fostering collective action among herders to enforce a community based regulated and controlled use of their common pastures. The main approach being taken is facilitating the formation of Pasture-User Groups (PUGs) comprised of herders who have received the right to manage pastures in their traditional grazing areas by the local government. This includes designating seasonal pasture rotations and developing technical and organisational pasture-management plans. PUGs are autonomous bodies supported by local governments, and receiving technical advice and financial support for their start-up. PUGs support and link two interests of herders; long term interests of preserving their pastures and short term interests of earning decent income to sustain their livelihoods. Herder communities have embraced the concept, and there has been a growing demand for assistance to form such groups.

In Khovd Aimag (Province), in Western Mongolia, the process of forming and institutional development of PUGs is well advanced so that at Soum (District) level PUGs have come together as an association and negotiated Soum pasture management plans. To be able to regulate and control open access grazing and in the future hopefully also to limit animal numbers, this process is planned also at Aimag and later at national level.

Furthermore, a more sustainable use of Mongolia's pastures also results in increased carbon sequestration. A pre-feasibility analysis indicates that the PUG system has an immense potential for soil carbon sequestration and that through the international carbon market additional incomes could be generated for Mongolia's herders.

**Keywords:** Collective action, mongolia, pasture management, tenure rights, tragedy of the commons

## Climate Change - A Challenge for Agriculture

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As one of the most climate-sensitive sectors, agriculture is under pressure to reduce greenhouse gas emissions and develop sustainable adaptation strategies to counterbalance future impacts of climate change. Estimations show that agricultural productivity in developing countries will decrease substantially due to climate change. It is therefore imperative to identify and institutionalize mechanisms that enable the most vulnerable farmers and local communities to cope with climate change impacts. At the same time agriculture is contributing substantially to greenhouse gas emissions, particularly methane and nitrous oxide.

Consequently, the agriculture division of GTZ (German Technical Cooperation) considers agriculture in this dual role. The programme NAREN (Sustainable management of resources in agriculture) carried out by GTZ on behalf of the BMZ (German Ministry for Cooperation and Development) promotes sustainable agriculture as an answer to adapt to climate change but also to mitigate greenhouse gas emissions and therein supports resource efficient production methods. To enable farmers to adapt to climate change further essential areas of action of the GTZ are support to and/or capacity development for:

- effective water management, including *e.g.* water harvesting methods as well as small scale irrigation;
- agricultural research to strengthen capacities for the analysis of climate impacts and the development of adaptation techniques such as adapted seed varieties;
- development and application of micro-finance and -insurance systems in rural areas to provide an additional safety net.

An example for the successful implementation of participative development of adaptation measures is AdapCC ([www.adapcc.org](http://www.adapcc.org)). This Public-Private Partnership (PPP) by the British Fair-trade company Cafédirect and GTZ supports coffee and tea farmers in developing strategies to cope with the risks and impacts of climate change. The farmers are affected by heavy rains, increasing temperatures, or less rainfall because their plantations are often in poor conditions. In many cases they have neither access to technical or financial support nor the capacity to strategically confront future challenges. The main output of this joint three years PPP project was that selected producer groups have created examples of how to strengthen their capability to cope with the impacts and risks of climate change and how to improve their access to respective financial and technical support mechanisms.

**Keywords:** AdapCC, adaptation, agriculture, BMZ, climate change, GTZ, mitigation

## Knowledge Management and Decision Support for Sustainable Land Management

HANSPETER LINIGER, GUDRUN SCHWILCH

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Much research has focused on desertification and land degradation assessments without putting sufficient emphasis on prevention and mitigation, although the concept of sustainable land management (SLM) is increasingly being acknowledged. A variety of SLM measures have already been applied at the local level, but they are rarely adequately recognised, evaluated, shared or used for decision support. WOCAT (World Overview of Technologies and Approaches) has developed an internationally recognised, standardised methodology to document and evaluate SLM technologies and approaches, including spatial distribution, allowing the sharing of SLM knowledge worldwide. The recent methodological integration into a participatory process allows now analysing and using this knowledge for decision support at the local and national level.

The use of the WOCAT tools stimulates evaluation (self-evaluation as well as learning from comparing experiences) within SLM initiatives where all too often there is not only insufficient monitoring but also a lack of critical analysis. The comprehensive questionnaires and database system facilitate to document, evaluate and disseminate local experiences of SLM technologies and their implementation approaches. This evaluation process - in a team of experts and together with land users - greatly enhances understanding of the reasons behind successful (or failed) local practices. It has now been integrated into a new methodology for appraising and selecting SLM options. The methodology combines a local collective learning and decision approach with the use of the evaluated global best practices from WOCAT in a concise three step process: i) identifying land degradation and locally applied solutions in a stakeholder learning workshop; ii) assessing local solutions with the standardised WOCAT tool; iii) jointly selecting promising strategies for implementation with the help of a decision support tool. The methodology has been implemented in various countries and study sites around the world mainly within the FAO LADA (Land Degradation Assessment Project) and the EU-funded DESIRE project.

Investments in SLM must be carefully assessed and planned on the basis of properly documented experiences and evaluated impacts and benefits: concerted efforts are needed and sufficient resources must be mobilised to tap the wealth of knowledge and learn from SLM successes.

**Keywords:** Decision support, knowledge management, participatory, SLM, stakeholders

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## Biodiversity and Sustainable Land Management in Namibia

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Namibia's unique landscapes and biodiversity are invaluable assets attracting thousands of tourists each year and earning substantial revenue for the national economy. Besides the value for tourism, biodiversity is essential for maintaining production systems, food security, income generation, and the provision of ecosystem services. However, natural resources and ecosystems are under substantial pressure by unsustainable land-use practices, deforestation, overstocking, habitat destruction and uncontrolled development reducing income possibilities of the population in the long term. As an arid country Namibia is depicted as highly vulnerable to the impacts of climate change which aggravate the effects of existing human-induced stresses on ecosystems. The Namibian government has not yet been able to create, to a sufficient extent, the support framework necessary for the sustainable management of natural resources.

The "Biodiversity and Sustainable Land Management Project" supported by the German Government through GTZ is implemented in cooperation with the Namibian Ministry of Environment and Tourism (MET). It aims to improve the legal and institutional framework to promote the sustainable management of natural resources by public and private users. The project focuses on (i) the improvement and implementation of selected statutory frame conditions, (ii) strengthening of MET's capacity and service delivery, and (iii) the addition of value to biodiversity by means of biotrade and bioprospecting. The presentation describes important achievements and illustrates how the project supports all four dimensions of capacity development to strengthen Namibian partners to develop, implement and oversee sustainable natural resource management practices: through system development, cooperation and network development, organisational development and human resources development.

**Keywords:** Biodiversity, biotrade, capacity development, environmental policy framework, natural resources management





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