

# Tropentag 2009

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

## **Biophysical and socio-economic frame conditions for the sustainable management of natural resources**

### Book of Abstracts

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# Preface

The TROPENTAG 2009 has moved to a new location, the city of Hamburg in the very North of Germany, thereby expanding the geographical range and the number of central European universities annually hosting the TROPENTAG in an alternating sequence.

This expansion underlines the success of the earlier TROPENTAG congresses, which have been hosted by Göttingen, Berlin, Hohenheim, Bonn, and Witzenhausen.

Therefore, the TROPENTAG 2009 follows the successful concept of the preceding congresses by offering an interesting arena of exchange for a wide range of participants, interested in development-oriented research in the fields of food security, natural resource management and rural development in tropical countries, in an institutional support environment including traditionally BMZ, GTZ/BEAF, ATSAF, the Eiselen-Stiftung, the DAAD and the DFG.

The range of participants includes students, junior and senior scientists, development practitioners, funding institutions, and media. The number of registered participants once again expanded with presently 973 registered participants from 76 countries, 133 oral presentations and 378 posters.

Besides the continuation of the traditional main topics, each TROPENTAG also should have a specific theme. Hamburg is a city with one of the longest histories as a trade city, starting in medieval times and based strongly on trade of spices and many agricultural products from tropical countries, brought by overseas vessels into the harbour and subsequently distributed to the hinterland and the Baltic sea via the Elbe river and a system of channels and land corridors. These trade relations early led to first research activities focused on tropical agriculture. In fact, an early anatomical institute created to evaluate the value of spices and other products for the merchants later became the cradle for the University of Hamburg.

Still today, the harbour of Hamburg is strongly linking the city with tropical countries and agricultural topics. It is based on this background, that recently a Museum for Economically Used Plants (Museum für Nutzpflanzen) has been established in the Loki-Schmidt-Haus at the Botanical Garden of the University of Hamburg, at Klein

Flottbek. Similarly, Hamburg also early became aware of the socio-economic frame conditions in the tropical countries. Important institutes dealing with Africa, Asia, Latin America, a UNESCO institute, the UN Tribunal for the Law of the Seas are just a few institutions at Hamburg dealing with socio-economic aspects of resource utilization in tropical countries. Furthermore, Hamburg is a hot spot of research of climate change and land use change.

Therefore, we found it adequate to choose the general theme “Biophysical and Socio-economic frame conditions for the sustainable management of natural resources”, in order to focus not on tropical agriculture and forestry only, but to also and strongly look at the rapidly changing environmental and socio-economic frame conditions which are impacting on tropical agriculture and forest management, and which probably will have even more impact, in not too distant future.

The expected demographic growth from now over 6 bn to ca. 9 bn humans on Earth during the next 4 decades will drastically increase the exploitation of natural resources for agricultural purposes. Furthermore, the use of land for food production will compete with a variety of other increasing needs, amongst these the growth of megacities, of transport infrastructures, the production of energy plants, etc..

Due to this development, we also expect that in the future land use can serve as a tool to buffer or mitigate effects of climate change or other environmental change. In any case, land management will need to be improved and optimised in order to keep the dwindling ecosystem services upright which are the basis for agricultural production and human welfare. The implementation of such new intensity of management will also be a major challenge for socio-economic disciplines, with regard to governance and institutions. We hope that the accentuation of these topics will generate a very interesting congress.

In this short preface we also would like to include our sincere thanks to all the many helpers and supporters who made the congress possible. Especially the experience of the ATSAF team and the logistic skills of the colleagues at Witzenhausen, *Christian Hülsebusch* and *Eric Tielkes*, were of immense value.

Our very special thanks with regard to planning the congress at Hamburg go to *Barbara Rudolph*, who during many months pushed the planning processes and kept the communication upright, to *Semra Ünsal*, who with great energy negotiated for the challenging logistics and the financial feasibility, to *Annegret Saphir*, who communicated with almost each single participant and convinced many companies and institutions to contribute a wealth of funding and sponsoring and to *Mariam Akhtar-Schuster*, who added many inspiring ideas to the design of the scientific program, to

*Rolf Bergmann*, who set up the IT support at Hamburg and to *Carsten Schmechel*, for the financial management.

And there are the many helping hands, who make such a big meeting logistically possible, by doing all the many practical steps which cannot all be described: *Daniela Abele, Allmuth Andres, Sabine Baumann, Wibke Berg, Detlef Böhm, Michael Brose, Martina Brumm-Scholz, Monika Bunge, Karen Dehn, Jürgen Dengler, Birgitte Doormann, Niels Dreber, Georg Gössler, Elisa Grätschus, Dariusz Gryschka, Daniela Haarmeyer, Ulrike Hermes, Desiree Huthmacher, Andrea Jounais, Amely Klein, Sylvia Kröger, Andrea Krohn, Jutta Krüger, Sabine Kruse, Silke Kuchenbecker, Pina Lammer, Claudia Mählmann, Heidrun Meyer, Monika Meyer, Sibylle Mixdorf, Jan Möller, Volker Nölting, Julia Nowack, Jens Oldeland, Imke Oncken, Simone Pampel, Monika Petersen, Dietmar Pierschel, Ursula Reinitz, Florian Rink, Azazi Rqibate, Inga Röwer, Marko Saggau, Isolde Scheffner, Judith Scheja, Carsten Schmechel, Sabrina Schmidt, Renate Schneider, Bent Schubert, Bernd Spitz, Caroline Stolter, Dagmar Swenson, Ole Theisinger, Caroline Thiem, Reiner Unseld, Esther Verjans, Anne-Marie Vogt, Renate Wegener, Dirk Wesuls, Jochen Wollschläger, Arnhild Woltmann, Sören Ziehe.* We would like to extend our sincere thanks to all of you.

We wish all participants a most interesting and rewarding conference and a pleasant stay in Hamburg.

Hamburg, September 2009

Jörg Ganzhorn  
Michael Köhl  
Reinhard Lieberei  
Norbert Jürgens



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# Desertification, sustainable management and global observatories

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# Socioeconomics of desertification

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## The Potential of Drylands Observatories to Contribute to Sustainable Dryland Development

ELENA MARÍA ABRAHAM

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The need for consensus on dryland development models valuing the contributions of science is discussed. We briefly set out the desertification problem in developing countries, options for dryland development models, and the need to translate knowledge into concrete measures, pointing out that science should be the basis for decision-making, giving priority to the role of Observatories. This presentation is framed within strategic goals of UNCCD regarding the reinforcement of its Committee of Science and Technology (CST) and the new role that knowledge generation must play in decision making. Emphasis is laid on the need to work with Benchmarks and Indicators (B&I) at all levels. The state of the art is presented for all Annexes, and a set of impact indicators in compliance with UNCCD's 10-year strategic objectives. For these goals to be accomplished, continuity, robustness and homogeneity of data collection and processing must be guaranteed. The potential of national and international observatories is analyzed, ensuring their permanence to enable them to contribute assessment and monitoring systems and constant surveillance to generate early alert systems. Observatories can add value to national databases, scientific collections (biodiversity, soils, climate, land use, etc.) overcoming problems of data collection and processing and information gaps. Strategies are put forward to incorporate local communities and governments into integrated assessment processes. International and national experiences are presented: the OSS (Sahara and Sahel Observatory), the Gobabeb Training and Research Centre in Namibia, and Ñacuñan Biosphere Reserve in Argentina. Opportunities posed by the Global Network of Dryland Research Institutes and the World Network of MAB Reserves are discussed.

**Keywords:** Dryland development models, observatories

## Implementation of a Web-based System for Predicting Soil Fertility Constraints in Africa Using Infrared Spectroscopy

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Information on soil fertility constraints is needed to target soil management recommendations especially for improved agricultural production in sub-Saharan Africa. Case studies in many parts of the world have shown the potential of soil infrared spectroscopy for predicting functional soil properties. However, there are few examples of this fast, cheap and reliable technique being implemented in routine soil analysis. Calibration equations work well under local conditions but soils are a very complex mixture of widely varying inorganic and organic materials and new calibrations have to be built or extended when moving to new locations with different conditions. An alternative approach is to collect continental or global soil spectral libraries, which cover a vast variety of soil conditions and to centralise the work of building calibration libraries. This has been attempted over the last five years at the World Agroforestry Centre (ICRAF) in Nairobi. A network of five near-infrared spectrometers is now being established throughout sub-Saharan Africa, which will collect new soil spectra and be supported by ICRAF's central laboratory, which will provide global calibrations. This approach needs attention in respect to (i) standardised sample labeling, sample pre-treatment and scanning procedures within and across labs, (ii) efficient data storage and transfer, (iii) spectral variable reduction tools for efficient calibration with big data sets, and (iv) regression tools which deal with non-linearities in soil spectral data. Solutions for all these steps for an African soil spectral library are presented. Moreover, one approach is introduced, which deals with the representation of the uncertainty of soil property predictions based on infrared spectra. Finally, the principles of a web-based soil constraint prediction service for the ICRAF satellite infrared labs are presented and the implementation outlined.

**Keywords:** Data reduction, infrared spectroscopy, soil constraints, sub-Saharan Africa, web-based prediction service

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## **International Agreements for the Conservation and Sustainable Use of Biodiversity — with Special Emphasis on the Convention on Biological Diversity (CBD)**

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Although there are several international agreements for the conservation and sustainable use of biodiversity in place, this article focuses on the UN-Convention on Biological Diversity (CBD) since it is the most comprehensive agreement in this field - as its objectives, its scope, and the number of Parties to the Convention are concerned. Please have a look at the full paper for more information.

**Keywords:** Biodiversity, Convention on Biological Diversity , conventions

## Rural Poverty and Soil Degradation: Some Evidences from a Land Reform Settlement in the Brazilian State of Goiás

ALCIDO ELENOR WANDER<sup>1</sup>, CLEYZER ADRIAN CUNHA<sup>2</sup>, MARIA IZABEL DOS SANTOS<sup>2</sup>, RODRIGO DA SILVA SOUZA<sup>2</sup>, AGOSTINHO DIRCEU DIDONET<sup>1</sup>

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In different continents there is a paradigm of a vicious circle of poverty and depletion of natural resources. Some authors however found that this vicious circle does not exist. Thus, the central objective of this study was to analyse the relationship between rural poverty and soil degradation in land reform settlement in the Brazilian Center West region. Therefore, farmers belonging to the Cachoeira Bonita land reform settlement in Caiapônia (GO, Brazil) were interviewed via questionnaire. The data was analysed through an econometric analysis of the probit model. Our hypothesis was that environmental degradation can worsen the rural poverty in the farm enterprises. The binary and dependent variable was the adoption of crop rotation as soil conserving practice. As independent variables that explain the probability to occur ( $y=1$  or  $y=0$ ) we considered the total (agricultural and non agricultural) income, the total herd size of cattle, the land ownership and the education level of farmers (years of school visit). We expected positive signs for all estimated coefficients in the probit model, i.e. the higher the values of independent variables the more likely the conservation practice (crop rotation) to be adopted. The estimated model was significant at 5 % level. The independent variables explain 50.41 % (McFadden R-squared) of the variation in the probability of adoption of crop rotation in the farms. Three of the independent variables had negative signs: total income, herd size and land ownership, meaning that increasing the values of those variables decrease the probability of the adoption of conservation practices. This result evidences an opposite relationship between rural poverty and environmental degradation. On the other side, the education level of farmers was positively related to the likeness of adoption of soil conservation practices. Thus, there is no relationship between rural poverty and soil degradation in the case of the land reform settlement of Cachoeira Bonita, in Caiapônia (GO, Brazil). However, there is a clear positive relationship between the education level of farmers and the likeness of adoption of soil conservation practices.

**Keywords:** Crop rotation, land reform, soil erosion

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## **The Impact of Desertification on Welfare Positions of Farmers: The Case of Konya-Karapınar / Turkey**

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Desertification is defined as “land degradation in arid, semiarid and dry subhumid areas resulting from various factors, including climatic and human activities”(UNCDD, 1995). “Degradation implies reduction of resource potential by one or a combination of processes acting on the land. These processes include water erosion, wind erosion and sedimentation by those agents, long-term reduction in the amount or diversity of natural vegetation, where relevant, and salinisation and sodication” (UNEP, 1992). In addition to these processes, there are many causes of desertification. For examples, these are over-cultivation poor soils, over-grazing by animals on fragile rangelands, excessive cutting of fuelwood in dry lands and inappropriate irrigation practices that results salination of agricultural land.

Although experts define and search the causes and indicators of desertification, it is important to reach how desertification affects on farmers from a sociological view of point. The main purpose of this paper is to discuss and evaluate how desertification affects on the living standard and welfare positions of farmers in Konya-Karapınar/Turkey. In this presentation, it will be shown the socioeconomic features of the families and their welfare position in terms of their saving, depth, and livelihood. Moreover, it will discuss how they evaluate their welfare situation. It is seen that in addition to structural condition, desertification have an enormous impact on the impoverishment of farmers. This paper depends on the research that was conducted in Konya Turkey in 2007. The data was collected from 150 women and 150 men who are farmers. Both qualitative and quantitative research methods were applied in this research. The research form that is applied in this research process consists of structured, semi-structured and open-ended questions.

**Keywords:** Desertification, impoverishment, socio-economic dimension, Turkey, welfare position of farmers



## **Sustainable Rangeland Management under Conditions of the Namibian Land Reform — Simulation Based Identification of Sustainable Strategic Patterns**

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The ongoing degradation of savannah ecosystems due to maladapted rangeland management has significant long term ecological and economic consequences. In many parts of Africa, like in Namibia land tenure has been and will be reorganised as a consequence of political changes. This in turn may significantly influence land use strategies. In our study we aim at identifying sustainable land use strategies for savannah rangelands. Specifically, we are searching for general sets of adaptive rules describing the reaction of land reform beneficiaries to rainfall, vegetation dynamics and animal condition, so that the outcome of land use meets economic and ecological requirements.

For our analyses we used a model framework that is built upon an eco-hydrological vegetation model which simulates the dynamics of the natural resources (namely water and vegetation) as a function of climatic conditions and land use impacts. By dynamically linking a vegetation model, which features the up-scaled dynamics of the eco-hydrological model, to an economic model we are able to include and test decisions of land users and land use strategies. Key triggers for decision making and management patterns were identified in a survey, where our ecological-economic model was used to conduct role-plays with Namibian land reform beneficiaries. This data in combination with information from interviews is used to parameterise our model to properly reflect the situation of resettled farmers. We ran simulations, in order to compare current management strategies resulting from two different land reform measures with possible alternatives and classical commercial strategies. We analyse whether, when and to what extent the land users should react to main factors such as precipitation, vegetation dynamics, animal condition and financial situation.

**Keywords:** Ecological-economic model, land-reform, rangeland management, savannah, sustainable land use



# Monitoring and assessment of desertification

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## **Fog Farming: Linking Sustainable Land Management with Ecological Renaturation in Arid Areas by Means of Reforestation**

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There is plenty of water in one of the driest regions on earth. At vast stretches of South America's Pacific coast below the equator, dense fog is a common phenomenon and has been used for water production since the 1980s. This paper presents the results and the outlook of a pilot project on periurban agri- and silviculture in Peru using fog as a water source. The project is set in the coastal hills (span. "Lomas") that used to be a self-maintaining ecosystem when the hills were still forested. The trees collected the fog water and irrigated themselves; weeds and bushes also profited from this effect, the surplus water fed wells. Once the trees were cut the natural water cycle was interrupted and today the Lomas resemble a desert. A source for irrigation of tree saplings is the bottleneck for a renaturation of the Lomas. However, structurally improved  $4 \times 8$  m fog collectors produce up to 2.500 liters per day in the area. During the first year of the project this water was used for the irrigation of a pioneer grove on the hilltop as future natural fog collectors and as the initiation of the recovery of natural Loma water cycles. During the second year the water was used for family horticulture and a plantation of 700 Tara (*Caesalpinia espinosa*). After one year, the hilltop trees had reached a mean height of 148,7 cm and thus had grown independent of irrigation by covering their water demand by their own fog collection. By April 2009, the Tara plantation had reached a mean height of 98,7 cm and is expected to give a first harvest by 2010. A key to the successful implementation was the high commitment of the community that volunteered over months on Sundays in the construction of reservoirs and the maintenance of the installations and plantations. People valued fog collection and reforestation uphill as a water supply for cash crops, other villages took the initiative to copy the project. An increase of natural vegetation at the project site entails the assumption that locally the natural water cycles can be restored.

**Keywords:** Climate change mitigation, fog farming, poverty alleviation, renaturation, water cycles

## Spatial Extrapolation of Biomass Measurements in Savannah Ecosystems by Means of Remote Sensing

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Information on biomass is crucial for different stakeholder communities, e.g. farmers, scientists, politicians, etc. This is especially valid for the vast semiarid savannah ecosystems on the African continent, but data is often not available and / or not spatially explicit. We present a study on the estimation of grass and shrub biomass of Namibian savannah ecosystems using a non-destructive life-form specific sampling approach. In 2006 a biomass survey in two savannah ecosystems in central Namibia was performed, a dwarf shrub and a thornbush savannah. After species-specific regression equations were generated, grass biomass was measured using a Disc-Pasture Meter; shrub biomass was estimated by applying volume calculations on simple in-situ measured shrub parameters such as diameter and height. Afterwards, information on cover was used to scale species-specific biomass up on the level of vegetation relevés. In-situ gathered biomass data were then related to multi- and hyperspectral remote sensing data information in order to achieve a spatial map of grass and shrub biomass. This information consisted of different vegetation indices, such as the normalised differentiated vegetation index (NDVI) and soil adjusted versions of this index (SAVI, TSAVI, MSAVI, etc.). Furthermore, biophysical indices representing cellulose and lignin content of the vegetation canopy were derived from hyperspectral data. We are confident that this workflow offers a way for the combination of simple field measurements, that are relatively easy repeatable, with the power of different satellite systems. The difference between the two sensor systems, the multispectral system Landsat and two hyperspectral sensors (HyMap, CHRIS-Proba) will be highlighted during the discussion.

**Keywords:** Hyperspectral, Landsat, NDVI, remote sensing, savannah, sensor types

## Assessment of Land Cover Change in Chieng Khoi Commune, Northern Viet Nam by Combining Remote Sensing Tools and Historical Local Knowledge

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In Viet Nam, upland areas are the dominating land form providing natural resources for all kinds of human activities and playing a crucial role in rural development. With increasing population, market access and economic development, forest and traditional swidden agriculture systems were converted into tree plantations and continuous maize cropping systems during the past decades. Watershed-wide effects of land use intensification have been reported to affect agricultural productivity and thus human livelihoods in positive and negative ways. Research at plot level has been conducted, but upland-lowland interactions such as erosion, siltation and macronutrient fluxes still remain poorly understood. This study was carried out within the SFB 564 Uplands Program and generated part of the data base for an integrated modelling approach on up- and lowlands biophysical connectivity in Chieng Khoi commune, Son La province, Northwest Viet Nam.

Due to limited availability of remote sensing data, a hybrid approach of satellite imagery and participatory methods was chosen to obtain spatially explicit and continuous information on land use history. Satellite images taken from 1993, 1999 and in 2007 were classified as reference points in time. Ground truthing included collecting GPS points along plot boundaries and farmer interviews of land use during those years covered by the satellite images. Missing ground truthing points in the past were complemented with land use history obtained from interviews for geo-referenced plots. Additionally, land use reports from commune committees, local soil maps and cropping rules were employed to reconstruct land use history over the last three decades. Crop yields associated with land uses over time were complemented through individual interviews with experienced local farmers. At landscape level information on land use history was obtained during transect walks and group discussions.

Land use maps obtained during this study will serve as input data of cropping systems development for the Land Use Change Impact Assessment (LUCIA) model to assess the impacts and consequences of land use cover change at landscape level on system productivity and environmental services. In addition, crop productivity levels under the given land use trajectory will serve as validation data sets for inverse modelling of soil fertility.

**Keywords:** Historical knowledge, land use/cover, satellite images, Viet Nam

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## The Desertification Paradox — Decreasing Degradability with Increasing Aridity in Semi-arid to Arid Rangelands

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In the context of the BIOTA Maroc project, we installed a transect of permanent plots on the southern slopes of the High Atlas, Southern Morocco. The transect covers a precipitation gradient from semiarid to arid ecosystems and was assessed annually since 2001. Using a pair-wise enclosure design, we observe the vegetation dynamics on dry steppes with and without grazing. Assessments are based on population censuses and measurements at individual level. The shifts in species composition and increasing differences in standing biomass between grazed and excluded plots over time are used as indicators for the intensity of degradation due to actual land use intensities.

With increasing aridity, we find decreasing differences in species composition and standing biomass. At the arid test sites below the 100 mm isohyet, species composition fluctuates according to annual precipitation pattern but does not show significant differences between fenced and grazed plots. With increasing mean annual precipitation, interannual fluctuations of species composition decrease but long term shifts in vegetation composition gain in importance. Vegetation increasingly differs between inside and outside the fences. After eight years of enclosure at semi-arid sites, the standing biovolume (as a proxy for standing biomass) strongly exceeds the biovolume at grazed reference plots.

Using the difference between enclosed and grazed plots as a degradation measure, we can conclude that semi-arid ecosystems in Southern Morocco are more prone to desertification caused by firewood cutting and overgrazing than arid ecosystems. Finally, we discuss the underlying ecological and socioeconomical processes of what we call the “desertification paradox” of dry rangelands and their consequences for sustainable land management.

**Keywords:** Enclosure experiments, monitoring, Morocco



## Severe Goat Grazing Alters Soil Seed Bank Characteristics and Regeneration Perspectives in Southern Arid Namibia

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High stocking densities and a lack in regimentations preventing a sustainable land management are the main driving factors determining the widespread degradation of communal rangelands in Namibia. Most often land degradation is exemplified by associated processes such as the expansion rate of bare land, the loss of soil stability or changes in above-ground vegetation. However, to describe the rangeland condition more precisely the condition of the soil seed bank should also be taken into account. By this not only information on potential below-ground degradation is gained, e.g. the composition of current seed reserves, but also on the recovery and restoration potential of disturbed habitats. The present study addresses the long-term effect of high grazing pressure on soil seed bank characteristics at a degraded communal rangeland in southern Namibia's shrub savannah as opposed to an adjacent reference site under sustainable land management. Soil samples were collected in contrasting microhabitats differing in their ability to trap seeds, and germination experiments conducted. Plant species composition, species richness and seed densities of the soil seed bank were significantly affected by grazing intensity, microhabitat, and sampling year. In general, seeds showed a clumped spatial distribution within the study sites, except seeds of perennial grasses, which showed to be randomly distributed on the degraded site. Further under shrub canopy seed banks were most species rich and contained highest seed numbers, while bare ground seed banks provided only limited seed material. Although highest seed densities per m<sup>2</sup> were found throughout all microhabitats on the degraded rangeland, the seed bank lacked favourable plant species occurring under low grazing pressure. While the seed bank of the reference site contained a high number of valuable fodder plants, the seed bank of the degraded site was dominated by two annual, generalist plant species of low grazing value only. It is argued that the seed bank of the communal rangeland could play a minor role in ecological restoration only if the aim is to improve the site. The study shows evidence for below-ground degradation taking place after decades of over-utilisation, and highlights the implications for rangeland restoration seed bank studies can provide.

**Keywords:** Degradation, land management, rangeland restoration, savannah, seed densities, species composition

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## Improving Community Response to Droughts

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Assessing decades of humanitarian action for pastoralist communities in East Africa, major actors appraised their intervention as predominantly ineffective. In recurrent droughts, each year more people in arid lands got affected by malnutrition, loss of livestock assets, and subsequently, loss of their livelihood system. VSF developed a framework for community drought preparedness in East Africa that is essentially community based and considers driving forces in pastoralist communities. The programme carried out since beginning of 2008 in Karamoja (Uganda, Kenya), Oromiya (Ethiopia, Kenya), and in the Somali ecosystems aims to enable the pastoralist communities to respond effectively and in an integrated manner to recurrent droughts. Pillars of the ECHO funded programme contain:

- 1) Elaboration and endorsement of community based preparedness plans by area authorities and the establishment of effective early warning networks to ensure an increased ability of communities to respond to droughts
- 2) Increased livelihood security through decreased conflict and increased sustainable access to dry season grazing and water
- 3) Protection of key livelihood assets through the establishment of private support systems and alternative sources of income for direct beneficiaries.
- 4) Compilation and dissemination of lessons learned to development partners and communities.

VSFG uses a participatory approach in designing and implementing its interventions in the areas of operation. Communities are engaged directly through open forums and committees in which all members are given the opportunity to decide on the support and intervention.

The communities elaborate resource maps in which essential features as seasonal fluctuation of resources, conflict prone areas, migration routes, settlements, etc are indicated. With assistance of these maps, the community based knowledge, but as well the technical expertise of the team, strategic and holistic interventions are planned and conducted. This results in more efficient use of grazing and water resources.

Recently developed tools such as reciprocal grazing agreements, pastoral field schools (PFS) and village community banking (VICOPA) have been evaluated as successful media for drought preparedness options.

We observed strong ownership by the communities of established water points, livestock pharmacies, community based animal health services, VICOPA initiatives, PFS, early warning systems and peace committees.

**Keywords:** Community based animal health services, pastoral field schools, reciprocal grazing agreements, village community banking

## GIS Based Gap Analysis as a Tool for Biodiversity Conservation Optimisation: The IITA Cowpea Collection

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Cowpea (*Vigna unguiculata* (L.) Walp.) is an important grain legume cultivated in most tropical and some temperate regions. It is one of the most widely adapted, versatile grain legumes of high nutritious value. Cowpea production across Africa accounts for approx. 91 % of world output. Cowpea has an impact on nutrition as valuable protein source and livelihoods of small scale farmers and plays a key role in the life of many people, especially in developing countries. The International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, holds the largest cowpea germplasm collection worldwide. Many literature sources cite that biodiversity is constantly diminishing and exposed to different hazards accelerating the speed of biodiversity loss. To avoid future losses of cowpea genetic diversity it is important to assess the cowpea accession collection at IITA to get an overview about the current conservation status and to guide future sampling.

For the present study a gap analysis is an evaluation technique to estimate the degree of coverage of already sampled regions, to identify regions that need additional sampling and those where no collections have been performed yet. First the country coverage of georeferenced cowpea accessions was estimated. Then ecogeographical site descriptors (temperature, precipitation, length of growing period, altitude) were extracted to determine areas with environmental conditions favoured by cowpea. Afterwards regions with similar environmental conditions were identified by using GIS techniques to predict areas where the possibility of filling gaps in the collection is most likely.

Furthermore, this study used the spatial analysis tools FloraMap<sup>TM</sup>, Homologue<sup>TM</sup>, ArcGIS<sup>TM</sup> and DIVA-GIS to identify potential areas for future conservation activities of cowpea.

The geographical scope of the present study was focused on sub-Saharan Africa. Results indicated that cowpea can be found approx. between 15°N and 20°S. With respect to new collections main focus should be put on countries where so far no collections have been done, but where the spatial analysis showed high probability of encountering cowpea — Burundi, Eritrea, Equatorial-Guinea, Guinea-Bissau, Namibia and Rwanda respectively. In countries with few georeferenced accessions, existing nongeoreferenced passport data need to be complemented or new sampling should be carried out.

**Keywords:** Biodiversity, cowpea distribution, *Vigna unguiculata*, GIS, FloraMap<sup>TM</sup>, gap analysis, genetic conservation, Homologue<sup>TM</sup>

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## West African Plant Database: A Photo Guide and Identification Tool

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The West African Plant Database, a new website currently including > 5000 photographs of > 1000 West African plants is presented. It shall serve as an internet photo-database as well as an identification help. The photographs can be accessed via browsing a hierarchical list of taxa and / or searching for specific morphological characters. For this identification aid a total of 18 characters regarding flower, fruit, habit, and leaf are encoded. You will then receive a result page with species names and up to three thumbnail images chosen to best represent the taxon. By clicking on either of them you get to the species page with all available images and further information plus links to internet databases. These are chosen to enable the user to retrieve further information on taxonomy, biogeography, use and its existence in preserved botanical collections (herbaria). The photographs are presented with taxon, locality information, time and photographer and an email-link for feedback and requests. The digital photographic documentations are a result of extensive field studies in the course of the BIOTA-West Africa and the SUN project. The photographed taxa are identified by experienced scientists. This website will be accessible for anyone interested in the plant diversity of West Africa. Currently the focus is on the the drier parts of West Africa (Sahelian and Sudanian zones) comprising the countries Burkina Faso, Benin, Cameroon, Ivory Coast, Niger, Nigeria, Gambia, Senegal etc. An offline version is available for fieldwork and researchers in the partner countries with insufficient internet connection. Please visit [www.westafricanplants.senckenberg.de](http://www.westafricanplants.senckenberg.de) for more information.

**Keywords:** Plant database, herbaria, plant photos, West Africa

## Establishment of a Hydrological Monitoring System through a Participatory Approach in a Small Tropical Catchment in Tanzania: Learning Hydrology from the Local People

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A hydrological monitoring system is necessary to analyse the hydrological system of a catchment, determine model parameters, provide input and validation data for rainfall runoff models and as tools for investigating impacts of climate change and land use options on water balance. Hydrologic monitoring networks in research catchments are typically established in remote areas where few or no people live. This leads to the risk of theft and vandalism. Thus, local stakeholders should be involved in the design and construction of the networks and in the subsequent monitoring. In the “Resilient Agro-Landscapes to Climate Change in Tanzania” (ReACCT) project, the Wami/Ruvu Basin Water Office (WRBWO), Sokoine University of Agriculture (SUA) experts and village authorities in the project area were involved and participated in establishment of a hydrologic monitoring network in the Ngerengere catchment within the Morogoro Region in Tanzania. First DEM, land use and soil maps were used to identify potential monitoring sites. Local and expert knowledge was collected on flow regime, indicators of shallow ground water plant species, precipitation pattern, vegetation and soil types. This knowledge was integrated and used to site a network of ten hydrologic monitoring plots for vegetation and soil surveys and locations for installation of automatic weather stations, automatic raingauges, river flow gauging stations, flow measurement sites and shallow ground water wells. This approach provided the opportunity for both the experts and local stakeholders to gain insight into the hydrological regime of the catchment which was the basis for determining the locations of the hydrologic monitoring system in the catchment. Local knowledge proved to be very important in site selection of hydrologic monitoring systems. Furthermore, there was complementarity on the roles of stakeholders in accomplishing this task where the local knowledge was integrated with the expert knowledge. Integration of local and expert knowledge in catchment monitoring and integration of new monitoring systems with existing systems helps to instil the sense of ownership and identify best sites for the hydrologic monitoring.

**Keywords:** African catchments, climate change impact assessment, hydrologic monitoring, participatory approach

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## **Biomass and Carbon Stocks Inventory of Perennial Vegetation in the Chieng Khoi Watershed, Northwest Viet Nam**

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With climate change being unequivocal, reducing CO<sub>2</sub> in our atmosphere has become a primary goal of international efforts. Scientific evidence shows that terrestrial vegetation can be a source or sink of carbon. In order to assist local and international stakeholders in decision-making precise primary data is needed to validate and further develop tools to quantify carbon stocks in various landuse systems. The overall goal of this study therefore is to fill the gap of lacking accurate primary data needed for model parameterisation in order to improve estimates of biomass and carbon stocks of perennial vegetation. Representative perennial landuse systems in the mountainous Chieng Khoi watershed Son La province, North West Viet Nam will be evaluated. For direct measurements within each selected area, a nested plot design according to Hairiah *et al.* (2001) will be used. For follow-up studies each plot will be mapped using GPS. Aboveground biomass parameters of trees will be measured non-destructively according to the allometric based fractal branch analysis. Parameters of shrubs and perennial grasses will be sampled destructively aiming to develop generic allometric equations for subsequent biomass estimation models. Belowground biomass of grass and shrub vegetation will be sampled destructively taking soil core samples with a root corer estimating root weight densities. In addition leaf area and ground cover will be measured with a LAI 2000 to estimate the potential of different landuses to reduce soil erosion. For information on landuse type and management, local farmers will be interviewed and local cadastral maps will be reviewed. The main objective of the study will be to establish a biomass and carbon stock inventory of the perennial vegetation in the Chieng Khoi watershed. In addition, allometric equations based on stem diameter or stem area shall be generic and applicable in twinned watersheds of the SFB 564 Uplands Program. Thus this study helps to improve modelling approaches to estimate biomass and carbon stocks of the terrestrial vegetation, and contributes to identify land use types as well as management recommendations, that concurrently lead to ecological and economical benefits for local farmers and international stakeholders, seeking possibilities to reduce CO<sub>2</sub> emissions.

**Keywords:** Carbon stocks, fractal branch analysis, inventory, land cover change, land use change, perennial vegetation

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## Simulating Consequences of Land Use Change on Hydrological Landscape Functions and Sustainability of Crop Production in Northwest Viet Nam

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The Northern Mountainous Region (NMR) of Viet Nam has undergone rapid land use changes in the past that shifted the traditional swiddening farming system to less sustainable continuous annual monocropping systems. This study aimed at assessing effects of rapid expansion of maize and rubber (*Hevea brasiliensis*) plantations in Tat hamlet watershed, Hoa Binh province, North Viet Nam, as response to increasing market demand. Effects of land use change on crop production and water balance were assessed over a 20 years simulation period using the Land Use Change Impact Assessment (LUCIA) tool, a spatially explicit dynamic watershed-crop model based on the PCRaster platform. The model was parameterised using four years of field data from the traditional swidden shifting cultivation system, collected by the Centre for Agricultural Research and Ecological Studies (CARES) from the study area and calibrated for crop yields and watershed functions using one out of the four year dataset. The results were validated against the remaining datasets (3 years) to verify model plausibility. Impact of land use intensification was investigated using four possible model scenarios. The first and second scenario considered agricultural intensification as expansion of maize with / without application of fertiliser, respectively. Upland forests were assumed to be largely converted to maize lands under these scenarios. The third and fourth scenario dealt with introduction of rubber plantations in the uplands by converting forest lands, with / without undergrowth to mitigate surface run-off. Runoff, stream flow and plant available water were assessed as components of the water balance. Total biomass production per hectare was simulated for the vegetation in the area. Agronomic yield per hectare for each crop type was also calculated for consecutive years to evaluate changes over time. Each of these parameters was simulated at test points along Local Drain Direction and at the watershed outlet. The interlinkage between uplands and lowlands was assessed based on the impact of land use change on crop production and the aforementioned hydrological functions. The findings under each of the scenarios were compared with the baseline situation and recommendations were made for sustainable management of essential watershed functions in the area.

**Keywords:** Crop production, landscape modelling, landuse change, rubber, water balance

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## Monitoring Spatio-temporal Dynamics of Land Cover/Use in the Gum Arabic Belt of Kordofan, Sudan by means of Remote Sensing and GIS

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Land cover/use change is a necessary step for an interdisciplinary research involving climate, ecological and socioeconomics drive and the process and response of change. The research was carried in Kordofan State in Sudan, which is situated in the gum arabic belt. The belt is situated at latitude between 12° and 14° N and covers one fifth of the Sudan area. The vegetation cover is dominated by *Acacia senegal*, which is regarded as sustainable in terms of its environmental, social and ecological benefits. The objective of this study was to classify, investigate and analyse the land cover/use dynamics over 35 years in the gum arabic belt using supervised image classification and vegetation indices. Multi-temporal MSS (1972), Landsat TM (1985), Landsat ETM+ (1999) and ASTER (2007) data has been utilised to analyse the historical vegetation changes. Five land cover/use classes were extracted by remote sensing classification after the image pre-processing such as geometric correction and registration. A change matrix was created in order to map the land cover/use changes from 1972 to 2007. The results indicate that the forest dominated by *Acacia senegal* class covers 23.12 %, while bare and farm land, grass and bush land, mixed woodland and residential area classes cover 16.65 %, 48.32 %, 10.17 % and 1.73 %, respectively. From 1999 to 2007, a considerable recovery and improvement in land cover in the gum arabic belt was observed, due to the good rainy seasons. The study concluded that, using the traditional *Acacia senegal*-based agroforestry as one of the most successful forms of natural forest management in the gum belt will give successful land cover/use recovery.

**Keywords:** GIS, Gum arabic belt, land cover use, remote sensing, Sudan



## Assessing Rural Land Resources through Spatial Analysis for Rural Development: A Case of Dieng Plateau, Central Java-Indonesia

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The development of upland agriculture in South East Asia has caused direct impact on degradation of rural resources and socio economic where attitudes toward primary activities have been shifting to inadequate and over use of natural resource. The condition of natural resources particularly land is affected by both natural factors (physical environment) and land use decision of the responsible families while the resource base is influencing and limiting the economic activities.

In Indonesia where most of the potentially arable land has already been utilised, input intensification on crop land has reached up it technical or even economic limits. On the other hand, population growth has also been influencing the increasing demand on agricultural land and consequently changes non productive land such as forest land into cultivated land. High level demand on agricultural land in upland area is usually followed by land clearing in some steep slope areas where land need to be extended to fulfil the scarcity of land in term of production activity. Therefore, further soil degradation thus becomes the central issue of concern in study area since deforestation has been taking place as well as high population pressure in marginal areas.

This study has been conducted in Dieng Plateau region -one of important upland farming region in Central Java Province, Indonesia. The purpose of the study is to analyse land use-cover change during certain period and to assess the potential of soil loss regarding land use-cover change. As the first step of analysis, land classification with different period of Landsat images (1991 & 20101) has been employed through the remote sensing processing. Furthermore, spatial analysis of Geographical Information System (GIS) was applied to asses the quantification of land use-cover change and soil degradation in study area. The result shows that forest area has been degraded more than 50 % from 1991 to 2001 and about 450 ha of study area have been shifted to the very high category of potential soil degradation.

**Keywords:** Geographical information system, Indonesia, land use-cover change, satellite images, soil degradation

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## The Study of Temporal Variations of the Cropping Period in North-Khorasan, Iran

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Climate change affect crop production. Especially in arid and semi arid regions, the undesirable environmental factors can be intense, inducing a low crop sustainability. The climatological factors, especially temperature affect plant growth and due to climate change, the temperature extremes change. Iran has arid and semi arid climate throughout the country. In order to help the farmers in the North-Khorasan province optimising their cropping period (planting time and harvesting time), this research was carried out.

One of the most important reasons for crop damage in this nort-eastern province is chilling. In this study, the dates for the begin and the end of the growth season were obtained by using Growing Degree Days (GDD) and the probability of the first and last freezing date for five synoptic stations (Bojnord, Qochan, Golmakan, Mashad and Sabzevar). The probability levels used were 75% and 95%. For this paper, two main crops were chosen: wheat (*Triticum aestivum* L.) and corn (*Zea mays* L.). The GDD was calculated for wheat and corn on the bases of 5 and 10 centigrade degrees, respectively.

With the calculated GDD the best planting and harvesting time for these two crops were determined and maps drown using GIS for this province. With this information and the maps, farmers in North-Khorasan can correct their planting and harvesting time. For example, the suggested planting and harvesting dates for wheat and corn in Bognord (main city in the North-Khorasan province) are: Wheat- planting: Sep. 23, harvesting July 20 and Corn: planting: May 28- harvesting: Sep. 3.

**Keywords:** Cropping period, GIS, growing degree days, maize, wheat

## Drought Monitoring by Using Remote Sensing Technique in Iran

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Iran is a country located in the arid and semi arid regions. In these regions natural disasters cause a lot of social and economical problems. Drought is such a disaster. Although this event takes place all over the world, it's intensity and force has nowadays increased. This phenomenon can be related to climate change. Drought is a complex natural event. A universally accepted definition does not exist. It is acknowledged that the major causes of drought are a lower than average rainfall. Due to the wide impacts of drought conditions on Iran in recent years, it looks necessary to apply monitoring techniques to measure these impacts on the affected regions. Also, this can help to come up with an optimum risk management during severe drought conditions. Recent research around the world suggests that the best method for this aim is the application of remote sensing techniques. In this paper these methods are explained, in particular reflective remote sensing, such as NDVI (Normalized Difference Vegetation Index), VCI (Vegetation Condition Index), MVCD (Maximum Value Composite Differential) and MVCI (Monthly Condition Index). With these indexes a number of maps were produced that visualise drought conditions in Iran. Further, the drought conditions for the years 1998 to 2000 could be forecasted for various regions of Iran.

**Keywords:** Drought assesment, monitoring, remote sensing, NDVI, vegetation index



# Climate change, carbon, soil and water

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# Socioeconomic aspects of resource management

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## Soil as a Water Resource for Food Security

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For decades the natural resource soil has received less attention than its counterpart water. This is unjust since nearly all the fresh water that is used by nature and humans comes from the soil. Soil is the best storage medium for water to overcome dry spells; it takes 1 liter of water to produce 1 kcal of energy in human food and most of this water comes from green water stored in the soil. Plant production suffers because water is not available due to deteriorated physical properties of the soil. Water scarcity and drought in Africa are often an indirect result of land degradation rather than a rainfall anomaly due to climate change. Where soil productivity is low and food security at stake, Green Water Use Efficiency (GWUE) is low. In sub-Saharan Africa GWUE is very low, only 15 % of the terrestrial rainwater is used by plants for the production of food, fodder and fibre. Although a millet crop grown under traditional circumstances uses only 50 mm in transpiration, the crop frequently suffers from agricultural drought due to excessive losses of rainwater.

Rainfall that meets land at the soil surface is divided over several pedo-hydrological components. Rain may be intercepted by vegetation, run off the ground surface, or infiltrate into the soil; this is reflected in the rainwater balance. Infiltrating water may be stored in the root zone or drain below the root zone to groundwater and stream base flow, contributing to what is nowadays called 'blue water'. These processes are reflected in the infiltration water balance. The maximum amount of water stored in the root zone available for plant growth is a very important soil characteristic because it determines the potential survival of plants during a dry spell. Water stored in the root zone may be lost as evaporation from the soil surface into the atmosphere, or taken up by plants and used as transpiration. This is reflected in the soil water balance. Land degradation decreases infiltration, water holding capacity and transpiration, but enhances runoff, percolation and soil evaporation. These agro-physical processes cause a decrease in GWUE.

A range of land management practices is available in sub-Saharan Africa to help improve GWUE. They can be classified according to their function: for reducing runoff; for improving water availability; and for improving GWUE. A focus on soil as a water resource will address problems of land degradation and drought, thereby improving productivity and food security in semiarid Africa. Going from 1500 to 3500 kg ha<sup>-1</sup> yr<sup>-1</sup> in Eastern Africa is easier than going from 5500 to 8600 kg ha<sup>-1</sup> yr<sup>-1</sup> in Eastern Asia. It could be that in 2030 an agriculturally active Africa helps alleviate global shortages of cereal production thereby turning the standard food security paradigm on its head.

**Keywords:** Africa, desertification, food security, land and water use, land degradation, soil and water conservation, soil water balance, sustainable land management, water use efficiency

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## Carbon Stock Changes with Relation to Land Use Conversion in the Lowlands of Tigray, Ethiopia

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Reduced emissions from deforestation and degradation are emerging as a strategy with big potential for mitigating climate impacts. This study analysed the effects of the conversion of free grazing lands to exclosures on ecosystem carbon sequestration in Tigray, Ethiopia. Replicated paired exclosures and adjacent free grazing lands were sampled. Three church forests were also sampled as a positive control. Soil carbon (C), carbon from woody and grass species as well as selected site and vegetation characteristics were determined. These were attained through standard procedures of soil analyses and destructive sampling of the identified sample plants. Significant ( $p < 0.05$ ) differences in soil-C concentration and stock, and woody species carbon were found between exclosures and adjacent free grazing lands. The oldest exclosure (15-year-old) had significantly ( $p < 0.05$ ) higher soil-C concentration and stock compared to the church forest. These differences were primarily attributed to the difference in amount and properties of input materials, inherent soil properties (% sand, silt, clay) and soil erosion. This was verified by the significant ( $p < 0.01$ ) correlation between soil-C with the measured site and vegetation characteristics. The general trend in the ecosystem carbon stock increased in the order of: free grazing lands ( $40.4 \text{ Mg ha}^{-1}$ ) < five year-old exclosure ( $49.0 \text{ Mg ha}^{-1}$ ) < church forest ( $74.0 \text{ Mg ha}^{-1}$ ) < 10 year-old exclosure ( $86.1 \text{ Mg ha}^{-1}$ ) < 15 year-old exclosure ( $94.9 \text{ Mg ha}^{-1}$ ). Our results show that the conversion of free grazing lands to exclosures has a significant potential to increase carbon sequestration, even in strongly degraded free grazing lands, both through additional below and above-ground carbon storage. Expanding exclosures on degraded free grazing lands can thus contribute to mitigation of climate change, if the local people will be sufficiently compensated.

**Keywords:** Carbon stock, church forest, exclosures, free grazing lands, land use conversion

## Climate Risk in Rural Value Chains: Using System Dynamics for Adaptation Planning in the Brazilian Amazon

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Increased incidence of extreme weather events and corresponding future projections suggest that the Amazon region will not be spared out by the consequences of climate change. Relative natural resource abundance in the Amazon does not, as often proposed, imply low vulnerability to increased climate variability. Amazon populations and their economic activities have developed under extraordinary conditions of natural resource abundance. As a result, adaptive capacity to sudden changes has not naturally developed over time. Unexpected changes in river flow volume and seasonal rainfall intensity may thus hurt Amazonian rural economies no less than those in traditionally more drought prone areas, such as the semi-arid north east. Climate change will also affect the capacity of Amazon biome to maintain the provision of globally and locally valued ecosystem services, such as carbon storage and endemic biodiversity.

In this paper we propose a System Dynamics approach to analysing representative value chains of the three main sectors in the Amazonian rural economy, namely agriculture (including cattle production), timber and non-timber forest extraction, and fisheries. Together these sectors contribute annually with over € 12 billion to the Brazilian GDP. Our research is based on field data collected in the Northern Brazilian Amazon in 2009 within the Small Grant research programme of the German Federal Ministry for Economic Cooperation and Development (BMZ).

Major value chains were identified using official statistics and characterised based on semi-structured interviews with local traders, producer cooperatives and government officials. Based on these data, we show how dynamic discrete time models can be developed and implemented using the dynamic simulation software STELLA. We analyse a set of prototype models for representative value chains in the Northern Brazilian Amazon with respect to their vulnerability to climatic changes as predicted by IPCC scenarios and the results of regional simulations of future climate-vegetation interactions. Subsequently we show how model results can be used to involve local stakeholders and decision makers in participatory strategic planning for climate change adaptation.

**Keywords:** Climate change, risk management, system dynamics

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## **Exploring Potential of Carbon Trading to Enhance Adaptive Capacity in Terms of Food Security in sub-Saharan Africa**

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Global change poses a threat especially to poor people whose livelihood depends directly on natural resources. Carbon and emission trading offers an opportunity to finance mitigation and adaptation to climate change and to conserve its natural resources. The value of the Clean Development Mechanism (CDM) involving carbon trading with developing countries more than doubled each year between 2005 and 2007. Still sub-Saharan Africa (SSA) accounts only 1,4 % of all registered CDM projects. The share is nine-times smaller than SSA's global share of emissions. Consequently SSA has potential for greater incorporation in global market. The mitigation potential of Africa through agriculture is estimated 17 % and forestry 14 % of the global total. SSA has a high projected growth rate in agriculture-related emissions in the near future, due to growing wealth and rising demand for livestock products. Thus agriculture sector has a great potential for mitigation. The objectives of the present study are 1) to create an analytical framework to examine the impact of varied mitigation options utilised in carbon trading on food security and rural livelihoods, and 2) to apply the framework to assess the potential of the mitigation options in Ethiopian agriculture and land use for mitigation and food security. To achieve the objectives the baseline for the study is examined; current land-use practices, especially of smallholders, and problems related to them are analysed. Mitigation options that suit to local agricultural systems and enhance adaptive capacity in terms of food security are identified and their potential for mitigation and food security is assessed. Mitigation options considered include improved cropland and grazing land management, restoration of organic soils and degraded land, livestock management, manure management, bioenergy use, improved energy efficiency, agroforestry, afforestation and avoidance of deforestation. Options for mitigation are quantified based on available literature and data from on-going projects. Differences among the mitigation options in distribution of benefits are evaluated based on stakeholder interviews.

**Keywords:** Adaptation, food security, greenhouse gas, land management, mitigation, soil carbon

## **Climatic Risk and Farm Planning: A Mathematical Programming Model for Typical Farms Households in the Mountainous Upland of Thua Thien Hue Province, Viet Nam**

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Weather calamities partly attributable to global climate change are increasingly affecting the central part of Viet Nam. Such shocks add to adversities like pest outbreaks and the Avian Flu. In addition, the recent hike in food prices adds additional burden to the often food-deficit farm households in the mountainous areas of the province of Thua Thien Hue in Viet Nam. Hue is one of three Vietnamese provinces where a large scale household panel survey was undertaken in the context of the DFG research project “Impact of Shocks on the Vulnerability to poverty: Consequences for Development of Emerging Southeast Asian Economies”. Data were collected in a panel survey from some 250 households in the mountain stratum of Hue province.

Using a mathematical programming model including risk following the concept of typical farm households the effect of risks on household food security and the probability to fall into poverty is analyzed. The model represents the main economic components of rural households in the mountainous upland of Thua Thien Hue province such as farm and forest based income generating activities. External shocks are incorporated in the model by means of a Monte Carlo based simulation of random events. Extensions of the model will allow capturing the dynamic nature of changes in natural resources such as forest land and soil fertility. Furthermore demographic changes and household dynamics as well as changes in asset positions will be included in future versions of the model. Results are expected to be useful for the design of policies which aim at reducing vulnerability to poverty while taking into consideration households’ medium- and long-term economic development.

**Keywords:** Climatic risk, farm planning, mathematical programming, Viet Nam

## **Designing Sustainable Soil Fertility Management Programmes: What Have we Learnt from Farmers' Perceptions and Preferences in Zambia and Malawi?**

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The diminishing natural resources per capita arising from growing population means that more resilient and efficient agricultural technologies are needed. A number of resilient farm production technologies that have high biophysical performance have been developed. However, apart from a few cases, their widespread adoption by smallholder farmers has been limited in many developing countries. Several studies have identified lack of understanding of the attitudinal components- specifically farmers' perceptions about the technologies- as important causes for the low adoption. Using the case study of "fertiliser tree systems", a sustainable soil fertility management that was developed in southern Africa based on nutrient cycling principle, this study aims to (i) understand farmers' knowledge, attitude and perceptions on soil fertility management, (ii) identify opportunities and constraints to the widespread adoption of these technologies and, (iii) provide feedback to the technology developers by highlighting implications for the design and modification. The data for the study was collected using a stratified sampling approach involving 603 smallholder farmers in Malawi and Zambia. The results show that farmers' preference for specific tree species is influenced by multiple criteria: quantity of biomass produced by trees (60%), ease of tree establishment and management (15%), ability of tree to re-grow after being pruned (6%), amount and market value of seeds produced (5%). Other criteria are duration (waiting period) before farmers begin to obtain benefits from the trees, compatibility of the technologies with ox-drawn ploughing. A dis-aggregation of the data revealed that important differences exist in the perception and preferences for tree species among different social groups (sex and wealth groups) within the communities. These differences have implications for the potential adoptability and farmer uptake of fertiliser trees in the targeted farm communities. An understanding of this preference will assist researchers to develop sustainable technologies that are appropriate to and enhance acceptability by farmers. It is concluded that in addition to economic models, an understanding of the farmers' attitudinal preferences provide greater insights to their adoption behaviour regarding sustainable production systems.

**Keywords:** Agroforestry, nutrient recycling, participatory research, southern Africa, sustainable agriculture

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## **Agriculture and Water Resource Management: Implication for Rural Development in sub-Saharan Africa**

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The planning and management of sub-Saharan African's agricultural and water resource management by governments and private sectors are increasingly becoming more important in the face of increased agricultural activities, water for domestic and industrial use, and other activities requiring water resources. To enhance this, integrated policy approaches should be adopted to eliminate incomplete execution of policies on water resource management and haphazard implementation and project duplications on water resources. This calls for a comprehensive basic research, soil testing, water budget, and environmental pollution analysis for increased food production and other uses of water resources. Increased in food production will eventually lead to increased agro-based industries especially in the rural areas, thus enhancing even distribution of industries between rural and urban areas. This will further integrate and stabilise the rural population, thus arresting the major problem of rural-urban migration in sub-Saharan Africa. The enormous volume of water used in raising tree crops, arable crops, fisheries, poultry, cattle, and the use for domestic and industrial purposes emphasises the need for integration of agricultural and water resource management in sub-Saharan Africa. Production and development in the savannah regions of southern Africa are primarily determined by interactions between the limitations imposed by ecological determinants (such as rainfall and soil quality) and the management strategies of the specific region. Good planning, focusing on both the short and long-term effects of water use, is needed in water management strategies. Botswana is already experiencing so-called 'water stress' which is related to a number of factors such as rapidly increasing population leading to a sharp increase in water demand, low and variable rainfall, high rates of evaporation, and the high cost of exploiting existing water resources. At the current rates of abstraction, the lifetime of surface and groundwater resources is limited to decades. This paper discusses the interrelationships between agriculture and water resources, identifies the need for an integration approach in food production and the essential requirements for enhancing the integrated relationship.

**Keywords:** Agrobased industries, rural development, rural-urban migration, water resources

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## **Indigenous Knowledge on Soil Conservation for Crop Production in Yua Community, Northern Ghana**

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In this paper, the author sheds light on indigenous knowledge systems on soil conservation for crop production in Yua, a rural community located in the 'Atankwidi Basin' of northeastern Ghana. The Atankwidi basin is part of the larger Volta Basin in West Africa and specifically spans through four administrative districts of the Upper East Region of Ghana. These districts mainly include the Kassena-Nankana West and East districts, and to a lesser extent the Bongo and Bolgatanga districts. This area is largely part of a guinea savannah zone in northern Ghana undergoing environmental degradation due to a combination of factors: agricultural and construction activities, desertification and changing rainfall patterns. This situation has negatively impacted on soil fertility and agricultural production so that food poverty is widespread. In response, actors at the household level have become more committed to indigenous knowledge practices on soil conservation for sustaining crop production.

Drawing on qualitative empirical research and data, the author concludes that there is intensification and adaptation of indigenous soil conservation knowledge systems on for sustaining crop production in the phase of environmental and soil degradation. In the domain of indigenous knowledge systems, the author reports on preparation and application of various forms of traditional farm yard and organic manure locally called 'naandeene posigo' and 'tampogre posigo'. The author also examines emerging new forms of organic manure preparation and application which essentially include 'Naabene' and pitch compost applications.

**Keywords:** Ghana, indigenous knowledge, soil conservation



## **Problems and Critics Toward Water Management in Megacities: A Case in Indonesia**

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Jakarta, the capital city of Indonesia, has been facing the problem of clean water shortage for years. In pace with rapid industrial and demographic development of the city, many buildings and households are consuming groundwater through private water drilling systems in order to fulfil the high demand of clean water. It leads to an over-exploitation of groundwater, which has further negative impacts; for example land-subsidence, severe flood, and seawater intrusion. These impacts have been becoming more evident in the last few years; *e.g.* the decrease of groundwater level by up to 5 m, year<sup>-1</sup>, land subsidence rate of around 10 cm year<sup>-1</sup>, and severe Jakarta flood in 2007 that caused total lost of 2.05 billion USD and 159 lives loss. These phenomena have been recognised in earlier studies about Jakarta's groundwater in 1983–1985 as well. Despite the early indication of negative impacts, there is no comprehensive published research so far. Therefore, the objective of this paper is to present the latest facts of these problems and critics concerning the water management accordingly.

We have found out that the core problematical issue behind the water shortage problem in general concerns with management of competences, which can be categorised into several groups: (1) technology – the choice, implementation, and control of technology; (2) networking – creating partnerships and maintaining cooperation; (3) behavioural – knowledge, abilities, and commitments; (4) regulation – water-law construction, enforcement, and control; and (5) marketing – promoting awareness, motivation, and active participation in water management. These competences are targeted to improve the effort to fulfil water demand not only in term of quantity, but also in term of quality by accomplishing the international safety standard of clean water. The implications of our research finding are to provide a scientific contribution by analysing the water shortage problem from management perspective and to stimulate further research projects in pursuit of providing sustainable water management solution.

**Keywords:** Clean water shortage, management competences, water management

## **Cropping Pattern and Nutritional Status of Soils in Hyderabad District of Pakistan**

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Intensive cropping systems, improper use of fertilisers or no fertiliser application, unreliable and poor quality of irrigation water, have led to reduce soil fertility in the district Hyderabad (Pakistan). Arid climate in the region, low precipitation and high evapotranspiration, dictate the need for irrigation of crops using water either from canals or tube-wells. As there is to date no comprehensive overview about the nutrient status of those soils and yield constraints due to *e.g.* micronutrient deficiencies (especially zinc in the soils of the study region), a study was initiated to assess cropping patterns and soil properties and nutrient constraints in representative units of the area. The objective of the study is not only to prepare the detail spatial maps for the soil fertility of the region but also to link the status of fertility with agricultural practices. GIS mapping of the district area showing zones of different nutrient constraints will be presented. Soil samples were taken from 80 different locations at depths of 0–15, 15–30 and 30–45 cm. The soil samples were analysed for texture, electric conductivity, pH, total nitrogen, available phosphorous, potash and micro nutrients (Zn, Cu, Fe, Mn, and B). The nutrient status of the wheat crop is currently assessed as well by diagnosis and recommendation integrated system (DRIS) and critical level (CL) approaches to further identify the most limiting nutritional factors. Data regarding fertiliser application, cropping pattern, crop rotation and irrigation practices will be linked to farmer's practices and recommendations be made to improve nutrient supply and increase crop yields.

**Keywords:** Farmer's practices, nutritional status, Pakistan, soil fertility

## Hydrochemical Observation and Analysis of Streamflow Composition in a Mountainous Agricultural Watershed in a Subtropical Region

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Population growth causes an increasing pressure on natural resources in the mountainous regions of northern Thailand. To extend crop production to the whole year and to secure yield, a lack of soil fertility is compensated by increasing amounts of agrochemicals. These agrochemicals might be lost to aquatic systems, posing a risk to environment and human beings. The purpose of this project is to identify preferential flow paths during rainfall events at the catchment scale and to study the impact of land use changes on the fate of agrochemicals by using the SWAT (Soil and Water Assessment Tool) model. The Mae Sa watershed is located close to Chiang Mai (Thailand) and has a total area of 77 km<sup>2</sup>. It is characterised by steep slopes and narrow sub-basins with mainly mixed evergreen forests and deciduous forests. The cultivated areas are dominated by flower and vegetable production. Discharge was measured at three locations equipped with ultrasonic sensors. Rainfall was measured at fourteen locations distributed over the whole area, including two weather stations. During single events water samples were taken from stream water, soil water, surface runoff and rainfall to assign a hydrochemical fingerprint of each component. Electrical conductivity (EC) was measured during rising and falling limbs of the hydrograph and water samples were analysed for the main ions and will form the base of a hydrograph separation. The EC values could be successfully applied for hydrograph separation, whereas ion analysis brought up difficulties in distinguishing the different runoff components due to low concentrations of the single components. Tropical soils in general show a low concentration of ions and preceding rainfall amplifies this effect by washing out the ions. The baseflow component dominated two events with 68 and 62 %. A third event showed a slightly lower fraction of event water (54 %). Pesticide concentration during the third event was measured and will be combined with the information drawn from the hydrograph separation. The results will help to improve the understanding of pesticide transport to the stream during single events.

**Keywords:** Flow components, hydrograph separation, pesticide transport, pesticides

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## Assessment of Soil Erosion and Soil Conservation Practices in Angereb Watershed, Ethiopia: Technological and Land User Context

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Soil conservation technologies that fit well to local scale and are acceptable to land users are increasingly needed. To achieve this at small-holder farm level, there is a need for an understanding of specific erosion processes and indicators, the land users' knowledge and their willingness, ability and possibilities to respond to the respective problems to decide on control options. This study was carried out to assess local erosion and performance of earlier introduced conservation terraces from both technological and land users' points of view. The study was conducted during July to August 2008 at Angereb watershed on 58 farm plots from three selected case-study catchments.

Participatory erosion assessment and evaluation were implemented along with direct field measurement procedures. Our focus was to involve the land users in the action research to explore with them the effectiveness of existing conservation measures against the erosion hazard. Terrace characteristics measured and evaluated against the terrace implementation guideline of Hurni (1986). The long-term consequences of seasonal erosion indicators had often not been known and noticed by farmers. The cause and effect relationships of the erosion indicators and conservation measures have shown the limitations and gaps to be addressed towards sustainable erosion control strategies. Less effective erosion control has been observed and participants have believed the gaps are to be the result of lack of land users' genuine participation. The results of both local erosion observation and assessment of conservation efficacy using different aspects show the need to promote approaches for erosion evaluation and planning of interventions by the farmers themselves. This paper describes the importance of human factor involving in the empirical erosion assessment methods towards sustainable soil conservation.

**Keywords:** Erosion control, erosion indicators, land-user participation

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## Carbon Sequestration and Microbial Residues in Secondary Grassland Top Soils in the South African Highveld

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Soil restoration is a prerequisite for combat desertification in semiarid and arid parts of the world. This study was designed to evaluate how fast and to which degree degraded cropland may resequenter carbon when converted to permanent secondary pastures. We determined the soil organic matter stabilisation in soil particles as well as the influence of soil structure and influence of microorganisms on the C and N dynamics during the regeneration of the secondary pasture soils. Top soil samples (0–5, 5–10 and 5–10 cm) were taken from chronosequences of secondary pastures (1–31 years old) at three agro-ecosystems in the South African Highveld. Long-term cropland and primary grassland served as control. Soil samples were fractionated according to particle size and to aggregate size and characterised by their C and N content. Amino sugars as indicators for microbial residues were analysed to elucidate the influence of microorganisms on the C and N sequestration in the secondary pastures. In all ecosystems, the carbon stocks increased exponentially until a maximum was reached 10–95 years after land conversion. This gain in soil C was clearly pronounced for the top 0–5 cm of soil but already hardly detectable at 10–20 cm soil depth. The sand fraction recovered carbon more rapidly than did the finer size separates. Yet, in all three ecosystems the extend of restoration of total carbon stocks varies between 57 % and 74 %.

In contrast, soil structure recovers nearly completely within 20 years. This suggests that the influence of the physical protection in the aggregates affects the regeneration of soil organic matter very slowly. The amino sugar concentration increased exponentially to some extent but a complete regeneration was not feasible. Previous intensive cropping resulted in a change of microbial residue composition towards more fungal residues. Increasing glucosamine to muramic acid ratio indicates a continuing increasing contribution of fungal-derived C and N to the microbial residue pool during the pasture management. We concluded that previous losses of soil organic matter cannot easily be counterbalanced and that the native grassland ecosystem are only partly resilient to land-use change.

**Keywords:** Amino sugar, chronosequence, land use change, grassland restoration, secondary grassland, soil aggregation, soil organic matter

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## Adaptation Practices and their Acceptance by Rural Smallholders: A Literature Review

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Climate change will have a significant impact on the livelihoods of the rural poor living in developing countries. Projected reductions in yield in some African countries could be as much as 50 % by 2020, and net crop revenues could fall by 90 % by 2100. This amounts to a serious threat to food security and to the achievement of major development goals.

The project, “Strategies for Adapting to Climate Change in Rural sub-Saharan Africa: Targeting the Most Vulnerable” (financed by GTZ/BMZ) provides adaptation practices resulting from impact modelling (IFPRI, PIK). However, considering the often low rate of uptake of adaptation practices by farmers, it is urgently necessary to improve the appropriateness of practices for the farmers. As long as the practices are not adapted to farmers’ needs and interests, they won’t be accepted, regardless of their effectiveness from a technical point of view.

The ZALF sub-project is therefore focused on identifying the degree of acceptance of adaptation practices by smallholders in vulnerable rural areas in Tanzania. Acceptance analysis can provide an indication of the willingness and ability of farmers to adopt innovations in order to cope with climate change impacts.

The contribution presents the results of a literature review on the acceptance of adaptation practices by smallholder farmers in the developing world. Acceptance is defined as “the property of an innovation, when introduced, to evoke a positive response from the individuals affected by it”. A “positive response” may range from consent to adoption of an innovation.

A conceptual framework developed at ZALF has been applied which, based on social scientific concepts, proposes a series of explanatory factors in adaptation. Farmers’ individual disposition, the interaction process during policy adoption, policy design and dissemination, and the societal environment are all considered as equivalent influencing domains.

The aim of this contribution is to present relevant factors influencing and limiting the decision to adapt, in relation to three categories:

- (1) the object of acceptance (*i.e.* the specific measure);
- (2) the subject of acceptance (*i.e.* the decision maker); and
- (3) the surrounding context (*i.e.* the social environment).

**Keywords:** Adaptation practices, climate change, literature review

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# Land, soil and water resources under a changing climate

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## **Preparing for the Inevitable: The Role of Sustainable Agriculture in Addressing the Challenge of Climate Change**

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Climate change is no longer a hypothesis. It is widely agreed to be already a reality and its effects are expected to continue and increase. Climate change will have adverse impacts on the vulnerability of poor communities and further reduce access to drinking water, negatively affect the health of poor people, and will pose a real threat to food security in many countries in Africa, Asia and Latin America and hence undermine the achievement of the Millennium Development Goals. It is generally recognised that, among all sectors, agricultural production activities are the most sensitive and vulnerable to climate change. Increases in temperature and atmospheric carbon dioxide, decreases in rainfall and increased frequency of extreme weather events, such as drought, fire and flooding will affect agricultural productivity. Agriculture also contributes substantially to climate change through emissions of carbon dioxide, methane and nitrous oxides. Sustainable agriculture is a rapidly growing field aiming at meeting the food demand of the present generation without sacrificing the needs of future generations. Sustainable agriculture is therefore vital to the pursuit of combating climate change. This paper provides a discussion on the impacts of climate change on agriculture and the role of sustainable agriculture in addressing these impacts based on peer-reviewed literature and research findings. It discusses how sustainable agriculture can assist in mitigation through various activities to reduce CO<sub>2</sub> and other greenhouse gas emissions and carbon sequestration. Sustainable adaptation options in agriculture such as high degree of diversity, intercropping and use of locally adapted drought tolerant varieties are also explained. The study also highlight how higher education in sustainable agriculture can help in adapting to climate change through training, dissemination of knowledge, breeding of new cultivars and breeds and development of models through research.

**Keywords:** Climate change, mitigation, sustainable agriculture

## The Implications of Climate Change on Livelihoods of Small-farmers in Mesoamerican

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According to the fourth IPCC report Mesoamerica is 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. Besides cash crops such as coffee, small farmers depend also on a variety of crops that are not well studied.

Under 2 different scenarios, and 12 downscaled GCM models we map the changing geographies of crop suitability for 2020 and 2050. First we quantify the impact of climate change on coffee suitability using data of thousands of geo-referenced coffee farms all over Mesoamerica and a maximum entropy approach. We then appraise the suitability of more than 30 major and minor crops that are important to small-farmers livelihoods (identified using the FAOSTAT database) and a modified version of the crop-niche suitability model Ecocrop. Combining the two analyses we quantify the impact of climate change on Mesoamerican agriculture in general and especially on coffee farmers livelihoods.

The analysis shows that a great deal of opportunities are likely to appear in Mesoamerican agriculture as a result of climate change if farmers have the access and information to change varieties and, if necessary, their crops. When crops are grown for cash, this is easy. However, when the crops are of large cultural importance and highly traditional, adaptation measures could be significantly more difficult. We use this approach to identify hotspots of both opportunities and significant challenges where fundamental shifts in the agricultural system may be required.

**Keywords:** Climate change, coffee, livelihoods

## Contribution of Dairying to Total CO<sub>2</sub> Emissions Impact on Climate Change in Different Countries

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Based on sector calculations of IPCC (Intergovernmental Panel for Climatic Change) and FAO (Food and Agricultural Organisation), agriculture contribute about 13 % of the global emissions. There is an increasing consciousness of global climate change. The emission of Green House Gases (GHS) from dairy cattle is a great concern as it is accepted worldwide as a threat to environmental sustainability.

The aim of this paper is to measure CO<sub>2</sub> emissions of different dairy farming systems in different countries and to quantify CO<sub>2</sub> emissions from milk production on total global anthropogenic emissions. The analysis is based on the IFCN database of typical dairy farms with an extension on the life cycle analyses.

The results show that, low yielding farming systems in Africa and South Asia have the highest emissions while high yielding farming systems show significantly lower emissions per kg of milk produced. Regarding the GHG emissions on the farm level, methane (CH<sub>4</sub>) contributes highest followed by carbon dioxide (CO<sub>2</sub>) and nitrous oxide (N<sub>2</sub>O). Based on farm activities, and depending on farming systems, the most important emission drivers are manure handling and storage (10–20 %), purchase feed (5–10 %), fertiliser usage (up to 10 %) and usage of energy in the form of electricity and fuel (5–10 %). Meanwhile the major part of the emissions (about 50 %) comes from rumen activities. The average emission of the 117 dairy farming systems from 38 countries is 1.50 kg CO<sub>2</sub> emissions per kg milk with the lowest emissions in Israel (0.88) and the highest in Cameroon (4.08).

The employed methodological approach of a life cycle analysis based on typical farms enables the comparison of dairy farming systems on an international level. Though the IFCN method uses typical farms which might not be statistically representative for a country the IFCN database is unique as a consistent international set of typical farms.

**Keywords:** Carbon footprints, dairy farming, sustainability

## Responses of Sorghum Varieties to Climatic Variability: A Case Study within the RISOCAS Project

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Cropping systems in West Africa are expected to be seriously affected by climate change, particularly in terms of rainfall amount and distribution and temperature. In order to adapt to the required changes in land use and management, the search for 'climate-ready' crops is one of the options to sustain food production especially of subsistence farming systems within the Sudano-Sahelian zone. In order to evaluate responses of Sorghum [*Sorghum bicolor* (L.Moench)] varieties to water availability and temperature, 10 selected West African sorghum varieties were sown at three sites and with staggered sowing dates along a latitudinal gradient in Mali. Varieties differed in growth type and the degree of photoperiod sensitivity. Fertiliser was applied in order to avoid nutrient disorders and chemicals to protect plants from diseases and insects. This experimental approach was used in pursuit of ideotypes with general or specific adaptations to both temporal and spatial climate variability. Plants were harvested regularly during the growth period and biomass partitioning, number of leaves, leaf area and plant height recorded. Growth data were supplemented with measurements of leaf gas exchange, light interception of the canopy and root production in the topsoil. Data for the calculation of field water balances were collected by measuring the temporal dynamics of soil water content down to a soil depth of 100 cm, bare soil evaporation and maximal rooting depth. Sowing date and sites influenced plant architecture in terms of height, number of leaves on the main culm, leaf area as well as the cycle duration. The response of these parameters to the main and interactive effects of varieties, sites, and sowing dates is summarised. The implications for modelling phenology, leaf development, biomass accumulation and partitioning, water use, radiation use, yield components, and yield is discussed.

**Keywords:** Climate change, radiation use efficiency, water use efficiency

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## Livelihood Strategies and Resource Availability of Agro-pastoralists in Mopti Region, Mali

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Climate data show, that the Sahel region and its neighbouring regions are exposed to a continuous reduction of precipitation and an increase of climate variability that might result from climate change. In the Mopti region, former pastoralists of the Peulh 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. Being part of the BMZ funded project “Supporting the vulnerable: Increasing the adaptive capacity of agro-pastoralists to climatic change in West and Southern Africa using a transdisciplinary research approach”, the study examines the relationship between resource availability and the livelihood strategies of Peulh agro-pastoralists. Four villages in two different ecological zones (Seno and Niger delta) were chosen. Data collection had a focus on qualitative methods, including communication tools and different forms of interviews and participatory observations. The research team lived for two weeks in each of the villages and conducted among other methods, village maps, livelihood analyses and seasonal calendars. The results show a high variety in livelihood strategies followed by different people. Although in all villages the same livelihood strategies were used, the importance of the strategies varied between the villages. The agro-pastoralists manage their livelihoods based on the resources they can access. This resource accessibility is highly variable in terms of inter-annual variation and intra-annual variation. The comparison between the four different villages shows how the agro-pastoralists adapt their livelihoods according to the resources availability. For instance in the Niger delta they have access to bourgou plants even in the dry season so they keep more milk cows in the village to sell the milk all year round, whereas in the Seno the main outcome of livestock keeping is meat, milk is for self consumption and for selling in the rainy season only, because they cannot supply enough fodder for milk cows in the village during the dry season. The results also point to factors that either constraint or promote sustainability of the livelihood system at the local and regional level.

**Keywords:** Agro-pastoralists, climate variability, livelihood strategies, Mali, participatory methods

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## Study on the Variations of Water Quality of Sikan River Influenced by Agriculture Wastewater

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Sikan river is one of the end branches from Saymareh river. 57 % of agriculture lands in Dareshaher, Ilam province, Iran, exist around of this river. In attention to consume 1343 ton chemical fertilisers per year, the discharge water of these lands can influence the quality of river water. For providing the basic management strategies, the seasonal variations of water quality was evaluated. In this way, quality characteristic of river water was measured in four season of year. Data showed that with progressing in year,  $\text{NH}_3$  and followed it, pH decreased. The dissolved oxygen (DO) was minimum in summer. The lower DO and higher COD (chemical oxygen demand) in summer are influenced by various factors. Higher concentration of phosphorus caused higher growth of alga and phytoplankton and therefore organic matter accumulation, which decreases the concentration of dissolved oxygen with biodegradation. The high negative and significant correlation between phosphorus and DO ( $r = -0.92^{***}$ ) confirm this hypothesis. In addition, the increase in temperature causes a decrease in oxygen solubility, which further reduces the DO concentrations. Lower concentration of phosphorus in winter compared to other three seasons was due to less discharge and more precipitation of this nutrient by Fe, Al and Ca ions. After P, organic matter had high correlation with DO ( $r = 0.80^{**}$ ). The maximum discharge of  $\text{PO}_4$  and  $\text{SO}_4$  occurred in summer and fall that can be due to application of flood irrigation system.  $\text{NO}_3$  had no correlation with DO and COD. The maximum entrance of nitrate to unit of water volume occurred in summer.

**Keywords:** Pollution source, wastewater, water quality

## Evaluation of Soil Texture and Organic Matter on Atrazine Degradation and its Half-life

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Atrazine is the most important triazine herbicide with moderate persistence in soil. In order to study the effects of soil texture and temperature on atrazine degradation, an experiment was conducted in a completely randomised design with factorial arrangement and 3 replications. The experimental factors included, soil texture (sandy loam and silty clay), organic manure (0, 2 and 5 percent (w/w)) and 4 incubation periods (0, 20, 40 and 60 days). Soil was contaminated with atrazine at a rate of 50,mg kg<sup>-1</sup> soil.

The results showed that soil texture and organic manure had significant effects on the atrazine degradation rate. Atrazine degradation rate in clay soil with no organic amendment was 1.54 times higher than in a sandy soil and its half-life time were 131 and 90 days in the two soil textures, respectively. The atrazine degradation coefficient increased by 1.14 and 1.8 times in sandy soils and by 1.54 and 2.46 times in clay soils with an organic amendment of 2 % and 5 %, respectively. The atrazine half-life time decreased with an organic amendment from 139 to 122 and 77 days in a sandy soil and from 90 to 58 and 38 days in clay soil with 0, 2 and 5 % organic amature application respectively. It seems that atrazine in clay soils is more persistence than in sandy soils and soil organic matters have an important role in atrazine bioremediation.

**Keywords:** Soil texture, atrazine, half-life, soil organic matter



## Study Effect of Heavy Metals Contamination on Growth of Earthworm (*Eisenia fetida*) in two Calcareous and Acidic Soils

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Heavy metals are entered to environment by mining and by applying sewage sludge and agricultural inputs to soils. These metals have detrimental effects on environment and soil organisms. The potential hazards of environmental pollutants to soil invertebrates have been assessed in recent years by the use of earthworms. To determine The effects of different concentrations of cadmium, copper, lead and zinc on survival, growth and cocoon production of earthworms (*Eisenia fetida*) in an acidic and a calcareous soil amended with 0 and 5 % organic matter, two pot experiments were conducted. The concentrations of heavy metals in soils were 0, 10, 20, 40, 60 and 80 mg kg<sup>-1</sup> and growth parameters of the earthworms were measured with 15 day intervals over 75 days. The results showed that the toxic effects of heavy metals were higher in the acidic soil compared to the calcareous soil. Addition of organic matter to soils reduced the toxic effects of heavy metals to earthworms. In the soils contaminated with Zn and Cu, the weights of the earthworms increased with increasing the concentrations of these metals up to 60 mg kg<sup>-1</sup> and then decreased in higher concentrations. While, in Pb contaminated soils the decline in earthworms, weights occurred in concentrations higher than 40 mg kg<sup>-1</sup>. Cadmium had the highest negative effects on cocoon production and the weights of earthworm decreased in all concentrations of this metal. The toxic effects of heavy metals on cocoon production in the calcareous and acidic soils were in the orders of Pb> Zn> Cu and Zn> Pb> Cu respectively. The highest earthworm's mortality was recorded in soils contaminated with lead and cadmium and zinc contamination had the least effect on this traits.

**Keywords:** Earthworm, *Eisenia fetida*, heavy metals, organic matter

## Flood Regimes of the River Ala in Akure, a Peri-urban City of Nigeria

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Growing environmental challenges posed by floods on humans and animals is generating growing interest in measuring flow from open channels, especially in the developing countries. The stage and discharge of River Ala in Akure, Nigeria was investigated by use of trapezoidal weirs, placed at three major tributaries (westward: WT07 and WT08, northward: NT07 and NT08 and southward: ST07 and ST08) of the river during the 2007 and 2008 peaks of rainfalls (May-July). Climate analysis over a twenty five year period (1982-2006) showed a mean maximum rainfall of 17.8 mm, maximum mean air temperature and mean relative humidity of 38.6°C and 96.7 %, respectively. Mean discharges from the WT07, ST07 and NT07 were  $2.561\text{s}^{-1}$  ( $\pm 1.15$ ),  $2.83$  ( $\pm 1.19$ ) and  $2.41$  ( $\pm 0.89$ ), respectively. The highest and lowest discharges,  $2.831\text{s}^{-1}$  ( $\pm 1.19$ ) and  $2.351\text{s}^{-1}$  ( $\pm 1.01$ ), were obtained from ST07 and ST08, respectively. The least significant difference among all measured discharges during the 2008 experiment was 0.408 and comparison of means among measured discharges from WT08, ST08 and NT08 showed no significant difference at 5% probability level. However, the difference between discharges of ST08 and NT08 were highly significant (LSD at  $p \leq 0.05$ ). The highest and lowest water heads (h) values of 0.077 ( $\pm 0.032$ ) and 0.064 ( $\pm 0.027$ ) were obtained from the ST07 and NT08, respectively. Comparison of means of water heads in ST07 and NT07 showed a highly significant difference at ( $p \leq 0.05$ ). The difference in mean water heads from WT08, NT08 and ST08 were not significant (LSD at  $p \leq 0.05$ ). The result from this experiment is useful for the calibration of river stages (water heads) and the prediction of discharges that may accompany storm events during the peak of rainfall in the study area.

**Keywords:** Water discharge, Nigeria

## Smallholder Production and Climate Risk in the Baixo Amazonas Region, Brazil

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Climate models consistently predict higher incidence of extreme weather events such as droughts in the Amazon region a warmer and drier climate especially in the Eastern part of the biome. Past Amazon droughts demonstrated the vulnerability of both forests and people to such local impacts of global climate change. This research seeks to (1) identify the degree of rural livelihood's exposure to climate risk, (2) understand related risk coping strategies, (3) elicit representative local producer risk profiles, and (4), develop recommendations for local producers and decision makers to reduce vulnerability to climate an other risks. Representative production systems (PS) in the study area were analysed and classified through randomly sampled semi-structured interviews and official statistics. Following the classification, detailed individual and group interviews with local producers of every PS in the studied communities were conducted and complemented by official information from government institutions and producer cooperatives. Probability distributions of income and output were simulated for each PS using Monte Carlo techniques. As a result, representative producer risk profiles were constructed and subjected to climate change and adaptation scenario analyses. It was found that the major sources of variation in producer welfare and output result from normal and well-known fluctuations in economic and weather related variables. Climate change scenarios, however, significantly increase the share of climate born risk especially for poor and specialised producers. The lack of appropriate risk-sharing institutions and safety nets for rural producers are therefore likely to become a more important policy issue in the decades to come. The analysis of local producer risk profiles and their composition appears as a precondition for well targeted adaptation efforts. Few studies have addressed risk in Amazonian production systems. This study demonstrates that relative resource abundance in Amazonian producer settings is no guarantee for resilience against future climate shocks. This research is embedded in the Small Grant research program of the German Federal Ministry for Economic Cooperation and Development (GTZ): Small-scale producers' adaptation to climate risk in the Brazilian Amazon; Promoting knowledge-to-action trough collaboration in research and technical cooperation.

**Keywords:** Climate change, production systems, risk analyses

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## Morphological Characterisation and Genetic Identification of Rhizobacteria in Cuban Agricultural Soils

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The microbial activity in soil is one of the most important factors for maintaining sustainability in crop production. The ecology and diversity of microbes is the base to unravel the different process that take place in several ecosystems. This report aims the isolation and characterisation of microorganisms in cereal-legume intercropping system. Samples from common bean (*Phaseolus vulgaris* L.) nodules, soil and sorghum roots (*Sorghum bicolor* (L.) Moench) were analysed to determine the biodiversity of diazotrophic and rhizosphere bacteria in an agricultural Cuban system. The morphological analysis demonstrated several groups of isolates with differences in growth type, colour, polysaccharide production and border of the colonies. Genetic characterisation using 16S rDNA revealed 8 groups of bacteria belonging to the genera: *Agrobacterium*, *Rhizobium*, *Ochrobactrum*, *Sphingomonas*, *Stenotrophomonas*, *Bacillus*, *Brevibacillus* and *Paenibacillus*. 47 % of the sequences matched for 100 % sequences in the EMBL database, while 53 % of the sequences scored above 99 % of identity. In nodule samples 37.5 % of the isolates were 100 % similar to *Agrobacterium tumefaciens* or *Rhizobium* species. Two species of *Rhizobium* isolated (*R. etli* and *R. tropici*) were detected in nodule samples. In nodulation tests, *Agrobacterium* isolates were unable to nodulate the original host. No statistical difference was observed for nodulation between the *Rhizobium* isolates and the *R. etli* reference strain. The results presented in this study are of importance to determine the interspecies microbial relationships in the rhizosphere, possibly increasing our understanding on biotic factors interfering with the *Rhizobium*-legume symbiosis and as a source of inoculant strains for local environmental conditions.

**Keywords:** 16S rDNA, bacteria, diazotrophic, rhizosphere

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## Developing Rice and Sorghum Crop Adaptation Strategies for Climate Change in Vulnerable Environments in Africa – RISOCAS

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Climate change in Africa affects staple crop productions systems by increasing climate variability and weather extremes. To avoid negative impacts for food production and security, crop adaptation strategies are required that comprise varietal development and crop management. The RISOCAS project, a collaboration between the University of Hohenheim, The Africa Rice Center (WARDA), CIRAD and two national partners IER and FOFIFA, focuses on irrigated rice, rainfed sorghum and rainfed upland rice as representatives for mayor cereal cropping systems in sub-Saharan Africa. Responses of a wide range of contrasting genotypes to existing environmental gradients covering the range of expected climate change scenarios allow the assessment of adaptation potential within the existing genetic variability in each crop. Gradients cover oceanic to continental climate with 2 sites in Senegal as representative environments for irrigated rice production in the Sahel, a latitudinal rainfall gradient representing environments for low altitude dryland sorghum production with 3 sites in Mali and an altitudinal temperature gradient for rainfed upland rice on 3 sites in Madagascar. With 5–12 staggered planting dates at each site genotypes are subjected to a large number of climatic environments. Meteorological and phenological observations, growth and yield analysis are combined with physiological measurements including a field plot water balance and studies on microclimate effects on the canopy structure. Using these data valuable traits for better adapted cultivars will be identified and ideotype concepts for varietal selection will be developed. For this, existing phenological and agronomic crop models will be adapted, calibrated, and validated with field data. In particular the models RIDEV, IMPATIENCE, and SARRAH as well the architectural model ECOMERISTEM will be used to extrapolate the varietal responses and adaptation potentials for different climate change scenarios. The poster illustrates a concept of trait analysis for genotype responses to multiple environments on a supra-regional scale in order to support the parameterisation of models so far validated on regional to local scales only. RISOCAS will deliver models to propose crop ideotypes in the context of climate change scenarios and develop a basis for tactical and strategic decision making to adapt African cereal cropping systems to climate change.

**Keywords:** Climate change, crop adaptation strategies, modelling, rice, sorghum, sub-Saharan Africa

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## Resilient Agro-landscapes to Climate Change in Tanzania (The ReACCT-Project)

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Rain fed mixed crop livestock systems of north-eastern and central Tanzania are likely to be severely affected by numerous changes caused by climate change and its impacts. This project aims at assessing the regional impacts of climate change on agro-landscapes and environment in Tanzania (Morogoro) and at identifying adaptation strategies for small-scale agriculture. Assessments on related land use sectors as forest, hydrology, nature conservation and biodiversity are considered involving local partners and farmers.

Driven by regional climate change scenarios, integrated agro-ecosystem models are used to assess combined climate change and management effects on crop production, water resources and soil fertility. These agro-ecosystem models are linked closely to hydrological models. Complementarily, stakeholders develop options of management practices in potential future agro-landscapes based on the same regional climate change scenarios.

The ReACCT - project started in May 2008. Since March 2009 a part of the project team is based in Morogoro. In this poster we share experiences of research planning and implementation in multidisciplinary researcher teams. Additionally, we show first results and conclusions elaborated in collaboration with the Sokoine University of Agriculture (SUA) in Tanzania.

CCLM modelling runs produced first promising climate scenarios for Tanzania. Historical vegetation maps of Tanzania have been identified and are currently being evaluated to create a local database of occurring tree species. Readiness for adoption of the recommended species, adapted to the relevant climate scenarios, will be explored among smallholder farmers by socioeconomic surveys. Participative research activities started in the Ngerengere catchment, which was also chosen for the hydrological modelling exercises. Trial sites for field experiments in three regions are identified and sensor installation is expected to occur soon. Together with scientists from national research institutes and the Sokoine University appropriate crops and varieties for the field experiments are selected. Supplemental irrigation and water use efficiency experiments with maize will be planted.

**Keywords:** Climate change adaptation, impact assessment, land use change, modelling, scenario development

## Spatial Variability of Nitrogen Mineralisation in Wine Grape Fields in Chile

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Nitrogen is the most important element determining yield and quality of wine grape. Actual management has tended to minimise the use of mineral N on vineyards, relying more on the soil N being mineralised each season. The balance between vineyard N demand and N supply is critical, not only from the production stand point but also from the environmental one; however few studies have been performed to estimate the amounts of N mineralised and the variability of the mineralisation in vineyard fields, in Chile.

Two fields of different soil texture, of approximately 2-ha each, were studied during the growing season (November through April). Intact soil cores (0–20 cm), containing ionic resins in the bottom, were incubated *in situ*, for 4 or 5 periods lasting 35 days each. Sampling points were systematically distributed over the fields with the help of a GPS receiver and a Geographic Information System, with an intensity > 10 samples ha<sup>-1</sup>. After each incubation period soil and resins were extracted with 2 M KCl to determine N-NH<sub>4</sub> and N-NO<sub>3</sub>; N mineralised during each period was estimated subtracting the amount of N present in the soil + resin at the end of the incubation from that at the beginning of it.

Results showed a large spatial variability (CV > 60 %) of N mineralised in both fields. Over the entire season, net mineralisation was positive in all areas of the fields, ranging from 0.1 to 1.5 kg N ha<sup>-1</sup> d<sup>-1</sup>. Average mineralisation rate was approximately 0.5 kg N ha<sup>-1</sup> d<sup>-1</sup>, which would yield enough nitrogen for sustaining grape yields of up to 15 ton ha<sup>-1</sup>, much higher than actual yields for high quality grapes.

**Keywords:** N mineralisation, spatial variability, wine grape, GIS

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## **Impacts of Climate Change on Insect Pests: A Case Study of Effects of High Temperature Pulses and Drought Stress on *Plutella xylostella***

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Climatic changes have a great impact on plant-pest interactions. These changes include among others the rise in global temperatures, rise in carbon dioxide concentration and a rise in drought-stress due to increased evapo-transpiration brought about by a rise in temperatures. More specifically, there will be notably seasonal extremes in weather changes in different regions. It is therefore expected that these seasonal changes brought about by a dynamic climate will consequently affect range distribution, development and behaviour of various insect pests and their effects on the agroecosystems.

We investigated effects of seasonal extremes in high temperature pulses coupled with drought stress on the lepidopteron pest species *i.e.* *Plutella xylostella* on Brussels sprouts plants. Half of the plants were drought stressed while the rest were normally watered. This was done in four climate chambers maintained at 24, 28, 32 and 36 °C respectively.

Contrary to other studies done in constant temperatures, which have recorded hardly any egg hatch at high constant temperatures, we found that at the above extremes in temperatures, more than 50 % hatchability was experienced. Likewise, at extreme temperatures, there was significantly faster development from egg to pupation. Additionally, there was a trend for faster larval development on intermittently drought stressed plants as compared to regularly watered plants. With high temperatures and drought stress there was further an accumulation of L3 and L4 larval instars at the apex part of the plants. This is critical for the quality of the crop.

These results give a starting point on the outlook to investigate further the impact of extreme temperatures and drought stress under field conditions. Should these results be reproducible under field conditions, they will open new fields of study of the effects of climate change even on other insect herbivores pests and their respective natural enemies.

**Keywords:** Climate change, developmental rate, drought stress, extreme temperatures, oviposition, *Plutella xylostella*



## Impact of Tillage Practices on Dry Soil Aggregate Distribution in Different Soil Types in Austria

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Soil aggregation is one of the main factors controlling the chemical, physical, and biological processes that contribute to soil productivity and agricultural sustainability. A research was conducted to investigate the impact of different tillage practices on dry mean weight diameter (DMWD) in different soil types and to determine the range of aggregate sizes that are affected by tillage practices in spring and autumn. Composite surface soil (0–10 cm) samples were collected from five experimental sites treated with different tillage practices in spring and autumn 2008 in lower Austria. The management practices were conventional tillage (CT), reduced tillage (RT) and No till (NT) that are implemented for different period of time. The soil textures were loam (L), sandy clay loam (SCL), clay (C) and silt loam (SL). Samples were air dried and passed through a nest of sieves to provide soils with aggregate sizes <1 mm, 1–2 mm, 2–4 mm, 4–8 mm and 8–22.4mm. The overall result shows that NT has significantly higher ( $p < 0.0001$ ) DMWD followed than RT and RT has also significantly higher DMWD than CT. NT in L and C has significantly higher DMWD than in all other soil types and tillage practices. This shows the strong interaction (0.0136) between tillage practices and soil texture. L has the highest DMWD than SCL and C whereas SL has the lowest. The DMWD of all soils in autumn was significantly ( $p < 0.0001$ ) higher than in spring. In general, the application of NT resulted in 2 % to 26 % increase in DMWD. NT produced significantly higher amount of large aggregates (8–22.4 mm) and lower amount of small aggregates (<1 mm) than RT and CT in autumn in C and L. Tillage has no effect on 2–4 mm aggregates. This study suggests that implementation of conservation tillage practices improve the stability of larger aggregates. Further research has to be done in order to see the impact of tillage practices on wet mean weight diameter and aggregate stability.

**Keywords:** Tillage practices, no tillage, reduced tillage

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## Climate Change and Anthropogenic Impacts on Land Use and Agriculture in the la Plata Basin, South America.

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La Plata Basin (LPB) is one of the biggest basins in the world, occupying 17 % of South America's surface with unique regions like Pantanal, Atlantic Rainforest, Cerrado, Chaco, and Pampas. Land use in LPB is highly dynamic and of particular importance for the region and also for the world economy and food security. During the last 40 years new agricultural technologies, increase in demand of agricultural products and favourable climate conditions have caused significant land use change processes in the region, resulting in the prevalence of monocultures and cattle grazing. The major agricultural products in LPB are highly susceptible to climate change, such as: soybean, maize, cotton, sugar/alcohol (sugarcane), forests products (planted forests), meat (pastures), rice, wheat, coffee, and orange, destined mostly for exportation. The project CLARIS LPB – A Europe-South America network for climate change assessment and impact studies, funded by EU FP7 – aims to predict and assess the impacts of climate change, as well as to design adaptation strategies for land-use, agriculture, rural development, hydroelectricity, river transportation, water resources and ecological systems in wetlands. The project initiated in October 2008 and it will take four years. The primary objective of CLARIS LPB is to reveal insights from the complex net of impacts and interdependencies of climate variability, change and anthropogenic adaptation measures on land use, agriculture and deforestation. Interdependencies and relations between land use sectors and other sectors (hydrology, fire) will be taken into account. Future land use scenarios will be elaborated for different climate scenarios through collaboration between researcher groups. The focus is the agricultural sector, especially regarding to small scale versus large-scale farmer's issues. The vulnerability of current cropping systems of major socio-economic relevance for LPB will be analysed through simulations for different climate scenarios by using DSSAT models. Projection of cropping systems under climate change forcing scenarios, sustainability of present cropping systems and adaptation strategies will be elaborated. The costs of climate change for agricultural systems in LPB will also be estimated and the linkage to other land-use sectors will be established.

**Keywords:** Climate change adaptation strategies, climate change, climate models

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## **Erosive Potential of Rains in the Climate Change Scenarios in the Upper Taquari River Basin, Brazil**

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Brazilian Centre-Western Region has become a great producer of grain crops along the last forty years. The vegetation is formed by “Cerrado” composed by bushes and grasses and “Cerradao”. Soil studies in the region have pointed predominantly nutrient poor soils, iron- and aluminum-rich, good physical properties. These conditions, added to the management system used without conservationist practices and not obeying the environmental laws brought drastic consequences to the region such as the water erosion process, especially severe in the Upper Taquari Basin (UTB). Around 90 % this area of UTB is in the north region of Mato Grosso do Sul state, and the erosion effects are reflected downstream in the river, that is connected to the Pantanal Basin. Focused on these problems and based on the IPCC assumptions, Climate Change scenarios were estimated to UTB, seeking to identify the areas with high vulnerability to erosion. Using dynamic modelling of TerraME topopluvial scenarios were generated up to 2100, considering increases and reductions of 15 % in precipitation, by integrating the isoietes to the Shuttle Radar Topography Mission (SRTM) data to generate topopluvial isolines and their attributes were exported to the cell grid of TerraView. UTB is considered more vulnerable to erosion process caused by rains. Estimated rain erosivity in the UTB varies between 6 995.2 and 8 422.1 MJ mm ha<sup>-1</sup> h<sup>-1</sup> ano<sup>-1</sup>, and the higher values are in the north region, in the areas of the municipalities Alto Taquari and partially, the areas of Alto Araguaia and Costa Rica. In the municipalities Rio Verde de Mato Grosso, Camapua and Sao Gabriel do Oeste, the erosivity is lower than 7 120 MJ mm ha<sup>-1</sup> h<sup>-1</sup> ano<sup>-1</sup>. These values increase severely in incremental annual pluvial precipitation scenarios, showing that North of UTB the process will be worst in 2100 if conservationist management systems is not adopted, such as no-tillage cropping associated to the environmental laws application, such as the maintenance of vegetation in the riparian zone and in the areas with slopes higher than 45 degrees, considered by law as permanent preservation areas.

**Keywords:** Cerrado bioma, permanent preservation areas, TerraME, topopluvial scenario

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## **ALUCCSA: Adaptation of Land Use to Climate Change in sub-Saharan Africa (Concepts and Preliminary Results)**

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Farmers and pastoralists of the Sub-Saharan Africa (SSA) face severe challenges from changing climatic conditions (*e.g.* observed later onset of the rainy season), as well as the pressure of a rapidly growing population. Sub-Saharan countries are likely to be severely affected by climatic changes which will complicate the conditions for sustainability of agroforestry production systems and disturb the balance of natural ecosystems. Thus, adequate adaptation and mitigation measures must be developed and these require knowledge on potential trends of climate development in SSA.

The main objective of ALUCCSA is to develop ready-to-use scenarios and recommendations for agroforestry and silvopastoral ecosystems in SSA on highly-resolved spatial scale for the two SRES (Special Report on Climate Scenarios) climate projections (A1B, B1). Scenarios B1 and A1B as calculated from the coupled General Circulation Model ECHAM5-MPIOM are used as input for regional climate models (CLM, MM5) which downscale the climate projections to the regional and local scale for Burkina Faso. In addition, past climatic conditions, vegetation dynamics and current vegetation cover are analysed by means of tree ring analyses, remote-sensing and ground surveys.

The efficiency and sustainability of different land use types under conditions of climate projections is calculated by means of Soil-Vegetation-Atmosphere-Transfer (SVAT)-Model WaNuLCAS (Water, Nutrient and Light Capture in Agroforestry Systems). Climate scenario calculations are currently (as of September 2009) still running. The first results show the increase of mean air temperature and decrease of precipitation in Burkina Faso as compared to the reference period of 1980-2000. The sample based large area vegetation inventory and remote sensing imagery processing has started for Burkina Faso. A number of intensive study sites representing the major bioclimatic zones of Burkina Faso are chosen for the more detailed research and data collection on vegetation, livestock and microclimate, where the installation of automated weather stations has been completed.

**Keywords:** Adaptation, climate change, climate modelling, land use

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# Diversity and conservation

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# Conservation of biodiversity

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## On-farm Tree Diversity Management for Livelihood Improvement and Enhanced Farm Based Diversity: Experiences from the East Mau Catchment, Nakuru, Kenya

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Burgeoning population in Kenya is exerting too much pressure on the natural forests. The forests cover remains paltry <2 % against the UN recommendation of  $\geq 10$  %. Economic and political reasons are increasingly limiting re-establishment of natural forests. Consequently, the agricultural landscapes become increasingly important frontiers for biodiversity conservation and livelihood provisioning. Agroforestry is increasingly becoming a vital tool for achieving this goal. However, its potential and limits of contribution are insufficiently documented. Understanding of farmer strategies in the management of on-farm tree diversity is critical for the successfully implementation of agroforestry programs. Using a sample of 60 smallholder households in the East Mau catchment an assessment of on-farm tree diversity was carried out. Contributions of the current farming systems to tree diversity and various constraints faced by smallholders in establishing agroforestry systems are highlighted. Results indicate that there over 100 species of domesticated trees and shrubs on the farms of which 73 are woody shrubs. Approximately 60 % of trees inventoried on farms were deliberately planted. A number of shrubs were also maintained by farmers for a wide range of reasons: firewood, medicinal, timber and fencing. Most of the fruit trees (over 75 %) are planted by farmers. Following three tree species are ranked in order of preference by farmers: *Cupressus lusitanica* (28 %), *Grevillea robusta* (18 %) and *Persea americana* (13 %). The reasons cited for this preference are: good quality timber, fast maturity, multipurpose uses and soil fertility. Apart from deriving direct livelihoods through sale of firewood, timber and domestic energy farmers perceived trees on their farms to be attracting rains, moderating climate and conserving the catchment (70 %, 4 % and 3 % respectively). The major reasons perceived for poor successes of on-farm tree planting are: drought, lack of appropriate seedlings, costly seedling and smaller land holdings. Efforts should thus be directed at supporting the development of more tree nurseries closer to the communities. Farmers should be trained on seed collection practices. This will ensure timely and cheap provision of seedlings. Furthermore sensitisation on the importance of trees is still vital for the farmers to develop a tree planting culture.

**Keywords:** Agroforestry, livelihood, multipurpose uses, soil fertility, tree diversity

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## The Role of Environmental Education in Sustainable Management of Natural Resources: Insights from the São Paulo City Green Belt Biosphere Reserve, Brazil

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UNESCO's MAB Programme main aim is the improvement of the relationship between man and the environment within the natural resources management framework. According to MAB, the programme proposes an interdisciplinary research agenda and capacity building that targets the ecological, social and economic dimensions of biodiversity loss. MAB Programme considers population altogether with the safeguard of natural resources in the frame of Biosphere Reserves. The MAB Programme is based on an international network for knowledge sharing, research and monitoring, education and training, and participatory decision-making. In this regard the current research presents the discussion about the environmental education's role as a dialogue platform for the promotion of Biosphere Reserves management towards a sustainable development. The case study involves Sao Paulo City Green Belt Biosphere Reserve (RBCV), located within Mata Atlântica Biosphere Reserve, in Brazil. The RBCV was approved by UNESCO in 1994 and it covers 1 611 710 ha along 73 Municipalities. Peculiarly it is traced within a national important urban centre network, as a strategy to safeguard fragments of biodiversity left by devastating developmental processes. The results about the role of the Education in a participatory management of natural Resources, in the frame of Biosphere Reserve Management, are based in a dialog process happened in a meeting among different professionals working in the context of Environmental Education from all around the world. The main results of these analysis were: **(1)** policy recommendations to a more effective Natural Resources management must be based in a participatory learning process that must include all actors within the Biosphere Reserves, all levels of research an effective communication as precondition and; **(2)** in the study case a dialog process was established to face the main current problem target: the recognition of a local park as core zone of the RBCV.

**Keywords:** Biosphere reserves, environmental education, natural resource management

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## Diversity Distribution of Important Savannah Grasses in West Africa: Evolutionary Aspects and Implications for Conservation

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Poaceae is one of most important families in the world, both in ecological and economic dimensions. It is also a major component of African savannahs. As such, the family has been shown to be a good predictor for total plant diversity for the sahelo-sudanian region. Good diversity indicators are necessary where records of vegetation are scarce as it is the case in Africa and many other regions in the tropics. Our aim is to map the overall grass diversity of West Africa. We will compile field observations and herbarium data from large datasets (FloTrop from the CIRAD in Montpellier, Herbarium Senckenbergianum (FR), Ouagadougou University Herbarium (OUA)) and produce maps using GIS. From these maps, total vascular plant diversity will be extrapolated to highlight priority areas for plant conservation.

In second place, we will focus on the grass genera *Andropogon* and *Hyparrhenia*, as they are dominant floristic components of the West African savannahs in term of species diversity as well as in terms of total vegetation core. Both genera are composed of approximately fifty African species. Half of those species occurs in West Africa and ten are endemic to the area. Most of them are of great importance for wild grazers and cattle. Patterns of distribution will be shown including diversity, functional types and climatic preferences as well as modelled potential distributions of those grasses under different scenarios of climate change. Our results are important for the understanding of the grass savannahs biomes and are a prerequisite for anticipation of the influence of climate change on the distribution of economically important grass species.

**Keywords:** Biodiversity conservation, climate change, plant diversity map, Poaceae, species distribution modelling, West-Africa

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## **DNA Barcoding: A Method of Diversity Assessment of Termite Communities in Kakamega Forest, Kenya**

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Termites are among the keystone species of tropical ecosystems and contribute to ecosystem processes and carbon and nitrogen cycles. The role of termites for soil processes depends strongly on the species composition and their feeding habits. Termite workers are morphologically rather uniform, and thus exhibit only few traditional taxonomic characters for species identification and yet they dominate in ecological surveys. Therefore, the diversity of termites is poorly understood, especially in tropical forests which are hotspots of biodiversity and threatened by disturbances. Recently, the use of DNA-sequences (barcoding) has become more important for inventory and biodiversity assessment of hyperdiverse taxa and those which are difficult to identify. An approach towards establishing a DNA barcode library for termite species identification and biodiversity assessment using sequences of the mitochondrial COII gene is presented in this study. Kakamega forest is the remnant of the Congo-Guinean Forest reaching Kenya. This isolated forest is a hotspot of biodiversity which is threatened by the increasing human population. Depending on the land use, along a gradient from primary rain forest to farmlands, the species composition among the termites varied greatly, dominated by termite species feeding on wood in the primary forests and by grass feeding termites in farmlands. Hence, to interpret the role of termites in different land-use habitats the species composition needs to be understood. Here we present termite biodiversity assessment using sequences of the mtCOII gene. At least 16 termite species were observed in Kakamega Forest by morphological determination whereas at least 22 species (MOTUs) were found by molecular species delimitation. This highlights the advantage that molecular based species delimitation and reveals some morphological cryptic species.

**Keywords:** DNA barcoding, Kenya, termites

## Conservation of Endangered Plant Genetic Resources: Assessing the Role of Cultural and Religious Beliefs in the Sustainable Management of Sacred Forests in Pakistan

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In Pakistan high deforestation rates (2 % per annum) is causing the extinction of economically and medicinally beneficial plants. Several plant species of peculiar medicinal properties and genetic characteristics are on the verge of extinction. However, Muslims' Graveyards Forests are still preserved because of the local communities' religious beliefs. This paper assesses the relationship between conservation and religious beliefs in Phytosociological study using data of two sites in northern Pakistan. Muslim Graveyards forests unlike non-graveyard forests show a rich flora, which is a sign of their being naturally maintained ecosystems with minimal anthropogenic activities as people of the local community believe that cutting trees may harm their families.

In the first site, we counted 95 plant species (44 woody and 51 herbaceous). Second study site show 92 plant species (24 are woody and 68 are herbaceous). Important medicinal plants such as *Berberis lyceum*, *Vitex negundo*, *Acacia modesta* and *Olea ferruginea*, *Quercus diltata*, *Daphne mucronata*, *Celtis australis*, *Justicia adhatoda*, *Rubus fruticosus*, are abundantly found in the Muslim graveyard forests while non-graveyard forests with the same agro ecological conditions these plant species are not available due to forest degradation.

This study signifies the role of certain religious beliefs in environmental conservation in a community and thus Muslim graveyards forests could be used as a gene pool for future preservation of the important endangered medicinal plants species. Some biotic interference such as grazing, cutting and fuel wood extraction are occurring with changes in the society as well as changing landscape of overpopulation and urbanisation leading to the loss of the plant habitats which could endanger the conservation of these forests. Therefore, these plant genetic resources need to be conserved through the active participation of the local communities. The conservation agencies should focus on these sacred forests on one hand and should involve local elders and religious leaders in conservation programs to give incentives for future plant conservation. Legislations and incentives are needed to ameliorate the effects of grazing, lumbering and fuel wood extraction. Areas around these graveyards should be preserved to protect it from the effects of biotic interferences.

**Keywords:** Deforestation, medicinal plants, Pakistan, sustainable use

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## **Agro-biological and Socio-economical Diversity of Homegardens in Fereydan Region of Esfahan, Iran**

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Homegardens are microsystems within wider agroecosystems that include numerous levels of diversity, including cultural and agricultural diversity. Little is known about the species diversity and management systems of Iranian homegardens. The objectives of this study were therefore to inspect management system of homegardens as well as to develop an inventory on composition of agricultural species in homegardens of Fereydan region of Esfahan, Iran. Direct observation and semi-structured interviews were employed to collect primary data in 2008. Altogether 96 homegardens were surveyed in four different districts. Shanon-Wiener index was engaged to determine species richness of districts. From that, evenness was calculated to estimate the homogeneous distribution of species in the homegardens. The Srensen coefficient of similarity was employed to calculate the similarity of species composition between districts. All in all 47 plant species were identified which were classified based on their preferred uses by the households. Fruits showed highest species diversity within homegardens followed by vegetables and medicinal species. The evenness of total species distribution was similar in all restricts. The highest similarity was found for vegetables (91 %) followed by fruits (83 %) and medicinal plants (76 %). The average number of species richness varied from 4 to 18 in different homegardens. According to species groups, vegetables were the most homogeneously distributed followed by fruits and medicinal plants. Average size of homegarden areas varied from 800 m<sup>2</sup> to 2 400 m<sup>2</sup> in the different districts. Most of the products were used by family members and only partially (7 %) sold on local markets. The total income gained from homegardens was 5–13 % of total family income and women endeavour 2.7 times more than men in homegarden's routine activities. The results of this study confirm the impact of the socioeconomic characters of the homegardeners on the agrobiodiversity of their homegardens.

**Keywords:** Agrobiodiversity, agroecology, homegardens, plant genetic resources

## Assessment of Diversity in Areas with Different Use Activities in the Tamaulipan Thornscrub, Mexico

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The Tamaulipan Thornscrub is the second ecosystem more impacted in Mexico and there insufficient information about your restoration. This research assessed the shrub species in the Tamaulipan Thornscrub, of Northeast of Mexico, in three areas with different historical of use; cattle grazing, agriculture and clear-cutting, on which technique was applied as restoration, the exclusion of activities for forestry, agriculture and cattle grazing for a period of 21 years. The objective was assessing the recuperation of the areas without anthropologic activities and an comparative analysis of species richness, diversity and ecological parameters of arboreal layer in the three areas with different historical of use. In each area were established 4 sites for sampling of 250 m<sup>2</sup>, where obtained height (h), diameter (d0.10) and crown (N-S, E-W), with the values obtained are estimated the ecological indicators of abundance (Ar), dominance (Dr), frequency (Fr) and importance value index (IVI), the richness index of Margalef (DMg), of diversity index of Shannon (H') and an analysis of variance (ANOVA) for compare statistically the areas. The results showed that technique of exclusion of areas is an effective method of rehabilitation in the Tamaulipan Thornscrub, due to heliofilas shrub species and nitrogen fixing that after the cessation of activities are pioneers. The richness ( $S \geq 20$ ) and diversity ( $H' \geq 2.10$ ) of shrub species of the three areas is higher that pristine ecosystem. According of analysis of variance ANOVA the areas assessed showed significative difference in diversity ( $P=0.019$ ), according the Tukey test, clear cutting area ( $1,68 \pm 1,14$ ) not is significative different with agriculture ( $1,27 \pm 0,92$ ) and cattle grazing, while that agriculture and cattle grazing are different. The research contributed important information for the rehabilitation and restoration of affected areas for activities of forestry and cattle grazing in the Tamaulipan Thornscrub.

**Keywords:** Ecological indicators, exclusion of areas, rehabilitation

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## Conservation of Tropical Root Crop Agrobiodiversity: On-farm True Seeds Production and Use as a Mean for Geographic Distribution of Allelic Diversity

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The tropical root and tuber crops (cassava, sweet potato, taro and yam) are cultivated throughout the tropics where they play a major role for food security. In Vanuatu, an archipelago of 81 islands situated in the South West Pacific, traditional food gardens are at the basis of self-sufficiency with tuber and root crops as the main source of carbohydrates for smallholders. Emerging environmental changes such as climatic ones, the introduction of new plant diseases and/or changing diets are now endangering the local agrobiodiversity and the country's food security. As several molecular genetic studies have shown, the local tuber and root crops diversity of Vanuatu is narrow and in the course of genetic erosion, its resilience to changes is thus quite limited. To enlarge this genetic pool, introduction of exotic varieties has been conducted through *in vitro* genotypes but excessive distribution costs and the limited success of the operation, mainly due to the high fragmentation of the country, pointed up the need for other means of allelic dispersion. True botanical seeds production and use seems to be a promising way since it is easier to distribute and because it enables efficient protection of local allelic pool by crossing it with introduced one. However, the adoption of this innovative practice by traditional smallholders raises numerous problems since they are practicing exclusively clonal propagation and are not aware of tuber and root crops sexual reproduction. Our project aims at evaluating the potential for on-farm true seeds production and use through participatory methods. This study will focus on main environmental, economical, social and cultural constraints to the development of this practice in on-farm conditions. Since the sexual reproduction of these plants is poorly documented, this study will also assess the efficiency of this method through the characterization of reproductive biology and estimation of the percentage of new cultivars created during a cycle. We will finally evaluate the possible practical improvements by building on farmer's own experiments and analysis of their difficulties. As most of the work on tropical tuber and root crops true seed of has been limited to scientific research stations, it is of interest to develop this technique for on-farm activities.

**Keywords:** Food safety, genetic diversity, geographic distribution of allelic diversity, on-farm conservation, root crops

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## Invasive Alien Plant Species in Ethiopia: Impacts, Challenges and Responses

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Invasive Alien Species (IAS) are of a great concern in Ethiopia, posing particular problems on biodiversity of the country, agricultural lands, range lands, national parks, water ways, lakes, rivers, power dams, roadsides and urban green spaces with great economic and ecological consequences. Foremost among these are *parthenium* weed (*Parthenium hysterophorus*), prosopis (*Prosopis juliflora*), water hyacinth (*Eichhornia crassipes*), cactus (*Euphorbia stricta*) and lantana weed (*Lantana camara*). They have been identified by the environmental policy and the national biodiversity strategy and action plan as a major threat to biodiversity of the country and economic well being of its people. However, little attempt has been made in terms of research and management of IAS. Their high seed production capacity and spread, adaptation to wide climatic and soil conditions, spread by animal movement and their association with pastoralists way of life and overgrazing are challenges to their management in Ethiopia. Manual control of *Parthenium* by farmers resulted in some of them developing skin allergies, itching, fever, and asthma. Prosopis form impenetrable thicket that prohibits free movement of people and animals and its thorns damage eyes and hooves of animals. The social cost of *parthenium* in Ethiopia was measured by disability adjusted life years and its equivalence in terms of monetary value was estimated at 2,535,887–4,365,057 USD. More resources have to be invested to tackle the IAS problem as the estimated loss is disproportionate to the cost of investment on IAS research and development activities. This paper attempts to document the available research information on IAS, *i.e.* distribution and spread, impacts, control measures and suggest the future prospects on research and management.

**Keywords:** Invasive alien species, *Parthenium*, *Prosopis*, water hyacinth

## Screening for Variability in Salt Tolerance within a Georgian Wheat Germplasm Collection

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Bread wheat *Triticum aestivum* L. possesses a genetic variation for the ability to survive and reproduce under salt stress conditions. Durum wheat (*T. durum* Desf.) is in general more sensitive in comparison to bread wheat, however, exceptions can be found showing the same extent of salt tolerance. Endemic wheats in general are characterised by a high adaptability to their environment. In Georgia several wheat species were already cultivated since the Neolithic and Early Bronze Age and the region is known for the abundance of endemic species. The level and variability of salt tolerance were assessed in a germplasm collection of 144 winter and spring wheat accessions from Georgia comprising *Triticum aestivum* L., *T. durum* Desf., *T. dicoccon* Schrank, *T. polonicum* L. and Georgian endemics: *T. carthlicum* Nevski, *T. karamyshevii* Nevski, *T. macha* Dekapr. et Menabde, *T. timopheevii* (Zhuk.) Zhuk. and *T. zhukovskiyi* Menabde et Ericzjan. The accessions were tested for salt tolerance at the germination stage using four sodium chloride (NaCl in H<sub>2</sub>O) concentrations (0, 175, 210 and 350 mmol l<sup>-1</sup>). Large variability in salt tolerance within the Georgian germplasm was found among the different wheat species. The genetic background of the endemic hexaploid winter wheat *T. macha* comprises a higher potential for salt tolerance traits than *T. aestivum*. In general, the accessions of the tetraploid species responded to the lower sodium concentration with similar germination scores as the hexaploid wheat accessions, but germination and growth were severely reduced when the genotypes were subjected to the highest concentration of NaCl. The endemic wheat *T. timopheevii* was among the most tolerant tetraploid materials. Therefore, the Georgian endemic wheats represent promising donors for salt tolerant traits for future breeding efforts for salinity tolerance in wheat.

**Keywords:** Georgian germplasm, germination stage, salt tolerance, *Triticum*

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## Ethnobotanic Examination of Tropical Home Gardens in Calakmul, Campeche, Mexico

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Tropical home gardens are unique land use systems with high agrobiodiversity and important contributions to livelihood sustainability. Problems addressed in this work are the loss of biodiversity and traditional knowledge of plants and poverty in the research area.

Applied research questions shall clarify, i) what and how many plant species are used in the home gardens, ii) what are the differences between the home gardens, ...

In 2008 an ethnobotanical research was conducted in 20 home gardens in 4 villages in Calakmul (Campeche, Mexico). The inhabitants are exclusively farmers and immigrants with different origins.

Data was recorded on the botanical composition, structure and infrastructure of the home gardens, on the socioeconomic background and on the traditional knowledge of the farmers (use of plant species, garden management and preparation of the products of the home gardens). A Ranking was applied to show the valuation of the farmers on different functions of the home gardens.

A total of 310 plant species were found, of which the most abundant families were the Leguminosae (29 species), the Euphorbiaceae (16 species) and the Palmaceae (13 species). The herbaceous plants were most abundant with 119 species, followed by trees (93 species) and bushes (57 species). The most frequently found species were *Citrus sinensis*, *Chenopodium ambrosioides* and *Spondias mombin*. The most frequent use of plants is ornamental (41%), followed by food (35%) and medicinal use (30%). 28 plant species were exclusively found in home gardens of Mestizos and 5 plant species appeared exclusively in Chol home gardens. The number of species varies between farms (32–141 plant species) and villages (111–203 plant species).

The botanical composition of the home gardens is strongly related to the cultural background of the farmers. Nevertheless age, gender or culture (being Chol or Mestizo) does not have an impact on the farmers' valuation of the different functions of home gardens.

The high number of plants found in the home gardens and the amount of traditional knowledge imply that the products of the home gardens fulfil many needs in the livelihood systems of the farmers of Calakmul.

**Keywords:** Biodiversity, ethnobotany, sustainable livelihood, tropical home gardens

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## Medicinal Knowledge in Cuba — Domestic Prescriptions Using Front and Backyard Biodiversity

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For about a decade the Portuguese Tropical Research Institute (IICT) has been interviewing traditional healers, urban gardeners, peri-urban farmers, medicinal herb traders and plant therapists in Latin America, in order to assess local resources usage and built-up local knowledge databases that might provide future generations' alternate ways to deal with health problems. During April 2009 a sample has been extracted from a couple of La Habana municipalities (Playa and Plaza de la Revolución) totalling fifty interviews both to households possessing front or backyard (47) and to small herb traders (3). Results proved to be quite similar to previous cities and metropolitan areas investigated, starting with Belém (Brazil) in 1998 and 2005, followed by Santiago (Chile) from 2002 to 2005, Mexican Central Metropolitan Region in 2004 and 2006 and Lima (Peru) in 2006. A total number of sixty medicinal species have been registered in Habana, the most consumed being Tilo or Tila (*Justicia pectoralis*) an anti-flu and anti-stress half a metre Caribbean herb possessing the same common designation of *Tilia europaea*, a tall old world tree, with identical therapeutical indications. In matter of fact, the top ranking species consumed in the other four countries has always been an eclectic herb, either European (Peru and Chile) or local (Mexico and Brazil), yet named after a European plant species with comparable prescriptions usually a mild tranquiliser. Results discussion is an ongoing joint La Habana University (CESBH) — IICT process aimed at exploring local ethno-botanical resources pharmaceutical virtues so as to present alter ways to cope with aches, flu, chronic diseases while mitigating more serious health problems. The expectation is to promote life quality and adequate medicinal herb management among urban gardeners and plant therapy believers worldwide.

**Keywords:** Cuba, Latin America, local medicinal knowledge

## Protected Areas: From Vertical Institutions to Collaborative Dynamics

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By shedding light on nature/society relations, the articulation of complex networks is revealed. It is essential, however to consider the heterogeneity of such arrangements - composed of human actions and non-human counterparts. Within this framework forest fringe communities are seen as a network of micro-power relations. From two cases studied, I bring into the debate arena the institutionalisation process of protected areas. Through Serra da Capivara National Park case, in northeast Brazil, I seek to illustrate the National Parks concept and the patrimonialisation of the territory. The research questions in one hand socioeconomic processes undergone by fringe communities on the face of institutionalisation, and on the other the challenges of park's conflict management. Seen as a step ahead on the management perspective, not only optimising resources but also recognising the importance of local networks on the issue of biodiversity protection, the case of Ankasa Conservation Area in Ghana further the discussion. It questions the institutional initiative of community empowerment in resource management and its expectations. Overall, I seek to locate the agenda in which biodiversity protection is inserted, both internationally and locally. Therefore empirical analyses are sensible to the cultural milieu, sometimes requiring the change of lenses so as to perceive the richness of local livelihoods contingencies to the institutional arrangements and the impact from the introduction of alternatives. The participatory approach of contemporary policy-making brings into discussion strategies not only for conflict resolution but to promote socio-economic inclusion into the decision-making process and, therefore a development that is more sustainable. However, the attempt to secure social, ecologic and economic sustainability is met by the challenge of coalescing interests of conservation and uses of natural resources. It means that protected areas should not be considered as ecological islands but recognise the importance of off-reserves' participatory rural development. Management alternatives aiming integration of rural communities and devolved authority - such as benefit sharing, community-based management and multilateral panels - are then included into the modern preservationist agenda.

**Keywords:** Collaborative strategies, fringe communities, forest management, protected areas

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## **Tropical Deforestation Affects Long Term Persistence of Sumatran Tiger: A Modelling Study**

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Road construction has been used to explain deforestation patterns in tropical areas. Roads divide tropical forest into several forest fragments and lead to isolation of wildlife. The presence of roads provides good accessibility for predators such as the Sumatran tiger as well as for its preys. However, at the same time, roads increase the probability of animals being exposed to humans and consequently increase their mortality. Could road development be used to explain the mortality of the tiger and its prey? Do Sumatran tigers survive in the presence of roads encroachment in protected area?

Deforestation through road development within the Tesso Nillo national park was investigated during 1982 to 2005 using satellite images. The results were used as input for an individual-based model of Panthera Population Persistence (PPP) describing the spatial dynamics of the Sumatra tiger population in order to provide a better understanding of the mechanistic effects of deforestation on this endangered animal. This model considers tiger reproduction, feeding behaviour, and prey dynamics. The importance of each process and its parameterisation was extensively tested by sensitivity analyses using the improved Morris method. The development of main roads, as well as logging roads were simulated for three different scenarios based on the observations in the national park. The time horizon of the simulations was 15 years. The effect of the different scenarios on the number of death tiger and its prey were assessed, and a ranking list was compiled serving as recommendation for a decision support system.

**Keywords:** Deforestation, individual-based model, Sumatra tiger, wildlife

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## Centres of Diversity and Narrow Endemism for Flowering Plants in the Mata Atlântica and their Potential Threats

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The importance of the Mata Atlântica as centre of extraordinary species richness and endemism is well-known, but distribution patterns for many angiosperm species are still unknown. In view of the ongoing degradation and destruction of the last remaining forest fragments in the Mata Atlântica, detailed knowledge about distribution patterns, in particular of endangered species, is essential. However, the tropics in general are under-collected and the taxonomical identification of the specimen collected is often difficult. Furthermore, heterogeneous sampling effort, concentrating on few sampling locations and selected plant species, obstructs the detection of broad-scale distribution patterns. In this study, we used an interpolation approach (at 1° grid resolution) which is adjusting for heterogeneous sampling effort, to analyse monographic data of 667 angiosperm species occurring in the Mata Atlântica, including non-tree species. We identified two diversity centres, one large centre covering the coastal belt between the western tip of Paraná and the centre of Espírito Santo, and a second centre south of Bahia. We further located centres of narrow endemism, which are characterised as areas holding many species with a narrow distribution (less than five adjacent 1° grid cells). These centres of narrow endemism are located along the Serra do Mar mountain range, stretching from São Paulo to Rio de Janeiro, in the centre of Espírito Santo, in Minas Gerais and south of Bahia. The combination of maps of narrow endemism and maps of protected areas as well as maps of forest and population development scenarios recognises areas most threatened by anthropogenic impacts.

**Keywords:** Angiosperms, interpolation approach, Mata Atlântica, narrow endemism, protected areas, species richness

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## The Diversity of *Inga edulis* Mart. (Mimosoideae) in Peruvian Amazon

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*Inga edulis* Mart. (Mimosoideae) is a tree leguminous species widely planted in the Peruvian Amazon. It has large use in agroforestry systems due to its delicious fruit, rapid growth, shade potential for productive plantations and soil-improving ability. *I. edulis* is said to show growth variability on different environmental sites. The objective of the study was to indicate whether the diversity is really significant and also if there exists the variability between natural and deliberately planted trees. The field work was conducted from June 2008 to October 2008 in Ucayali department, Peru. Twenty-four trees (both deliberately planted and wild ones) in three different villages, twelve trees on experimental site and three trees nearby primary forest were randomly selected and morphological evaluation was performed. The leafy material of each accession was collected and preserved in silica gel. The statistical analysis (basis statistics and principal component analysis) of gathered data was done and completed by neural network analysis (self organizing map, histograms and feature ranking analysis). The subsequent primary screening of DNA was done using PCR method. The results have shown low morphological variability among tree samples in different locations. There was not revealed neither qualitative nor quantitative feature with which the clear identification of trees from different locations should be done. On the other side, the more vigorous growth of wild trees and bigger pods of planted ones were observed. The polymorphism of tree samples was detected using ITS primers. The results from PCR analysis confirmed the variability among particular sites and even among particular trees on one locality, which was proposed in the statistical and neural network analysis.

**Keywords:** *Inga edulis*, morphological features, neural network analysis, PCR



## **Inventorying Diversity, Use and Conservation Status of Indigenous Fruit and Nut Species of Nepal for Developing ‘Conservation through Use’ Strategies**

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Nepal is considered one of the richest biodiversity hotspots, including numerous fruit and nut species. These plants play a significant role, especially for the well-being of rural people through providing nutrition, household income and employment. However, many of these species are said to be threatened and disappearing. This paper aims to determine the diversity, utilisation and conservation status of Nepal's indigenous fruit and nut species.

In different climatic zones of Central and Eastern Nepal, covering elevations from 200 to 4200 m asl., indigenous fruit and nut species were surveyed in forests, homegardens, along roadsides, and in markets. Information about the species' local names, life form, conservation status, and seasonal market availability was gathered by interviewing villagers and fruit traders, together with personal observations and reviewing literature.

In total, 124 indigenous fruit and nut species were recorded, of which 66 were trees, 34 shrubs, 11 climbers and 13 herbs. In homegardens alone, 39 indigenous fruit and nut species were grown. Most of these species are not domesticated, and they were found to be threatened by genetic erosion. Main reasons for this appear to be urbanisation, agricultural expansion and deforestation, but also few new plantings due to lack of knowledge and planting materials. Finally, particularly young people change their eating habits, which results in high demands for exotic instead for indigenous fruits and nuts.

There are obvious needs in Nepal for documenting the diversity and potentials of these species. This will serve to improve their propagation and production and to conserve their genetic resources. Currently, these species are being neglected by research and development programs in Nepal. The surveyed homegardens were found to be sites of a large variety of indigenous fruit and nut species because the diversity of products was highly valued by the managing households. Thus, we suggest homegardens as a very suitable agroforestry system for the conservation of fruit and nut genetic resources through use. This should be encouraged by initiatives, which promote proper management techniques and develop marketing strategies for indigenous fruit and nut products, but also make available improved planting material.

**Keywords:** Agroforestry, biodiversity, homegardens, rural livelihood, tree domestication

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## Wild Resource Use among Dai People in Nabanhe National Nature Reserve (NNNR): Cultural Importance of Medicinal and Food Plants

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Nabanhe National Nature Reserve (NNNR) located in Xishuangbanna Dai Autonomous Prefecture, SW China is rich in biological and cultural diversity. Plant diversity includes 1954 species, 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, Hani and Yi. Dai people are living mainly in four villages which are located in low altitudes. They have their own community forest, sacred forest and their own perception about forest and environment. In this study wild plant uses among Dai ethnic group have been studied. Data collection was done through conducting freelisting interviews, semi-structured interviews, field walks and botanical sample collections. Botanical samples were identified scientifically and cultural importance of useful plants has been calculated. Dai People in NNNR are benefiting from 143 species of wild food and medicinal plants from 51 families from which 76 species are used medicinally and 81 species as wild food and 14 species is considered as food and medicine. The culturally most important food plants are *Callipteris esculenta* (Retz.) J. Sm. (*Dryopteridaceae*), *Piper longum* L., *Piper flaviflorum* C. DC. (*Piperaceae*), *Solanum americanum* Mill. (*Solanaceae*) and *Musa acuminata* Colla. (*Musaceae*). Most important medicinal plants for Dai people include *Tacca chantrieri* Andre (*Taccaceae*), *Clausena excavata* Burnm. f. (*Rutaceae*), *Plantago erosa* Wall. (*Plantaginaceae*), *Boehmeria siamensis* Craib (*Urticaceae*) and *Artemisia argyi* Levl. et Van. (*Asteraceae*) The results shows that most of the food species are collected from farm edges, road sides or water streams near rice fields whereas most of the medicinal plants are collected from collective or secondary forest. Detailed information about the importance of land use type as a source of medicinal and food plants will be presented.

**Keywords:** Dai minority, ethnobotany, wild medicinal plants, wild food plants

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## **Analysis of Regional Industrial Cluster Development: An Example of Leather Industry in West Java-indonesia**

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Cluster theory has become a widely used concept in the literature on promoting regional economic development, innovation and growth. Cluster is an aspect of a broader re-orientation of research and economic policy towards the microeconomic foundations of prosperity and growth and as a new approach to help macro-economies reap the full potential of creation market institution. This has led the Indonesian government to adopt a clustering approach as an important element in its rural development strategy to promote the development of rural industry, which consists mainly of Small Medium Industries. In this paper, the study will focus on the empirical literature that is relevant to cluster identification, cluster development and to analyse the agglomeration forces that operating in the alleged cluster in West Java, Indonesia. This paper deals with the development of cluster capabilities inside industrial cluster firms and discusses the relationship between: firms networking with other firms and external partners inside their clusters; and the effects of this networking on the innovation performance of the cluster firms. Identification of alleged cluster using the Location Quotient (LQ) technique and to identify the agglomeration forces that operating in the alleged cluster using path analysis model. The paper reports findings from a research study conducted in West Java-Indonesia, where 110 enterprises based in industrial clusters responded to the questionnaire survey. The study shows that 'strategic networking' inside clusters improves both product innovation performance and overall speed of the innovation process inside technology-based SMEs, which ultimately effects competitive performance. Cluster has a higher employment concentration, productivity, and rivalry compare to non cluster, this could lead for competitive price. Buyer, supplier and competitor are proximity relevant as source of knowledge for innovation while universities and research & development institutions are not relevant. 70 % of input factors is acquired in cluster while 30 % only in non cluster.

**Keywords:** Industrial cluster, regional competitiveness, regional development

## The Potential of On-farm Fence Lines for Livelihood Improvement in Kakamega, Western Kenya

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Western Kenya is characterised by nutrient-depleted soils resulting from long-term unsustainable land use due to widespread poverty and a high population density. This desperate situation necessitates new approaches of managing the scarce land resources. Hence, we evaluated the potential of on-farm fence structures that cover about 4 to 5 % of the total area. These fences demarcate fields and homesteads, provide firewood and fruits, and are used as trash lines for maize stovers. Accordingly, we hypothesised that the soil below undisturbed live fences has a higher fertility status than the constantly tilled adjacent farmland. We further assumed that this effect varies by soil type and species that dominates the fence structure. Hence, we selected sites on Alfisols and Ultisols, the two dominant soil types in Kakamega District, with fence lines dominated by the following species: *Lantana camara*, *Tithonia diversifolia*, *Psidium guajava*, *Dracaena* spp. Topsoil samples were collected below the fence and with an increasing distance gradient and analysed for bulk density, aggregate stability, soil texture and pH, total nitrogen and carbon, available phosphorus and potassium, mineralisable nitrogen, and permanganate-oxidisable carbon. Additionally, in a greenhouse experiment the biomass of maize cultivated on the collected soils was determined and analysed for total nutrient uptake. Preliminary results indicate that the distance from the fence and the fencing species had a distinct effect on maize biomass accumulation on both soil types.

Chemical analysis revealed that depending on the fencing species soil parameters like pH, available potassium, and total carbon and nitrogen are positively influenced by the fence lines when compared to the adjacent field. In contrast, the amount of available P is in most cases reduced below the fence lines. These findings applied for both soil types but with a different extent.

Due to higher inherent fertility, on-farm fence lines have a significant potential for improving the livelihood of subsistence farmers in Western Kenya. By integrating high-value crops or trees in fences, valuable products such as firewood, timber, medicinal plants and fruits could be integrated into the farming systems and generate additional income, improve the people's health status and contribute to environmental conservation.

**Keywords:** Alfisol, *Lantana camara* L., soil quality, *Tithonia diversifolia*, Ultisol, *Zea mays*

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# Management and use of biodiversity

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## **Changing Landscapes, Changing Lifestyles in Xishuangbanna, SW-China identifying Farming-Systems and Emerging Inequalities in Naban National Nature Reserve**

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Xishuangbanna, a prefecture in the southern part of Yunnan Province bordering Laos and Burma, has always been- in many ways- a transition zone between Mainland Southeast Asia and Mainland China. Over the last centuries this remote area has evolved into a highly diverse natural, socio-cultural and agricultural landscape. Despite its peripheral location, Xishuangbanna has never been uncoupled from the developments in other parts of China and as a consequence of the rapid development, rubber growing has become a major occupation in the (sub)tropical area. The repercussions of population growth and rising demands in food and cash crops have strong impacts on the area; for example a sharp decline of biological and agricultural biodiversity is observed

However, profound institutional changes since the end of the collectivisation-period, for example the emergence of market structures and the introduction of the household responsibility system, have lead to an increasing diversity of income generation of notoriously poor rural households. Our paper is based on current research in the Naban National Nature Reserve, an area which is well reflecting the overall diversity of Xishuangbanna, in terms of ecosystems, altitudes, socio-cultural diversity and agricultural capacity and viability.

After presenting the political and cultural institutions and frameworks governing land-use in the Reserve Area, we will focus on different farm-types, which were identified in a quantitative household survey conducted in 2008. Three different farming-systems were identified, which show huge differences in rubber shares, income generation, farming activities, land-availability, sustainability of natural resource use, etc.

In combination with research based on qualitative methods, the paper attempts to explore the multiple causes for the emergence of local distinctions and inequalities and particularly importance of monoculture. Furthermore, we will discuss approaches and options to enhance rural development without compromising the Natures Reserve's task to conserve and protect natural resources as an economic base and biodiversity.

**Keywords:** Farming-systems, institutional change, land-use change

## **Management of Enset (*Ensete ventricosum* (Welw.) Cheesman) Diversity in Wolaita, Southern Ethiopia: Farmers' Knowledge and Implications for On-farm Conservation**

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Enset (*Ensete ventricosum* (Welw.) Cheesman), an endemic staple and co-staple food crop for about 13 million people of Ethiopia, is often called 'the tree against hunger'. The Wolaita are among the people of enset culture' in the Southern Nations Nationalities and Peoples Region (SNNPR) of Ethiopia. With the objective of assessing the extent and indigenous management of enset diversity, and there by identify factors affecting it, stratified random sampling technique was employed to select 225 households from nine Peasant Association (PAs) of Wolaita zone. A total of 59 named farmers' varieties/landraces were recorded. The number of landraces maintained on individual farms ranged from 2 to 33 with mean and standard deviation of 7.4 and 3.63 respectively. Most (78 %) of the landraces had limited distribution and abundance, and only few dominant landraces were widely grown. There was considerable variation amongst locations and farms with respect to landrace diversity. The number of landraces per farm was hghly correlated with household characteristics and with farm and livestock size. The Wolaita farmers maintain diversity as a way to ensure harvest security or stability of production, minimising crop failure risks, and for multiple use of the crop as food, fiber, medicine, animal feed and as income source. Perceived as morphological and cultural traits, individual landraces with their different group of classifications were identified. Combination of local practices: acquisition and selection, propagation, planting patterns, spatial arrangement, selective and mixed harvesting and processing of landraces were described for their implication of the role of farmers in managing the dynamics of enset diversity in Wolaita. Furthermore, the enhancement and conservation significance of the crop is discussed.

**Keywords:** Enset, Ethiopia, farmers' varieties, on-farm conservation

## Environmental Services in Agroforestry Systems. How to Assess Them?: Functional Biodiversity in Tomé-Açu, Northern Brazil

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Agroforestry, combining agricultural with forestry components at plot, community and landscape level, through a component-specific management can satisfy a series of multiple demands, among them, biodiversity conservation and in general the provision of environmental services.

Since environmental services are proposed as compensation schemes to prevent and remediate negative environmental impacts, incentives that support ecologically sound agricultural management practices are therefore needed. These incentives (*e.g.*, compensation payments) have to be based on an adequate understanding and evaluation of the services provided by the agricultural systems.

For this purpose, the concept of biodiversity in land-use systems has been revised. 'Functional biodiversity', in contrast to traditional approaches, emphasises the system's dynamics at various levels and the implications of these on its functioning as a whole. To operationalize such a concept, an assessment protocol based on multicriteria analysis has been developed. The approach combines productive, ecological and operational indicators to describe functional biodiversity, and aims at the identification of those management decisions and interventions that support this.

The suitability of the evaluation protocol was tested with 70 farms in the Brazilian Amazon region divided in three groups, which had been defined based on the time of settlement, property size, technological know-how, organisation and access to market, *i.e.*, 'CAMTA partners' long-ago established farmers, 'immigrated' some time ago and recently immigrated farmers 'newcomers'.

The analyses reveal that the most relevant factors supporting functional biodiversity in agroforestry systems are: (1) the farmers' technical qualification, (2) their preference for low impact techniques, (3) their capacity to adapt to environmental, social and political changes, (4) the diversification of species composition at plot level, (5) the increase in the use of perennial species; and (6) the financial profitability of the system. Concerning the differences among groups, the 'CAMTA partners' farmers are significantly superior to the two other groups only in agricultural practices related to production.

As the functional biodiversity concept is based on an integrative approach, its outputs provide a supportive platform for the proposed assessment framework. In turn, the developed protocol can be used to optimise biodiversity roles on farms and support decisions regarding compensation payments.

**Keywords:** Brazil, environmental services, functional biodiversity, multicriteria analysis, tropical agroforestry systems

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## **Analysis of Diversity among and Heterogeneity within Tomato Cultivars from Eritrea**

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Tomato production has a long tradition among farmers in Eritrea. Yet, the average yield of tomato in Eritrea has remained low, 15 Mg ha<sup>-1</sup>, compared with 19 Mg ha<sup>-1</sup> on average in Africa, 23 Mg ha<sup>-1</sup> on average in Asia and 27 Mg ha<sup>-1</sup> on average world wide. One of the main constraints for tomato production is the poor performance of the cultivars. This study aims at analysing diversity among and heterogeneity within tomato cultivars from Eritrea and compares these data with other African and Italian cultivars.

Simple Sequence Repeat (SSR) markers were used for the genetic analysis. Genetic similarities among the cultivars were calculated and a cluster analysis performed using NTSYS. Furthermore, individual plants of cultivars were genotyped to evaluate heterogeneity within the cultivars.

A high degree of diversity was observed in the Eritrean cultivars. Thirteen out of the 15 SSRs were polymorphic, with 2-5 alleles per marker. The average number of alleles per SSR locus was between 1.0 and 1.4.

The dendrogram showed two major groups of cultivars, distinguishing the San Marzano and Marglob types. It also showed the genetic relationships between the old Italian cultivars and the Eritrean cultivars in both types.

Analysis of the within-cultivar variation showed that the Eritrean tomato cultivars were less uniform than the other cultivars. This most likely results from mixing up of genotypes.

Farmers value 'new material' as a source of influx. A survey among farmers showed that some of them purposely mix seeds to get prolonged harvest, for yield stability and stress tolerance contributing much to the genetic diversity in their originally selected 'Secret seed'.

**Keywords:** Diversity, Eritrea, heterogeneity, SSR, tomato

## (Un)sustainable Use of Frogs in West Africa and the Resulting Effects for the Ecosystem

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Amphibian populations are declining world wide. One of the major reasons for this decline is overexploitation. All over the tropics many anuran species are caught from the wild, mainly for food, but also for medicinal purposes or the pet trade.

In West Africa the frog trade seems to increase dramatically in recent years. It so far was mainly restricted to local or national scale. However, we now could also detect intense cross-border trade of frogs from Benin to Nigeria. Whereas particular West African tribes have always used frogs as food, medicine or for cultural reasons, the current increase in frog hunting seems to be new. As savannah frogs are key-species for the functioning of temporary savannah waters, their decrease or even local extinction are likely to have unforeseen and negative ecological consequences, including effects on human welfare and health. In rural savannah regions of West Africa, freshwater ecosystems are essential water resources for humans and cattle. Altering these ecosystems therefore may have important economic and health consequences. Prospective impacts on water chemistry, algae and aquatic invertebrate taxa are therefore likely. In our project we are investigating the extent, the social, socioeconomic and the ecological aspects of a probably unsustainable use of frogs in northern Benin, south-eastern Burkina Faso and Nigeria. To address these topics we carried out semi-structured interviews in different areas in the respective countries. Surveys of natural freshwater ponds were undertaken in proximity to villages where frogs are exploited and in protected areas for comparative reasons in Burkina Faso. Additionally, we set up artificial tadpole communities involving species from different trophic levels. This approach allowed us to study the effects of a tadpoles species loss on species survival, algae growth, water quality and mosquito species and density. First analyses of experimental runs in 2007 and 2008 could already reveal significant differences in the survival rate of tadpole species, in water quality and in the survival rate of mosquitoes.

**Keywords:** Amphibians, temporary freshwater ponds, tadpoles, sustainability, West Africa

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# Crop science and land use

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# Mixed cropping systems / polycultures

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## **Agroforestry, the Art and Science of Multiple Cropping with Woody Perennials: Examples with *Theobroma cacao***

EDUARDO SOMARRIBA

*CATIE, Costa Rica*

Multiple cropping systems with annual crops have been the subject of research and development for many decades now. Agroforestry, a particular form of multiple cropping in which at least one woody perennial species is associated with other crops (annuals or perennials) or animals to meet the needs of the farmer, took form as a scientific discipline in the late 1970's. Then, land use scientist and development agents, realised that farmers all over the world purposely kept trees and other woody perennials in their field to meet several goals. Scientists and development agents immediately incorporated agroforestry as part of their portfolio of solutions to the long standing dichotomy between forestry (which was usually perceived as an environmentally friendly land use system) and agriculture (in its broadest sense, so as to include, livestock production systems). After 30 years of development, agroforestry has become a well established scientific discipline with applications in both tropical and temperate production systems, with impacts at different spatial scales, from interactions at microsites, to plot level interaction, and then to landscape scales.

In this presentation, I will: 1) describe several examples of agroforestry systems in tropical landscapes to illustrate the diversity of scenarios, species combinations and management systems typical of agroforestry land uses; 2) provide some quantitative data to illustrate how agroforestry is used in cocoa (*Theobroma cacao*) production systems to: a) provide shade and shelter to the crop, b) produce goods for the household (and their effects on the management of financial risk) and c) render environmental services to the global society (conservation of soil, water and biodiversity; mitigation of climate change); and 3) delineate emerging trends and pressing issues that will shape agroforestry science and development in the next decade.

**Keywords:** Agroforestry, cacao, environmental services, livestock

## Crop Diversity as a Livelihood Strategy? The Case of Wastewater Irrigated Vegetable Cultivation Along the Musi River in Periurban Hyderabad, India

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Along the Musi River in periurban Hyderabad, leafy vegetables are increasingly grown and sold in urban markets. Wide areas are irrigated with river water, highly polluted by sewage and industrial wastewater. Previous studies showed that periurban agriculture in Hyderabad plays an important role for the livelihoods of a diverse group of people, many of whom are women, from different castes, religions and social classes.

During a field study in 2007 (in cooperation with the International Water Management Institute and the University of Freiburg, Germany), a rapid appraisal of vegetables cultivated with wastewater irrigation was carried out. In order to estimate the risk from pathogens for consumers, the percentage of vegetables consumed raw was calculated. A large number of vegetable varieties were found in the vegetable gardens, also in those where wastewater was used for irrigation, contrary to expectations. The leafy vegetables - traditionally in high demand - have a short growing season and fetch high market prices due to their usage in traditional dishes. In 2008, the study was extended to explore the role of agricultural biodiversity for livelihoods and building resilience using the sustainable livelihoods approach as theoretical background. 54 varieties of vegetables from 20 families were identified. Among those, 18 were cultivated for the leaves most of which were usually cooked. There was no significant difference in biodiversity (Shannon-Index and Simpson-Index were calculated) between wastewater and groundwater irrigated fields, but a significant difference in the species composition (almost 95 % leafy vegetables where wastewater was used, around 70 % fruit bearing vegetables where groundwater was used for irrigation) for several reasons such as insecure land tenure, water and soil quality, risk mitigation and market demand. Previous studies show that the use of wastewater for irrigation can have both positive and negative effects on agriculture. Besides possible health risks, fertiliser costs could be saved due to the high nutrient content of the wastewater. Agricultural Biodiversity is thus not necessarily diminished by the use of wastewater and can contribute in many ways to resilience, some of which are analysed and discussed in the study.

**Keywords:** Adaptation strategies, agricultural biodiversity, agrobiodiversity, crop diversity, ethnobotany, Hyderabad, leafy vegetables, livelihoods, resilience, smallholders, wastewater irrigation

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## Developing an Improved Strip-intercropping System for Maize and Chinese Cabbage in the North China Plain

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Agricultural production is heavily contributing to degradation of water and land resources in the North China Plain. Due to the rapid increase of vegetable production environmental resources are even more deployed in the last decade. There is an urgent need to develop and disseminate more sustainable vegetable production systems. Intercropping, the cultivation of two or more crops in the same field is a traditional system in the NCP. Farmers intercrop various vegetables with grain crops, trees and other vegetables. Several studies showed that intercropping can use environmental resources more efficiently and reduce leaching and erosion. In a strip intercropping field trial with maize and Chinese cabbage, we tested the influence of the neighbouring crop on microclimate, growth and development. Spring Chinese cabbage was planted next to spring maize under two irrigation strategies. The experiment was run at Quzhou experimental station, China in 2008 and 2009. Even though the maize reduces the photosynthetically active radiation in the first rows of Chinese cabbage significantly, yield of Chinese cabbage is not affected negatively. The first four rows of the maize produced a significantly higher yield compared to the plants in the middle of the plot, which are exposed to a monocropping situation. No significant effects of the reduced irrigation could be observed on important growth parameters in neither crop. The first rows of each crop, which were exposed to a strong intercropping situation didn't show a higher yield under reduced irrigation. Thus, higher water use efficiency, an often mentioned advantage of intercropping, did not occur in intercropping of Chinese cabbage and maize.

**Keywords:** Intercropping, North China plain, sustainable production



## **An Assessment of Carbon Sequestration Potential of Different Land Use Systems in Leyte, Philippines**

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A system developed to reintroduce high diversity of indigenous trees in dense multi-storey structure, a so-called high-density closed canopy system is called rainforestation. The study assessed carbon storage in rainforestation, grass land and agriculture land in Leyte, Philippines. Soil samples were collected from top 10 cm and laboratory analysis was carried out to find out soil bulk density, soil pH, texture, total nitrogen. A Walkley-Black method was used to determine the soil organic carbon concentration in the soil. For the above ground carbon estimation diameter of the trees was measured and allometric equation was used.

There was significant difference ( $p < 0.05$ ) of soil organic carbon stock and above ground carbon stock in various land use systems namely rainforestation, grassland and agricultural land. Average soil organic carbon stock of rainforestation was estimated to be  $21.78 \text{ Mg C ha}^{-1}$ , in grassland it was  $24.24 \text{ Mg C ha}^{-1}$  and in agricultural land it was  $31.02 \text{ Mg C ha}^{-1}$ . Above ground carbon stock of the rainforestation was found  $53.6 \text{ Mg C ha}^{-1}$  and root carbon stock was found  $11.69 \text{ Mg C ha}^{-1}$ . The above ground carbon stock of grassland in Philippine was found to be  $17.15 \text{ Mg C ha}^{-1}$  where as agricultural field was found to be  $9 \text{ Mg C ha}^{-1}$ . Soil organic carbon concentration and stock was lowest in rainforestation. If we combine the above ground carbon and soil organic carbon the rainforestation sequesters the highest carbon and agriculture land sequesters lowest carbon. The effects on soil carbon stock and above ground carbon stock of conversion of agriculture land or pasture into forest are important to know in afforestation and reforestation project especially designated to mitigate carbon emissions through the sequestration of carbon. It is also necessary to calculate base line for cost-benefit analysis and monitoring. The key point is that the best potential for carbon sequestration in the humid tropics is above ground, not in the soil. If croplands and pastures were rehabilitated through conversion to tree-based systems of which rainforestation is one scheme, and then this would result in net carbon sequestration.

**Keywords:** Above ground carbon stock, carbon sequestration, humid tropics, rainforestation, reforestation, soil organic carbon stock

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## Soil Microbial Communities and Activities under Intensive Organic and Conventional Vegetable Farming in West Java, Indonesia

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Throughout tropical Asia vegetables are overfertilised and even more serious is pesticide overuse in the region. Organic farming methods, however, increasingly receive attention. How production methods influence the microbial community in tropical soils remains almost unexplored. In 2007 and 2008 soil microbiology was examined on three organic vegetable farms in humid tropical West Java. At one organic farm a distinction was made between plots cultivated organically for more than 20 years and plots converted from conventional management in 2005. In 2008 an organically managed field since July 2008 was included in the study. The organic farms were compared with conventional fields in their vicinity. We measured PLFA composition, and dehydrogenase and  $\beta$ -glucosidase activity. In July 2007 enzyme activity, especially dehydrogenase activity, was strongly depressed under conventional management compared to the organic fields. Dehydrogenase activity was 3.8 to 6.4 times higher on organic fields compared to conventional fields, while  $\beta$ -glucosidase activity was 1.6 to 2.9 times higher. In September and July 2008 differences in enzyme activity between organic and conventional production were less pronounced: dehydrogenase activity ratios ranged between 1.2 and 2.8, and the  $\beta$ -glucosidase activity ratios between 1.2 and 2.3. Enzyme activities of the organic field converted in 2008 were comparable to or even higher than on the organic farm in the immediate neighbourhood, probably due to the high initial application of compost (53 Mg ha<sup>-1</sup>). Enzyme activities of the organic fields converted in 2005 were comparable to those of the fields in long-term organic production, in both 2007 and 2008. In September 2008, at the end of the dry season, enzyme activities were significantly lower compared to July 2008 in the middle of the dry season. The composition of the soil microbial community, measured in 2007 by PLFA profiles, clearly differed between conventional and organic farming sites. Particularly C16:1 $\omega$ 5c, marker fatty acid for arbuscular mycorrhizal fungi, appeared to be suited as an indicator of the impact of management on the soil microbial community. The negative impact of intensive chemical fertiliser and pesticide use on soil microbiology will probably affect important soil processes such as carbon and nitrogen cycling.

**Keywords:** Enzyme activity, Indonesia, organic farming, PLFA, soil quality

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## Development of a Species Distribution Model for Lepidopteran Stem Borers and Associated Parasitoids in Kenya

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Maize [*Zea mays* L.] and sorghum [*Sorghum bicolor* (L.) Moench] are among the most important cereal crops in Africa and any factor affecting their production is considered a threat to food security in the continent. In Kenya, these crops are grown mainly by small scale farmers under rain fed farming system. However, the produce rarely meets the mean annual demands and with the projected climate change, food deficit and associated implications may worsen as demand to feed the growing population rises.

There is therefore need to identify sustainable options that would enhance cereal production without compromising the quality of the environment of which reducing losses associated with field insect pests have been given serious consideration. Lepidopteran stem borers are the major field insect pests with yield losses estimated between 10 and 21 % in different climatic zones in Kenya. Integrated pest management (IPM) approach has used in different occasions as a measure to minimise pest associated losses. However, development of pest management strategies requires a profound understanding of the ecology of the target species and associated natural enemies.

Over the last two decades, ICIPE has made considerable contributions to improve understanding on ecology of the pest species and the role of wild habitats on their dynamics. In their studies, ICIPE scientists have examined the spatial distribution of indigenous and invasive stem borers and their parasitoids. New approaches based on environmental data, Geographic Information Systems (GIS) and ecological niche modelling offer new opportunities to study and explain the geographical distribution of species. They also allow the development of prediction models, an important tool to develop pest management strategies and research based on climate change scenarios. This is of foremost importance to evaluate the future spread of invasive species and their control through related parasitoids.

The study presents the development of species distribution model (niche model) for stem borer species and parasitoids based on bioclimatic envelopes. The results will be discussed regarding IPM development and its application for climate change based studies with focus on invasive stem borer species and their parasitoids.

**Keywords:** Climate change, GIS, species distribution model, stem borer

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## Fruit Flies (Tephritidae: Diptera): Their Species Composition, Host Range and Field Response to Food-based and Male Lures Attractants

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Fruit flies belong to family Tephritidae are notorious pests of horticultural crops in Sudan. Their significance is increased after the introduction of *Bactrocera invadens*. This study was commenced during 2007–2009 to find out species composition of fruit flies at Khartoum and Kassala, determine host ranges and assess their field response to protein hydrolyzate (Nulure, Torula yeast, AFFI and GF-120) and male lures (Methyl Eugenol, Terpinyl Acetate, Culure, and Trimedlure). More than 10 species belong to 3 genera were recorded: *Ceratitidis capitata*, *C. cosyra*, *C. quinaria*, *B. invadens*, *Dacus ciliatus*, *B. cucurbitae*, *Dacus* sp., *Paradalopsis incompleta* and *B. longistylus* and two other not identified species. Mango and guava were attacked by *C. capitata*, *B. invadens*, *C. cosyra* and *C. quinaria*. Grape fruit, orange, mandarin and banana were infested by *B. invadens*. Lemon and anonna were recorded as new hosts of *B. invadens* at Kassala. Cucumber, water melon, musk melon were found infested by *Dacus ciliatus*, *Dacus* sp. and *B. cucurbitae* while Sidir (*Zizyphus spina-cristi*) and jubajuba were infested by *Paradalopsis incompleta*, Usher (*Calotropis procera*) was attacked by *B. longistylus*. *Ceratitidis capitata*, *B. invadens*, *C. cosyra*, *C. quinaria*, and *B. cucurbitae* responded positively to Nulure, Torula yeast, AFFI and GF-120. *B. invadens* responded to Methyl Eugenol while *Ceratitidis capitata*, *C. cosyra* and *C. quinaria* were attracted to Terpinyl Acetate and *Ceratitidis capitata* alone was attracted to Trimedlure. Torula yeast gave better results in trapping of all fruit fly species during the consecutive seasons 2007 and 2008.

**Keywords:** Fruit flies, male lures, protein hydrolyzate, Tephritidae

## **The Interactions of Arbuscular Mycorrhiza Fungi (AMF) with other Bio-control Agents in the Control of *Fusarium oxysporum* f. sp. *lycopersici***

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Biological control has been exploited as an alternative for the chemical control of plant diseases and is currently accepted as a key practice in sustainable agriculture as it is based on the management of natural resources. However, inconsistencies in success of bio-control have directed research to finding ways of reducing its variability by combining applications of bio-control agents.

The research presented here aimed at exploiting the use of arbuscular mycorrhiza fungi (AMF), an important and widely spread component of the rhizosphere known to reduce damage caused by soil-borne pathogens, together with other known bio-control agents. It focused at getting insight on probable synergistic interactions as well as understanding how varying conditions would influence such interactions.

The interactions were studied regarding the control of *Fusarium oxysporum* f. sp. *lycopersici* (FOL), a soil-borne pathogen that causes wilting in tomatoes, using AMF and *Trichoderma harzianum* (T-22) as the biological antagonists. Additional factors studied in the interaction included investigating the influence of nutrition by varying levels of Phosphorous to include a high and low level of P-fertilisation, and two types of substrates, i.e. sand and a sand peat mixture.

The results indicate the possibility of synergistic control effects achieved by the combination of AMF and T-22. However, there were clear differences regarding the influences of the substrate, P-level as well as environmental growing conditions. The most clear was the distinctive difference in symptom development of FOL under varying P-levels with plants having high P showing typical FOL symptoms of yellowing followed by gradual wilting, while those having low P directly wilted without yellowing.

**Keywords:** Arbuscular mycorrhiza fungi, AMF, biological control, *Fusarium oxysporum*, *Trichoderma harzianum*

## The Environmental Fate of Agrochemicals in Paddy Rice Fish Farming Systems in Northern Viet Nam

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During the last decades, high population growth and export-oriented economics have led to a tremendous intensification of rice production in North Viet Nam, which in turn has significantly increased the amount of agrochemicals applied in rice cropping systems. Since pesticides are toxic by design, there is a natural concern on the impact of their presence on the environment and human health. In northern Viet Nam, irrigated and rain-fed paddy rice production systems were identified to be the major non-point source of agrochemical pollution to surface and ground water, which are often directly used for domestic purposes. Hence, the quantification and forecast of pesticide losses to ground and surface water from paddy rice fields is of indispensable concern and a prerequisite for accessing the potential environmental exposure and risk of water pollution across vulnerable landscapes. The aim of the present study was to investigate the environmental fate of pesticides in paddy rice fish farming systems and to evaluate the risk of surface and ground water pollution. The study site is the Chieng Khoi watershed located in the mountainous region of northern Viet Nam. During consecutive rice cropping seasons (2007 and 2008) we intensively measured the water regime (inflow, outflow, water level, soil moisture) and the pesticide concentration in various system components (paddy water, soil water, pond water, soil sediment, inflow and outflow water) of an integrated paddy field - fish pond system. Two pesticides (Dimethoate and Fenitrothion) with different physico-chemical properties were manually applied. Preliminary results of the field experiment indicate that under current management practices considerable quantities of pesticides are lost to the surface and ground water.

**Keywords:** Agrochemicals, Viet Nam, paddy rice

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## **Integrated Pest Management Training and Information Flow among Smallholder Horticulture Farmers in Kenya**

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Horticulture is a key sector of the Kenyan economy. It improves household welfare through providing income, satisfying domestic food needs and improving human nutrition. Next to market access pests and diseases are the major constraints. With the adoption of Farmer Field Schools (FFS) and Common Interest Groups (CIG) as information sources in horticultural production, it is not yet understood how effective the two approaches enhance environmentally and health friendly production practices such as integrated pest management (IPM). It is expected that IPM information is to a greater extent communicated among farmers belonging to farmer groups because of the enhanced interaction among group members. This paper presents findings of farmer preferences in the choice of information sources and assesses factors that influence IPM information reception and sharing. The analysis applies a bivariate probit regression model for reception and sharing of IPM information to survey data from a random sample of 487 smallholder horticultural producers who are either FFS members, CIG members or non-group based farmers. IPM information and knowledge in this paper is defined as a range of practices including scouting, sanitation, crop rotation, mixed cropping, hand picking, solarisation, planting resistant varieties, applying plant extracts and selective pesticide application. Findings show that government extension staff, NGOs, friends, and neighbours are the three most important information sources for horticulture production and IPM. FFS farmers have more knowledge on IPM practices than CIG and non-group based farmers. Regression results show that membership in farmer groups, gender, education, locality, household size, land per capita, distance to extension service, frequency of listening to radio and literate household members significantly influence information flow. FFS farmers are more likely to receive IPM information than individual farmers whereas CIG farmers are not distinguishable from individual farmers with respect to receiving IPM information. Unlike FFS and non group based framers, CIG farmers are more likely to share IPM information. Implications may be that the intensive training of FFS farmers promotes information reception and knowledge accumulation but promotes close knit interaction in the group which prevents information leaving the group. This is being further tested.

**Keywords:** Farmer field schools, integrated pest management, Kenya

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## Interactions Between the Omnivorous Bug *Orius laevigatus* and the Entomopathogenic Nematode *Steinernema feltiae*, Natural Enemies of the Western Flower Thrips, *Frankliniella occidentalis*

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Studies were carried out to explore the possible interaction between predatory bug *Orius laevigatus* and entomopathogenic nematode *Steinernema feltiae*, natural enemies of western flower thrips, (predation, parasitism and synergisms) in both laboratory and field condition in Israel. Starved adult females *Orius* and fifth instars were placed in petridishes with filter paper socked with nematode suspension (5000 ml<sup>-1</sup> water) and filter paper socked only with water served as a control treatment. Significantly shorter survival time of *Orius laevigatus* was observed in nematode treatments as compare to control. About 80 % of the *Orius laevigatus* were observed infected with nematode. In the study the new food preference of *Orius* in the presence and absence of nematodes, negative response of predator towards the nematode recorded; the predator clearly avoided the nematode-infected arenas. In the experiments, ability of *Orius* to differentiate nematode infected thrips and healthy one; it was found that *Orius* was unable to preferentially feed on healthy thrips. In the study about impact of the nematodes on western flower thrips population, no significant differences were found in WFT populations in control and nematode treatments. Similarly, there was no significant different in the population of *Orius* in control and nematode treatments. *Orius* and nematode were found to be incompatible to each other in laboratory condition. It seems less possibility of combine use of these natural enemies to control western flower thrips population. No significant impact of the nematode was found to control western flower in the presence of naturally occurring *Orius* in Arava valley, Israel.

**Keywords:** Predator, *Orius*, Parasitoid, *Steinernema*, Western flower thrips

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## High-throughput Expression Profiling of Xylem Sap Proteome of Tomato from Both Susceptible and Resistant Genotypes with LC-MSMS

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The unidirectional long distance transport of water and nutrients in all vascular plants are principally carried out by xylem and phloem which is essential for the coordinated growth and developments of all plant organs. The xylem sap has been considered as the primary conduit for water and minerals translocation from roots to aerial parts but evidences of containment of organic macromolecules especially proteins in the sap are emerging continuously. However, the comprehensive proteome profile of the xylem sap is still at large. The xylem sap proteins from healthy adult tomato plants collected under root pressure exudates system were separated with one dimensional gradient polyacrylamide gel electrophoresis (1-D SDS PAGE). The analysis of whole protein bands by LC MALDI TOF /TOF MS revealed for the first time as many as 200 proteins in the sap. The xylem sap proteome displayed several physiologically important groups of proteins such as cell wall metabolism proteins; proteases; networks of defense related proteins including PR proteins, antioxidants, detoxifying agents, resistance proteins, and peroxidase; signalling molecules; transport proteins; transcription and transcription factors; and enzymes of both primary and secondary metabolism. The presence of peroxidase, cell wall associated proteins, proteases, and defense proteins were reported to be conserved in many plants indicating that they are involved in xylem growth, development, and differentiation process essential for the formation of functional xylem conduit. The presence of many signalling and transport proteins is expected to be required for root to shoot communication. The identification of numerous proteins without known functions may provide candidates with novel physiological functions. The xylem sap not only showed the presence of secretory proteins but also non- secretion signal proteins. The comparison between the healthy xylem proteins of the susceptible (WVa700) and resistant (Hawaii7996) plants showed the occurrence of higher percent of defense proteins and peroxidase in the resistant genotypes.

**Keywords:** Cell wall proteins, defense proteins, mass spectrometry, secretory signal proteins, tomato, xylem sap proteome

## The Efficacy of *Bacillus amyloliquefaciens* on Late Blight Development and Biomass of *Phytophthora infestans* in Tomato Leaf Tissue

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*Bacillus amyloliquefaciens*, re-isolated from the biocontrol agent FZB 24® (Biotechnik GmbH, Germany) has shown promising results in biological control of late blight caused by *Phytophthora infestans*. However, the mechanisms and metabolites involved are only poorly understood. In order to gain a better understanding of the mechanisms of action of the bacteria or their metabolites in reducing the disease severity of late blight, directly or indirectly by induced resistance, real time quantitative PCR were performed to determine the effect of foliar application on the pathogen biomass in tomato leaf tissues.

*B. amyloliquefaciens* cells and the excreted metabolites (culture filtrate) harvested after 72 hours of incubation time were applied on foliar parts of tomato plants in the greenhouse 24 h before inoculation with the pathogen ( $10^5$  sporangia ml<sup>-1</sup>). The effects were investigated on attached leaves as well as on detached leaves which were cut immediately after inoculation and incubated in plastic boxes under the same environmental conditions as the plants. Samples of attached and detached leaves were taken 3 h, 6 h, 12 h, 24 h, 48 h, 96 h, and 144 h after inoculation corresponding to different developmental stages after infection.

From frozen dried leaf tissues DNA was isolated using the Plant Mini Kit Method. Real-time PCR reactions were performed with PinfRAS-Forward primer (CATTACATTGCTCATGGCTTTC) and PinfRAS-Reverse primer (ATCACGCGGGGAC AAATG) in an ABI Prism®7000 SDS instrument. The results were reported as the absolute amount of DNA of *P. infestans*. The correlation coefficient of the standard curve was at least 0.99 while the slope ranged from -3.1 to -3.8.

Both, bacterial cells as well as the metabolites were effective in preventing infection; they inhibited the pathogen biomass development in the tissue of the tomato leaves and significantly reduced the expansion of existing late blight lesions. The suppression of disease symptoms and pathogen growth was evident from the first stages of infection.

The efficacy of the bacteria or their metabolites in reducing the development of *P. infestans* was higher in attached than detached tomato leaves. Six days after inoculation, compared to untreated leaves, both treatments reduced the pathogen biomass by 83 % on attached leaves compared to 40 % (cells) and 60 % (metabolites) on detached ones. The amount of pathogen DNA detected in detached leaves was 4.7 (untreated samples), 17 (cells) and 10 (metabolites) times higher than in attached leaves. There was an increase in treatment efficacy to suppress the pathogen development. The results provide evidence for an additionally activation of plant defense responses.

**Keywords:** *Bacillus amyloliquefaciens*, metabolites, *Phytophthora infestans*, quantification, real time PCR

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## Improving Methods for Inoculation of Endophytic *Fusarium oxysporum* to Tissue Culture Banana Plants

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Bananas (*Musa* spp.) are among the most important food crops worldwide. Plant-parasitic nematodes and insects are major limiting factors affecting cooking banana production in East Africa. The use of endophytic microorganisms that colonize the root system is a novel tool for biological management of plant parasitic nematodes on other crops in particular banana. Mutualistic fungal endophytes are known to improve plant growth, induced resistance, reduce nematode, insect and fungal diseases. It has also been shown that they produce metabolites that are toxic to these pests. The objective of this study was the improvement of existent methods of inoculation and the development of new techniques for apply endophytes to tissue culture banana plants before transplanting to the field. The investigations were tested in the production system of an established banana tissue culture producer in Uganda, Agro-Genetic Technologies Ltd. (AGT). Farmers buy clean planting material at AGT and plant the disease free tissue culture plants into fields contaminated with pests and diseases. The goal was to improve endophyte colonisation of these commercial plantlets, in order to provide healthy and biologically enhanced plants to the farmers. Two inoculation techniques were tested; in the first, the maize-bran technique as developed the International Institute of Tropical Agriculture (IITA-Uganda) and in the second, a new inoculation technique in which plants were set in planting trays and then the trays drenched in a spore suspension as developed by Bioversity (Costa Rica). These experiments were conducted at the facilities of AGT in Uganda with a nematode antagonistic *Fusarium oxysporum* isolate with known biological control activity. The results indicated a negative effect of the maize bran carrier on banana plant growth. There was a negative relationship between the amount of maize bran used and plant growth as well as plant mortality. In contrast the inoculation of the endophyte with the tray-soil drenching method produced resulted in effective colonisation of roots and corms by the non-pathogenic *F. oxysporum* antagonist. The results of this study demonstrated, the use of soil drench inoculation of endophytes resulted in a more labour and time effective inoculation system for commercial tissue culture banana plantlet inoculation.

**Keywords:** Banana, endophyte inoculation, *Fusarium oxysporum*, tissue culture

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## Factors Influencing Host Plant Preference of *Phyllotreta striolata*

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The striped flea beetle, *Phyllotreta striolata*, is a serious pest of crucifer crops in the tropics. This study aimed to elucidate the chemical interaction of this flea beetle species with its host plant to develop attractant-based lures, which may serve as efficient alternatives to chemical control. We focused on glucosinolates, the characteristic secondary metabolites of crucifers, and their hydrolysis products, which are known to be involved in host plant finding and/or acceptance of insect specialists, such as *P. striolata*. The feeding preference of *P. striolata* was examined among seven economically important crucifer crops (cabbage, kai-lan, Chinese cabbage, pak-choi, winter rape, leafy mustard, and radish). The leaf glucosinolate content and profile was analysed using high performance liquid chromatography and the total, aliphatic, and indolyl glucosinolate content was correlated with the bioassay data. The corresponding glucosinolate hydrolysis products were analysed with gas chromatography-mass spectrometry. Moreover, the leaf surface, which is the location of initial contact with the potential host plant, was examined using scanning electron microscopy. In multiple choice experiments, radish was the most preferred host plant, followed by leafy mustard, pak-choi, winter rape, and Chinese cabbage. Antixenosis (non-preference) was observed for *Brassica oleracea* var. *capitata* (cabbage) and var. *alboglabra* (kai-lan). The total glucosinolate content in the crops ranged from 10  $\mu\text{mole/g}$  dry weight in cabbage to 130  $\mu\text{mole/g}$  dry weight in radish and leafy mustard. Allylthiocyanate, a volatile GS hydrolysis product and known attractant for *P. striolata* was detected in leafy mustard (1.5  $\mu\text{mole/g}$  fresh weight) as well as in the non-preferred cabbage (0.02  $\mu\text{mole/g}$  fresh weight). Although *P. striolata* prefers to feed on plants with a higher concentration of glucosinolates, especially of aliphatic glucosinolates, the rejection of kai-lan and cabbage could not be explained from the results. Upon examining the leaf surface of the host plants, crystal structures from epicuticular waxes occurred only on cabbage and kai-lan. The waxy surface may hinder *P. striolata* from attaching to the leaves and block access to nutrients or infochemicals such as glucosinolates; it could be contributing to the insects' antixenosis.

**Keywords:** Crucifer, glucosinolates, host plant preference, *Phyllotreta striolata*

## Do Green Lacewings (*Mallada signata*) Contribute to the Mortality of *Helicoverpa* on Transgenic Bt Cotton?

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Over 85 % of the Australia cotton crop is transgenic, expressing Bt genes for the control of the key pests *Helicoverpa armigera* and *H. punctigera*. Using Bt cotton has reduced the number of pesticide applications, paving the way for a more concerted effort with integrated pest management (IPM), especially enhancing the impacts of natural enemies. There is field evidence that *Helicoverpa* larvae are surviving on Bt cotton. This study examines the predatory performance of a generalist predator, the green lacewing (*Mallada signata* (Schneider)) feeding on *H. armigera* eggs and larvae on Bt (Bollgard II®) or conventional cotton. Prey consumption rates on single leaves were measured under laboratory conditions in small arenas. Prey consumption rates on whole plants of Bt and conventional cotton varieties were investigated in controlled environment cabinets. *H. armigera* eggs or larvae were distributed evenly across seven plant positions; the stem, petioles, squares, flowers, bolls and upper and lower sides of leaves. Two, four-day-old, lacewing larvae were released and surviving *Helicoverpa* eggs and larvae recorded after 24 h for *H. armigera* eggs and 72 h for *H. armigera* larvae experiments. In the small arenas, lacewing larvae fed on similar numbers of *H. armigera* eggs (avg. 15) or larvae (avg. 8) whether searching Bt or conventional cotton leaves. Likewise, similar numbers of eggs were consumed by lacewing larvae searching whole plants of either Bt (avg. 15) or conventional (ave. 14) varieties in 24 hours. On whole Bt cotton plants 83 % of the *H. armigera* larvae died. Mortality increased to 98 % when the two lacewing larvae were present. Lacewings on conventional cotton consumed 65 % of the prey. This ‘mopping-up’ of surviving *Helicoverpa* on Bt cotton by lacewing larvae has the potential to reduce immediate pest damage but perhaps more importantly remove potentially Bt-resistant genotypes.

**Keywords:** Biological control, green lacewing, *Helicoverpa armigera*, *Mallada signata*, transgenic cotton

## Identification of Root-knot Nematode Species Infecting Banana and Grape Orchards in Ismailia Governorate, Egypt

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Samples of banana and grape roots infected with root-knot nematode, *Meloidogyne* spp., were collected from three different regions viz. Abou-Khalifa, Abou-Swair regions and Faculty of Agriculture Experimental Farm; representing Ismailia governorate, Egypt; and extracted females were used to identify detected root-knot nematode populations by using perineal patterns and SCAR-PCR techniques. Examination of the perineal patterns of the root-knot nematode females revealed the presence of three different species of *Meloidogyne*. Four root-knot nematode populations were identified as *M. incognita* from banana roots in Abou-Khalifa region, from grape roots in Abou-Swair region and from banana and grape roots in Faculty of Agriculture Experimental Farm. One root-knot nematode population was identified as *M. arenaria* from grape roots in Abou-Khalifa region, and one root-knot nematode population was identified as *M. javanica* from grape roots in Abou-Swair region. Using Sequence Characterized Amplified Region (SCAR) based PCR assays and DNA Gel Documentation System (D.G.D.S) programme analysis to identify the detected root-knot nematode populations, the same results were obtained and the species *M. incognita*, *M. arenaria* and *M. javanica* were easily differentiated. A 1200 bp fragment was detected in four root-knot nematode populations from banana roots in Abou-Khalifa region, grape roots in Abou-Swair region and from banana and grape roots in Faculty of Agriculture Experimental Farm. These populations were identified as *M. incognita*. A 420 bp fragment was detected in one root-knot nematode population identified as *M. arenaria* from grape roots in Abou-Khalifa region. In addition a 670 bp fragment was detected in one root-knot nematode population identified as *M. javanica* from grape roots in Abou-Swair region.

**Keywords:** *Meloidogyne* spp, root-knot nematode

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## Determinants of Pesticide Handling Practices in Vegetable Production in Kenya

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Pesticide handling practices have a strong bearing on the exposure of pesticide toxic effects to target and non target organism. A clear understanding of factor associated with farmers pesticide handling practices was thus deemed necessary in the design and implementation of policy intervention. To accomplish this, a survey of 425 respondents was conducted in 2008 with questions on the pesticide use, handling practices, risk perceptions, experiences of pesticide negative impacts (health effects and intoxication of livestock) and main sources of pesticide use information.

A two-equation bivariate-probit model was initially developed with risk perceptions as endogenous variable. Results showed that risks perception was significantly influenced by experiences of pesticide negative impacts, number of years in agricultural production (experience), global GAP certification, advice on pesticide use from pesticide dealers, target markets and geographical location. A second model to explain pesticide handling practices indicated that variation in global GAP certification, record keeping, vegetable plot sizes and geographical location are the main determinants.

These results highlight the necessity for training of farmers on pesticide risks, safe handling, averting behaviours and Integrated Pest Management. The information content of training should be more specific and more practical for pesticide storage, disposal of empty pesticide bottles and rinsate and human protection during pesticide handling. The results also point to specific locations with higher unsafe practices in the handling of pesticide. Focusing efforts on these geographical areas may have the most measurable effects on pesticide safe handling. It would be an added advantage to include farmers, in the design of the programme to better understand and reflect their needs in pests control.

**Keywords:** Integrated pest management, pesticides handling practices, policy intervention, risk perception

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## Occurrence of Cereal Cyst Nematodes (*Heterodera* spp.) in Wheat Fields in Ismailia Governorate, Egypt

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Cereal cyst nematodes (*Heterodera* spp.) are important plant-parasitic nematodes of wheat and occur in most wheat growing regions of the world. In Egypt and particularly in Ismailia Governorate, relatively little information is available on the occurrence of cereal cyst nematodes in wheat fields. Therefore, a survey to determine the occurrence and distribution of cereal cyst nematodes in wheat fields was carried out in 2008. Seven different localities representing Ismailia governorate, Egypt, were surveyed for the presence of cyst nematodes. Soil and root samples were taken to the lab and standard nematode extraction procedures were followed to determine juveniles and cysts, respectively, in the soil. Females if present in roots of wheat plants were removed and counted. The results of this work reveal that *H. avenae* is widely distributed in wheat fields of several regions in Ismailia governorate, Egypt. However, no cyst nematodes were detected during the survey in samples from El-Wasfia region and from the experimental farm of the Faculty of Agriculture, Suez Canal University. Samples from Abou-Khalifa and Abou-Swair revealed that wheat fields were slightly infested with cyst nematodes. Highest population densities and frequency of occurrence of second stage juveniles, cysts and females were recorded in samples collected from El-Shark, El-Kasaseen and Sarabium. Cereal cyst nematode populations from wheat fields in different regions of Ismailia governorate were identified as *H. avenae*. Morphometric identification of the populations from the surveyed locations revealed no distinct variations in shape and size of eggs, females, cysts, vulval cone and second stage juveniles among the populations from Ismailia, Egypt. The investigated populations also showed a great morphometric similarity to a German population of *H. avenae*. Data on population densities, frequency of occurrence and morphometrics are presented.

**Keywords:** Egypt, *Heterodera avenae*, wheat

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## Integrated Pest Management in Organic Vegetable Soybean Production

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Vegetable soybean (*Glycine max* L. Merrill) is an important vegetable in East and Southeast Asia. To control pests, farmers resort to repeated applications of synthetic chemical pesticides, the residues of which hinder the crop's potential for export. During 2006–2008 AVRDC — The World Vegetable Center developed an integrated pest management package for use in organic production systems. It was observed that *Helicoverpa armigera*, *Spodoptera litura*, and *S. exigua* caused slight defoliation during early crop stages; *Bemisia tabaci*, *Megalurothrips usitatus* and *Edwardsiana flavescens* were the major sucking insects; *Omiodes indicata* caused serious damage through leaf webbing; and *Porthesia taiwana* occasionally appeared as a major pest after eight weeks. *Etiella zinckenella* emerged as a major pod-borer during the pod stage. During autumn, *Maruca vitrata* also appeared. The integrated pest management package consists of sex pheromones, sticky traps, and bio-pesticides. Sex pheromone traps and sticky traps were used throughout the growing season to monitor and mass-trap the target insects. Neem was sprayed to control the sucking insects and defoliators in the early crop stages. *Bacillus thuringiensis* subsp. *aizawai* (Bta) was sprayed with neem to control *O. indicata* and *P. taiwana*. During the pod stage, the Bta and neem combination was sprayed against *E. zinckenella*. *Maruca vitrata* nucleopolyhedrovirus was also sprayed when *M. vitrata* damage was noticed. The package was compared with an untreated control (2006 and 2008), as well as farmers' practice (2007). The pod damage was significantly higher in control plots (2.45–17.9%) compared with integrated pest management (1.32–6.93%) plots. However, the integrated pest management plots did not record lower damage than the farmers' practice (0.92–1.8%). Although the total pod yield is mostly higher in integrated pest management plots (5.69–11.49 t ha<sup>-1</sup>) than control plots (5.08–12.06 t ha<sup>-1</sup>), the graded pod yield is always higher in integrated pest management plots than in control plots. During spring, farmers' practice recorded higher graded pod yield (8.9 t ha<sup>-1</sup>) than integrated pest management (4.9 t ha<sup>-1</sup>). Hence, it can be concluded that the integrated pest management package can successfully manage pests in organic vegetable soybean, and contribute to higher graded pod yields depending on the season and pest pressure.

**Keywords:** Integrated pest management, organic production system, vegetable soybean

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# Land use and water

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## Early Tomato Growth under Soil Aggregate Coalescence

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The phenomenon called soil aggregate coalescence occurs at contact-points between aggregates and causes soil strength to increase to values that can inhibit plant root exploration and thus potential yield. During natural wetting and drying, soil aggregates appear to ‘weld’ together with little or no increase in dry bulk density. The precise reasons for this phenomenon are not understood, but it has been found to occur even in soils comprised entirely of water stable aggregates. Soil aggregate coalescence has not been widely observed and reported in soil science and yet may pose a significant risk for crops preventing them from achieving their genetic and environmental yield potentials. This project used soil penetrometer resistance to measure the early stages of aggregate coalescence and to evaluate its effects on the early growth of tomato plants. A preliminary evaluation of how the early stages of aggregate coalescence might affect plant growth was attempted using tomatoes as a test plant. Seeds were planted in aggregates of a coarse- or fine-textured soil packed in rings. These were wetted at a rate of  $1 \text{ mm h}^{-1}$  to either near-saturation (maximum coalescence) or to a suction of 10 kPa (minimum coalescence). All samples were then transferred to a ceramic pressure plate for drainage to 100 kPa suction for one week. Samples were then placed in a growth-cabinet held at 20°C with controlled exposure to 14 h light day<sup>-1</sup>. Germination of the seeds, and length of roots were observed. Germination of the seeds held at near-saturation in both coarse- and fine-textured soils was delayed by 24 h compared with seeds held at 10 kPa suction. In the coarse-textured soil, the total root length over a period of 14 days was greater in the un-coalesced samples than in the coalesced samples. These results suggest that aside from delaying germination, aggregate coalescence may not have a large effect on early growth of tomato plants. However, this is not to say that detrimental effects may not be manifest at later stages of plant growth, and this certainly needs to be evaluated, particularly because aggregate coalescence increase with repeated cycles of wetting and draining.

**Keywords:** Aggregate coalescence, tomato, water suction

## **Technology Adoption and Commercialisation of Dryland Legumes in Eastern and Southern Africa: Determinants, Impact and Future Outlook**

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Despite the crucial role of dryland commodities for poverty reduction in dryland economies, market inefficiency and imperfections and lack of technological change have often locked small producers into subsistence production and contributed to stagnation of the sector. In the last few years, research and development interventions have attempted to facilitate the development of new technologies and market linkages for smallholders. The opportunities for market development and commercialisation are particularly favourable for legume crops like peanuts, chickpea and pigeonpea which tend to have higher domestic, regional and international demand. The objectives of this study are to (a) assess the role of market institutions, infrastructural and household assets in determining access to new technologies and markets for small farmers (b) examine the level of adoption of new legume varieties and its effects on the level of market participation and (c) evaluate how technology adoption would affect marketed surplus and market-orientation of production (commercialisation) and poverty outlooks for small producers. The study conceptualises commercialisation as the process by which dryland farmers are increasingly integrated into different markets such as input markets, food and non-food consumption markets, output markets and labour markets. Data were collected by means of farm household surveys in four countries of Eastern and Southern Africa, namely Ethiopia, Kenya, Tanzania and Malawi during 2007/08 cropping year. Overall, a total of 2321 households were selected randomly for the interviews - 700 from Ethiopia, 414 from Kenya, 613 from Tanzania and 594 households from Malawi. Different econometric models are applied to address the research questions. Treatment effect model and propensity score matching techniques are used to investigate the linkage between new variety adoption and integration of smallholders to markets whereas 2SLS is used to establish the link between market integration and poverty. There seems to be a two-way link between markets and technology adoption. Increased market integration may facilitate adoption of new varieties and increase incomes for smallholders but it may also be that adoption of new varieties and greater income leads to more integration. The two-way relationship or endogeneity problem can be corrected by instrumenting the endogenous variable using instrumental variable techniques.

**Keywords:** Commercialisation, dryland crops, impact, technology adoption

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## Assessment of Water and Nitrogen Limitations to Paddy Rice Performance Using N-15 and C-13 Stable Isotopes

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Considerable research regarding impact of land use intensification on erosion and runoff production has been carried out in various tropical mountainous regions in South East Asia. However, little is known about the impact of resulting sediment contribution from eroded upland fields, with intensive agricultural activities, to lower paddy fields which produce up to two rice crops a year. Increase in agricultural productivity to match the people's needs was mainly achieved by the clearance of upland forests for the cultivation of cash crops like maize and cassava. These procedures have a large impact through erosion and nutrient fluxes downstream. Depending on the availability of rain and irrigation water, rice paddies are cultivated either once in the rainy season or twice, by supplemental irrigation water. Overall crop productivity of paddies is hampered by water shortages, mainly during the first season. In order to assess impacts of seasonal conditions, fertilisers and uplands-sediments on the lowlands crop, Isotope Ratio Mass Spectrometry (IRMS) was used to examine the plant and soil composition of nitrogen (<sup>15</sup>N) and carbon (<sup>13</sup>C) stable isotopes. Analysis performed during this study proved the hypothesis that the isotopic composition of rice grains shows clear relations to growing conditions, particularly for <sup>13</sup>C. The relative extents and proportions of the limitations on crop performance caused by lack of nitrogen and water shortages could be shown. Still, depending on the position of paddies across the lowlands (along a cascade) the trends illustrated the varying allocation of water and resources like nutrients, in particular nitrogen. Close to the channels, nitrogen and water stresses were lowest in the rice grains according to stable isotope discrimination method, with a clear increase in all treatments and in both seasons towards the middle-lower parts of the cascades. Total nitrogen of soil samples, however, showed an accumulation until the middle of the cascade and decreased thereafter. Therefore water seems to be strongly influencing nutrient uptake in the cascades. These results show the importance of the use of stable isotopes in order to understand the impact of erosion sedimentation and nutrient fluxes on catchment scale influencing its crop productivity.

**Keywords:** Crop performance, rice, sedimentation, spatial variability, stable isotopes

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## Effects of Land Use on Carbon Cycling of Tropical Ecosystems in Panama

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Land-use change has a significant impact on the carbon cycling of ecosystems. In particular tropical ecosystems are affected by ongoing land-use changes. Due to biophysical and biogeochemical feedbacks this also influences the global climate. An improved understanding of the effects of land use on carbon cycling of tropical ecosystems can facilitate the development of mitigation strategies. However, continuous measurements of ecosystem carbon fluxes are sparse in tropical regions and only few localities exist in Central America. Thus, our objective is to analyse the carbon cycling of two tropical ecosystems (native tree species plantation and traditionally grazed pasture) in Sardinilla, Central Panama based on flux tower measurements using the eddy covariance method.

Considerable differences are observed in diurnal Net Ecosystem Exchange (NEE). In the rainy season, midday assimilation is higher in the pasture ecosystem. However, nighttime respiration rates in the pasture are higher during all seasons. Furthermore, the pasture is more susceptible to soil water limitations (likely due to shallow roots) and assimilation is reduced in the dry season gradually to zero until the beginning of the rainy season. Unlike, in the plantation ecosystem assimilation is lower on average but is sustained in most of the dry season. Consequently, the pasture ecosystem is a carbon source during most of the year, and particularly in the dry season. The plantation ecosystem remains almost continuously a carbon sink. Both ecosystems were carbon sources in April and May 2008, which might be related to ENSO (La Niña) and a prolonged dry season in 2008. Carbon release in the 9 hectare pasture seems to be related to grazing intensity.

Our results show considerable diurnal and seasonal differences of NEE between a tropical pasture and a native tree species plantation in Panama. High midday assimilation rates in the pasture ecosystem are related to the intense productivity of dominating C4 grasses. However, respiration losses exceed photosynthetic inputs. Besides the seasonal constrained availability of water, grazing intensity seems to be a major influence in the pasture ecosystem. Our results indicate a carbon storage potential for the plantation ecosystem.

**Keywords:** Carbon cycling, land use, Panama, tropical ecosystems

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## Estimating Nutrient and Carbon Losses on an Irrigated Sandy Soil in Northern Oman

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Little is known about gaseous and leaching losses of carbon (C) and nitrogen (N) in irrigated agriculture of the hyperarid Arabian Peninsula. Therefore, gaseous emissions of  $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{CO}_2$  and  $\text{CH}_4$  were measured on an experimental field near Sohar (Oman) with an INNOVA photo-acoustic infrared multi-gas monitor connected to a custom made cuvette (closed chamber system). Conducted on an irrigated sandy soil with four replications the experiment comprised two manure types (characterised by a C/N ratio of 24 with high fibre content and a C/N ratio of 15 with low fibre content) and a control treatment with equivalent levels of mineral nitrogen (N), phosphorus (P) and potassium (K). These three fertility treatments were factorially combined with a crop rotation at two levels comprising cauliflower (*Brassica oleracea*) and carrot (*Daucus carota* subsp. *sativus*) each preceded by a crop of radish (*Raphanus sativus*). Experimental leaching losses were calculated using the solute concentrations of N, P and K in leachate samples and the cumulative amount of leached solutes determined by ion-exchange resin cartridges. Seepage was estimated with the software Hydrus 1d using estimates of crop-specific evapotranspiration.

Gaseous N emissions averaged  $27 \text{ kg N ha}^{-1}$  (60 %  $\text{NH}_3\text{-N}$ , 40 %  $\text{N}_2\text{O-N}$ ) for a cropping period of 120 days, with little variations between treatments. During the same period C emissions were  $6 \text{ t C ha}^{-1}$  (99 %  $\text{CO}_2\text{-C}$ , 1 %  $\text{CH}_4\text{-C}$ ) on plots treated with organic manures. Plots treated with mineral fertiliser had a mean emission rate of 3 tons  $\text{C ha}^{-1}$ . Repeated measurement analysis of the gas emission data revealed significant effects of crop rotation and manure treatment for  $\text{NH}_3\text{-N}$  and  $\text{CH}_4\text{-C}$ . Crop rotation had a significant effect on emissions of  $\text{CO}_2\text{-C}$  and  $\text{N}_2\text{O-N}$ . Cumulative leaching averaged  $5 \text{ kg N ha}^{-1}$  for plots treated with organic manure of low C/N,  $28 \text{ kg N ha}^{-1}$  for plots treated with organic manure of high C/N and  $15 \text{ kg N ha}^{-1}$  for the control treatment.

**Keywords:** Hydrus 1d, INNOVA multi-gas monitor, leaching, organic agriculture

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## Effects of Local Resources and Nitrogen on Soil Water pH and Yield of Lowland Rice in Nepal

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Rice is the most preferred staple food crop of Nepal fulfilling more than 50 % of the calorie requirement contributing 25 % of the agricultural gross domestic product and 50 % of the total food grain production in the country. Lowland rice is the principal source of rice production, however, productivity of lowland rice in Nepal is very low as compared to many developed and developing countries. Out of the multitude of limiting factors, nutrient management especially nitrogen comes to forefront. Nitrogen fertiliser applied in lowland rice paddy is subjected into several fates of which loss of nitrogen through  $\text{NH}_3$  volatilisation is important and is influenced by floodwater temperature and pH. The rapid loss of N through  $\text{NH}_3$  volatilisation under high pH is related to the growth of algae in the floodwater. As a result of depletion of  $\text{CO}_2$  in the water by algal growth, the pH rises as high as 9 by mid-afternoon leading to loss of nitrogen.

An experiment aiming at finding the effects of conjoint use of local mulch materials with inorganic nitrogen on floodwater pH and yield of rice was conducted under subtropical condition of Nepal. Ten treatments were tested with two levels of nitrogen (50 and 100 t ha<sup>-1</sup>) with different mulch materials (wheat straw, *Ipomoea cernua* and *Cassia tora*) under randomised completely block design. Floodwater pH was measured at an interval of 4 days at 12 noon. The mean maximum and minimum pH was recorded in the nitrogen-omitted treatment (7.28) and in the 100 kg N plus 3 t ha<sup>-1</sup> of wheat straw mulch treatment (6.87), respectively. The grain and straw yields were higher under the latter treatment which discernibly shows that less nitrogen have been lost through volatilisation. There was a significant negative relationship between pH and grains per panicle ( $r=-0.789^{**}$ ), pH and grain yield ( $r=-0.754^{**}$ ), and pH and straw yield ( $r=-0.727^*$ ). As  $\text{NH}_3$  volatilisation is the pH driven phenomena, straw mulch applied in rice field is considered a good source to decrease the pH of floodwater concomitantly improving the nitrogen use efficiency in rice, save the water bodies; soil and aerial environment vis-à-vis provide better production at lower cost.

**Keywords:** *Cassia tora*, floodwater, *Ipomoea cernua*, mulching materials

## Traditional Institution in Tank Water Management: Case of Tamil Nadu, India

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The traditional irrigational institution seems to have functioned relatively effective in almost all the tank villages in Tamil Nadu, India at least until the early 1970s. There were two layers of irrigation functionaries at village level. One is to enforce the rule and regulation for sharing and caring of tank water resources and another one to execute the work based on deemed direction of rules in force. While upper caste large farmers invariably constituted in the first category, the scheduled caste farmers and labourers were employed for second type of employment like sluice operation, field water management and others. In this second type of employment the water man traditionally called as “Neerkatti” has an important role to play since the quantity of irrigation water is become very scarce. The Neerkatties are critical for ensuring inflow of water to the tank and its equal distribution among the field in ayacut. This paper proposed to capture contemporary condition of traditional irrigation institution and its efficiency and in particular the role of the Neerkatti on tank water management. This paper provides empirical evidence about different type of irrigation functionaries existed and their perceived roles and performance. We also tried in this paper to capture the possible reason for dismantling of traditional institution. It concludes that traditional institution is demonstrated its ability in the past and has potential to maintain tank resources sustainably in the present condition. This is based on our data collected through field survey in seven tank villages and interviewing 31 irrigation functionaries’ families from seven irrigation tanks in Madurai District of Tamil Nadu.

**Keywords:** India, institution, Neerkatti, Tamil Nadu, tank irrigation

## The Quality of Geodata in Viet Nam in the WRM Process – A Challenge

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Within the German Vietnamese research project “Integrated Water Resources Management Viet Nam” a Planning- and Decision-Support-System on a regional scale is being developed which includes tools and methods for the analysing data with regards to water resources, water use, water quality and additional environmental data by using ArcGIS. The research area is situated in the Dong Nai river basin (Southern Highlands, Viet Nam).

During the data collection difficulties had to be solved concerning how environmental data are generated, edited and provided by the different institutions and authorities in Vietnam:

The socio-economic and land-use data collected on the province and the district level are not equal in all provinces. One solution was to abstract the land use classes to higher levels of aggregation (for instance: The various forest types were summarised into two classes natural and planted forest).

The geodata features had various technical errors such as gaps between adjacent polygons, overlapping polygon areas, interrupted line (for instance: River and streets), incorrect attribute tables etc. (for instance: Streets where classified as land for aquaculture). With the help of actual satellite images, topographic maps and a redigitalisation of interrupted lines the errors could be fixed.

The errors where categorised and cleared to get consistent geodata features. The definition of digitalisation rules, the specifications of metadata information and the content of the attribute tables in shape files are necessary tasks to build up a consistent geodata management.

The importance of the quality of geodata in the IWRM process is being communicated with the Vietnamese institutions and authorities.

**Keywords:** Dong Nai Viet Nam, geodata management, IWRM

## Effect of Land Use Patterns on Soil Properties of Agriculturally Used Wetlands in East Africa

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With growing demographic growth and emerging land shortages, wetlands in East Africa are increasingly converted into agricultural land. Wetland soils play an important role as storage compartments for water, carbon and nutrients. Their conversion into sites of production is seen to affect soil parameters as a function of soil type and soil management and the land use intensity, and thus determine their production potential. We collected soils from 50 wetlands in Kenya and Tanzania, differentiated by parent material, hydrological regime and the type and intensity of land use. Soils varied from coarse-textured sandy clay to heavy clay with large differences in the mightiness of the A horizon and the content in C, N and P. Wetland soils differed in their resilience to anthropogenic interventions. In undisturbed wetlands under natural vegetation, the average soil organic C, N, and P contents ranged from 0.8–7.1 % total C, 0.09–1.2 % total N and 4.3–28.0 mg P kg<sup>-1</sup> available P. Land drainage and crop production were associated with a reduction in the soils' C, N, and P contents. Most dramatic effects were observed with carbon and nitrogen in sandy textured soil which declined with intensified use from 2.17 to 1.87 % C, 0.26 to 0.19 % N and from 14.1 to 11.1 % P. Sandy soils appear to be particularly vulnerable and are unlikely to sustain intensified cropping. On the other hand, clay soils showed little reduction in organic C and soil nutrient contents after conversion into cropland and may thus be preferentially selected for agricultural conversion. These findings are preliminary and a more complete understanding of the role of agricultural practices on the spatial and temporal changes of soil properties is required before making informed decisions on future wetland conversion and uses.

**Keywords:** Kenya, land use intensity, nitrogen, phosphorus, soil organic carbon, Tanzania

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## Annual Variation of Water Use and Yield of Irrigated Rice in the Sahel

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Rice production in the Senegal River Valley strongly depends on inter-annual climatic variation. At present, rice is grown in the hot and dry period from March to July and in the hot and wet period from August to October. During the cold and dry season from November to February fields remain fallow. Rising temperatures and shifts of seasons are already observed and are expected to increase. With a changing climate, shifting of planting dates might be necessary.

In Senegal, rice is the most important cereal and its consumption is steadily increasing. The Senegal River valley is characterised by Sahelian climatic conditions and an annual rainfall of less than 350 mm. Currently, fuel prices are an important economic factor, since water is pumped from the river to the fields. With an increasing demand for arable land, water will be the limiting factor for rice production in the near future. Water use, plant development, and yield differ strongly as a function of sowing date within a year. Adaptation of cropping calendars might be needed aiming at lower water consumption and stable, high yields.

For the ongoing study 10 contrasting genotypes were selected representing a large variation in terms of duration, water use, and heat and cold tolerance. In bi-monthly planting dates, irrigation water input, water use, plant development, physiological parameters and yield were observed at 2 climatically different sites in order to characterise genotypic traits enhancing water saving rice production the Sahel. Results for water use, crop development, and yield for the first completed year at WARDA's Sahel station in Ndiaye will be presented and possibilities for adaptations of cropping calendars and choice of genotype will be discussed.

**Keywords:** Climate change, genotype adaptation, irrigated rice, water use efficiency



## Agent-based Simulation of Human-environment Interactions in Small Wetlands in Kenya and Tanzania

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Large numbers of small wetlands in Kenya and Tanzania are currently drained for agricultural and horticultural production purposes. Socio-economic changes, biophysical and policy-related factors are the main driving forces. Understanding and quantifying complex interactions for scenario analyses requires the application of integrated research approaches. Agent-Based Models (ABMs) have been recognised as useful tools for representing human-environment systems. Numerous studies have shown that ABMs are capable of simulating the mutual relations between humans and their environments in mechanistic and spatially explicit ways. Building credible ABMs to provide guidelines and tools for wetlands planners and decision makers requires empirical analyses of agent's behaviours as well as rigorous analyses of wetland use dynamics and farmer's decision-making processes plus identification of main drivers which influence these decisions.

Prior to the application of an ABM for characterising integrated scenarios of wetland use in East-Africa we conducted intensive households and field surveys to characterise household agents' behaviours. Individual interviews combined with village wetland farmers' group discussions were used to capture livelihood typology of households based on human, social, financial, natural and physical capital. Additional data was collected on wetland historical use, and the main drivers for wetland use as well as conflicts occurring between agents who compete for wetland resources. Data of spatially explicit land uses and management practices as well as cropping systems and outputs were gathered at the farm level from household interviews.

Rural farming communities have diverse livelihoods which are reflected in complex attitudes towards wetland use. They have created high pressures on wetland resources for maintaining their livelihoods. Multivariate analyses techniques are applied for classifying wetland types and to define and characterise the different household livelihood typologies as well as socio-ecological determinants of their wetland use choices. In addition, multi-nominal logistic regression methods are used for identifying key determinants of wetland land-use choices by each agent groups based on plot-based datasets. Effects of wetland contributions to the livelihoods and consequences for land degradation were quantified in a screening study. We chose the Repast simulation toolkit which interfaces both with Java and ArcMap. First results of this study will be presented.

**Keywords:** Agent-based modelling, agricultural use, decision-making, human-environment interactions, Kenya, small wetlands, Tanzania

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## Water Governance in Zambia: The Case of the Kafue River Basin

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Water is critical to Zambia's sustainable development and poverty eradication, but, as the population increases, there is a corresponding increase in the demand for the available resources making it imperative to reduce on potential competition. The challenge is to ensure sustainable, efficient and equitable management and use of the scarce water resources, but a growing literature indicates lack of proper governance in the water sector is the main factor causing the loss of possible potential that could be harnessed from Zambia's existing water resources.

The Kafue River Basin plays an important role in Zambia's economic development: it is host to more than 40 % of the Zambian population and drains the major industrial, commercial and agricultural areas of Zambia. The complex web of consumptive and non consumptive uses of the waters of the Kafue River generates a strong intersectoral competition and the lack of proper governance mechanisms in the basin, which affects the allocation and use of the common water resources, sharpens the existing conflicts. In this context, the research aims at conducting an institutional analysis of the regimes that govern the use of water resources in Zambia as applied to the specific case of the Kafue River Basin waters. The practical implementation of the regulatory provisions will be analysed and the study will explore how the different institutions deal with consumptive and non-consumptive uses of the waters of the Kafue River. The study will, thus, concentrate on the analysis of the stakeholders' objectives and interactions to individuate on one side the endowments and on the other side the discrepancies with the current regulatory framework, that would require a substantial institutional change to re-align the social/stakeholders' goals and the institutions that govern the Kafue's waters.

The study will be based on a stakeholder consultation process conducted via direct interviews and questionnaires. Through these consultation processes solid policy recommendations could be produced to fill the gaps identified which will, in turn, enhance the water management of the Kafue River Basin concurrent to the institutional framework and relevant stakeholders' objectives.

**Keywords:** Kafue, river basin, water governance, Zambia

## Does Political Power Matter for the Amount and Type of Resource Contribution in Locally Managed Irrigation Systems: A Case Study from Nepal

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Nepal is an agricultural country where more than 76 % of the population depends upon agriculture for their livelihood and this sector provides 38 % GDP for national economy. Irrigation is considered as the heart of agricultural growth but it is the most limiting factor in Nepalese agriculture because only 32 % of total cultivated land is irrigable even though Nepal is considered as rich in water resources. Water scarcity is more prominent in mountainous and hill area than the plain areas of Nepal. Many studies show that the scarcity of resource leads to the politicisation which ultimately affect benefit and cost sharing among the beneficiaries. Therefore, three water scarce villages of trans-Himalayan region namely Lomanthang, Chhoser and Chhuksang of Mustang district of Nepal, where people used to manage the irrigation system through institutional approach and the class stratification have direct influence on water allocation and resource contribution, were selected. The major source of resource in the form of cash, labour, food and material are considered as the fuel of irrigation system in this locality and beneficiaries from the different classes used to contribute the resource differently in this locally managed irrigation system. The objectives of the research are firstly to analyse the types and amount of resource contribution by different classes and secondly finding out the scientific base of this resource allocation practices, remodelled it if necessary considering the equity and efficiency aspect. The result of the study revealed that people who are politically strong are more involved in the decision making and distribution aspect of the irrigation system while the people who have weak political powers contribute more labour force for repairing and maintaining the irrigation system irrespective of their landholding.

**Keywords:** Beneficiaries, institution, political power, resource allocation

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## **Economics of Groundwater Recharge for Sustainable Watershed Development**

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Sujala watershed project initiated by Government of Karnataka with the assistance of the World Bank is a community driven programme implemented by Watershed Development Department with tripartite cost-sharing arrangements. This project involves the participation of people in decision making process to empower the farming community to build up a sustainable development. In the present study, the economic impact was assessed on groundwater recharge, the resultant equity in the distribution of benefits and synergistic effect of sujala watershed programme in the state of Karnataka, India. Field data was collected for the year 2004–05 from 30 farmers each in the upstream and downstream areas of Devarathorehalla sub-watershed and 30 farmers from non-watershed area to represent the control. The data collected from sample farmers was grouped according to the size of land holdings and physical access to groundwater. The economic impact of watershed includes net returns per acre of irrigation was found to be 15 % higher in watershed area over non-watershed area. Environmental impact of watershed includes physical access to groundwater irrigation was higher by 17 % in watershed area compared to non-watershed area. Environmental economic impact of watershed includes savings on cost and net returns from groundwater irrigation. The irrigation cost was found to be 15 % lower in the watershed area compared to non-watershed area.

Equity in distribution of benefits showed by comparing Gini co-efficient with respect to distribution of net returns per farm, the higher inequality was noticed in non-watershed area compared to watershed area. The synergistic contribution of sujala watershed programme enlisting the participation of NGO's and farmers was shown by incremental net returns per acre in watershed area over non-watershed. For example, the incremental net returns per acre in rainfed farms, was INR 2200 [net returns per acre in watershed (INR 3886) minus non-watershed (INR 1686)].

**Keywords:** Equity, irrigated farms, irrigation wells, rainfed farms, watershed

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## The Consequences of Ground-water Level Lowering on the Socio-economic Conditions of the Population at the Darab Central Plain, Iran

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Many arid and semi-arid countries in the world are experiencing serious ground-water lowering, with far-reaching consequences for the population. As the related problems seem to be far in the future, taking care of them is a generally neglected issue. Future generations seem to be those who at the end will have to bear the negative consequences due to lower access to water. However, the problems are increasingly affecting the present population in an increasing part of the world. One of the regions which is confronted with such a problem is the Darab central Plain.

The Darab central plain is located in the southeastern of Fars province in Iran (684.4 km<sup>2</sup>). It includes 126 villages (about 63.236 inhabitants). About 90 % of the income in the region is due to agricultural activities. The annual average precipitation of about 248 mm makes farming dependent on ground-water resources which are provided by the Darab watershed (700 km<sup>2</sup>). Due to the ground-water overuse, the ground-water table of the Darab watershed has decreased, on average, by 1.18 m annual between 1993 and 2006. The pressure on ground water resources led to an annual negative water budget of 41.47 million m<sup>3</sup> in the Darab watershed. The dependency on agriculture, the lack of alternative employment possibilities, and the population growth imply high priority on present irrigation farming, yet at the expense of future generation in term of water availability. However, the consequences of increasing water scarcity can already be observed in some villages. So, due to ground-water level lowering, drinking and irrigation water shortage has occurred in the region.

The research focuses on the consequences of ground-water level lowering by investigating the socio-economic conditions of the inhabitants of 45 villages in the Darab central plain. For that purpose the link between water depletion, migration and unemployment will be investigated. The socio-economic conditions of different groups are studied and compared based on migration figures, cultivated area, income and ground-water level data. Secondary data, collected from governmental organisations of Iran, Fars province and Darab, are used. The results demonstrate the sensibility of the villages to the ground-water level lowering.

**Keywords:** Arid and semi-arid regions, ground-water depletion, Iran, migration, socio-economic development

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## The Effects of the Current Cropping Pattern on the Sustainability of Ground-water Resources in the Darab Central Plain

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The cropping pattern implemented in many regions of the world is not adapted to the ground-water resource restrictions in terms of sustainable use. Ground-water resources are sensitive to cultivation patterns, especially in arid and semi-arid regions. Darab central plain is a region confronted with ground-water level lowering. The research hypothesises that the cropping pattern is significantly enhancing ground-water depletion in this plain.

Due to ground-water level lowering, water availability in the Darab central plain (684.4 km<sup>2</sup>), in Iran's arid and semi-arid climate zone, is increasingly restricted. The ground-water level has dropped on average, by 1.36 metre per year. With an annual average precipitation of about 248 mm (during 1996–2006), farming in this area strongly draws on ground-water resources for irrigation, resulting in an annual negative water budget of 41.47 million m<sup>3</sup>. Currently, some villages are starting to face drinking water shortage. As in some areas, there is not sufficient water for agricultural purposes, some farmers have lost their employment and live on governmental support or have to commute for work in the other areas or migrate to the cities where they often join the mass of underemployed.

The paper will present the effects of the current cropping pattern on the sustainability of ground-water resources in the Darab central plain. The cultivation area of different agricultural products and their water needs are compared with the amount of ground-water decrease in different areas. The amount of ground-water used for different agriculture purposes in proportion of the ground-water used for agricultural purposes in relation to the total available ground-water in the Darab watershed is calculated. For the analysis, secondary data, collected from governmental organisations of Iran, Fars province and Darab sub-province, are used. The results indicate that the current cultivation pattern of the Darab central plain has led to ground water depletion in this region. In particular wheat and maize production significantly affect the ground water level in Darab central Plain.

**Keywords:** Arid and semi-arid regions, cropping pattern, Iran, water shortage

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## The Impact of Scarcity of Water and Land Resources on Poverty and Migration in East Java

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Rapid economic growth in various sectors in East Java puts pressure on land and water resources, resulting in gradual degradation of these resources in particular. Industrial development has frequently sacrificed agricultural land to the construction of factories, roads, housing and other land-based infrastructure.

Due to population pressure on the land and increasing demand for labour force, the population's mobility has changed. People increasingly migrate to marginal agricultural lands or frontiers, to urban areas, and/or to international locations either permanently or as contracted wage labour. Legal systems and lack of government control of land use encourage the sale of farm land which is then used for non agriculture purposes. Therefore, agriculture land has become increasingly scarce leaving many smallholders with insufficient land to secure their livelihood. Those who still live as farmers mostly live on subsistence level. Using econometrics analysis, based on secondary data of 7767 villages in East Java Province, surveyed by the Agricultural Census 2005, the paper will examine the impact of the scarcity of land and water on poverty and migration in East Java.

The paper is organised in four sections. The first section presents the problem statement of the research including background information, research questions and hypothesis. The second section highlights the state of research which is relevant to analyse the implication of land use and water resources on poverty and migration. The third section will present the methodology employed for econometric estimation. Conclusions and policy recommendations will be presented in the last chapter as derive from explicit econometric model and contain a discussion of the results and their implications for policy and future research.

**Keywords:** Land resources, migration, poverty, water





# New crops - new potentials

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## The Paradox of Crop Selection in Semi Arid Chivi District, Zimbabwe

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Climatic conditions in Chivi district are typically semi-arid while the soils have inherent low fertility. Occurrence of recurrent droughts in recent years has negatively affected agricultural production. In a bid to increase productivity, farmers are shifting from crops that are more efficient in water utilisation, such as sorghum, towards less drought tolerant crops, like maize. However, research has shown that the yield potential of maize in the district remains low ( $<1.5 \text{ t ha}^{-1}$ ). Could the current livelihoods insecurity be attributed to this shift? What would be the way out of this paradoxical situation? This study was carried out to explore farmer crop selection in semi-arid Chivi district. Participatory methodology was used to collect data in four wards of Chivi district in 2006. This was coupled with an analysis of institutional reports over the period 1996–2006. Results indicated that farmers are dedicating more land to maize production though yields of this crop remain far below its yield potential. Crop selection among farmers in the district is not based on compatibility with soils, climatic conditions and available resources. The prioritisation of maize could be attributed to modernisation-based development planning, leading to the promotion of maize production at the expense of small grains. The other factor could be a perceived unavailability of a ready market for small grains. To improve livelihood security and efficient water utilisation (grain output per drop) under the semi-arid conditions, farmers need to focus more on small grains production. There is need to revisit the current crop pricing policy in favour of small grains. Small grains are not only feasible under the climatic conditions in Chivi district but also have the potential of reducing the rural household food deficit.

**Keywords:** Climate change, maize production, livelihood security

## Medicinal Plant Resource Management for Health and Livelihood Security in Some Rural Parts of India

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435 local health traditions were documented for 61 prioritised health conditions from selected areas of Andhra Pradesh, Chattisgarh, Karnataka, Kerala, Maharashtra, Orissa and Tamil Nadu were done. Thirteen Community Health Knowledge registers were prepared for 13 locations. The documented local health traditions were rapidly assessed for selecting the safe and efficacious practices using Indian Systems of Medicine especially Ayurveda and Sidha. 388 safe and efficacious local remedies were identified. These safe and efficacious practices were promoted through 21,454 Home Herbal Gardens (HHG). 91 Nurseries were established and 5,24,418 seedlings were raised. These seedlings were used to establish 21,454 HHGs in 451 villages. 2083 Women Village Resource Persons (VRPs) were trained for establishing HHG and using the plants grown in the HHG for preparation of home remedies as the first response to any primary health care needs. These VRPs in turn trained the households to establish and use the HHG for their primary health care needs. A training manual on Home Herbal Garden was prepared in local languages and given to the VRPs. The baseline survey indicated that households in these areas used to spend an average Rs. 391 per quarter for their PHC needs. An intervention feed back study showed that at the end of three years period the expenditure has come down to Rs. 82. Thus the family saves on average Rs. 308 per quarter.

Thirteen community based enterprises were registered. 29 economically important local species had undergone cultivation trial and package of practice for 24 species had been prepared. 18 species of raw drug are collected and sold in the local markets and the CBE has earned about Rs.13,95219 in the last two years. There are 71 products produced in 13 community based enterprises and marketed through various CBOs such as SHG and Cooperative

**Keywords:** Community health knowledge register, home herbal garden, livelihood, local health traditions, medicinal plants, primary health care

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## **New Life for Ancient Grains: Improving Livelihoods, Income and Health of Andean Communities**

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Agricultural biodiversity offers poor communities living in harsh environments options to improve their livelihoods, generate incomes, attain food security and enjoy better nutrition and health. Andean grains, such as amaranth, cañihua and quinoa have been used by local communities in Bolivia and Peru for centuries, and sustained them thanks due their high nutritional values and capacity to thrive in the harsh environmental conditions of the Andes. In spite of their significance though, several factors, including poor market competitiveness, lack of good planting material, laborious processing and a perception of traditional Andean grains as ‘food for the poor,’ have conspired against these crops causing them to fall into disuse. This paper presents preliminary results of an international effort initiated in 2001 aimed at enhancing the use of these crops using a holistic, inter-disciplinary and participatory approach and contribute to strengthening the reliance of communities over their traditional resources and knowledge. Highlights of this work include:

1. Participatory selection of higher yielding varieties, resistant to drought, frost, pests and diseases;
2. Reintroduction to farmers’ fields of more than 40 varieties of quinoa and cañihua which had been lost;
3. Strengthening of *ex-situ* conservation through gap filling germplasm collections in centres of diversity and characterisation, multiplication and regeneration of hundreds of accessions;
4. Documentation and rescuing of local knowledge and institutionalisation of Diversity Fairs to promote exchange of knowledge and genetic material;
5. Development of better cultivation practices, low cost technology for threshing and removal of saponin meant to reduce drudgery and increase household consumption of crops for nutrition security;
6. Assessment of the nutritional variation of target crops in raw and processed products and awareness raising among urban consumers along with popularisation in restaurant chains;
7. Development of national quality standards for the commercialisation of target crops, allowing communities to enter into lucrative export markets;

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8. Capacity building of community members over enhanced practices, value addition, nutrition and marketing, and development of collaborative platforms to scale up experiences and reinforce sustainability of use of target species.

**Keywords:** Andean grains, livelihoods, underutilised species, human nutrition, traditional knowledge

## Minimum Tillage Systems with Potato in Winter Cropping Regions of Subtropical China

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With the introduction of early maturing rice varieties in the cropping systems of subtropical China, the earlier harvesting of the summer rice crop and the later planting of the spring rice crop resulted in a fallow period of about 90–100 days of paddy rice soils in winter time. The mild cool temperatures of the season are suitable for vegetables and potato or sweet potato production. This opens the opportunity to increase food production without competing for arable land, by making more efficient use of already cultivated areas.

However, heavily worked paddy rice soils often have a high clay content and are low in organic matter, and therefore difficult to plow. In China, some farmers have tackled this problem through minimum tillage and mulching, to produce potatoes on paddy soils, with a limited amount of labour input. The system consists basically in placing potato seeds on the ground and covering them with a thick mulch of rice straw. The crop then develops with irrigation or in rainfed conditions and produces yields ranging from 15 to 30 t ha<sup>-1</sup> providing farmers with an additional source of income. A product of farmer innovation, the system has not been long in use. But it has already spread across a few provinces in China.

Usually farmers use the straw from two to three hectares of rice to mulch a single hectare of potato. The rice straw is an important source of organic material that also benefits the subsequent rice crop. But there are competing alternative uses for the straw (as feed, fuel or building material) which in effect limit application of the cropping system.

Since 2008 the International Potato Center is analysing the potentials and constraints of this system via researcher and farmers surveys and the implementation of on-farm trials to improve management components and evaluate and eventually promote the system in other winter fallow regions of subtropical Asia.

**Keywords:** Farmer innovation, mulch, rice straw

## Assessment of the Importance and Utilisation of Cowpea (*Vigna unguiculata* L. Walp.) as Leafy Vegetable in Small-scale Farm Households in Tanzania

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Cowpea (*Vigna unguiculata*) is an important food legume and its use as a leafy vegetable is essential in many African countries. Drought tolerance, short growing period and its multipurpose use make cowpea a very attractive alternative for farmers who cultivate in marginal areas, where infra-structure, food security, and diminishing malnutrition are major challenges. Despite its regional importance, cowpea used as leafy vegetable has been neglected in research and improvement programs.

Within the project “ProNIVA”, conducted by the World Vegetable Center (AVRDC) and partners, this research was performed in order to reveal the current status of cowpea use as leafy vegetable from small scale farmers in Tanzania.

Semi-structured questionnaires were applied in non-standardised interviews, and group meetings were held in three main cowpea-growing districts of Tanzania (Arumeru, Mwangi and Dodoma) to gather farmers’ experiences and knowledge on cowpea use as leafy vegetable. 138 farmers participated in the survey. The analysis was stratified by different levels of infrastructure and agro-ecological conditions. Mainly descriptive statistics were used to describe the basic features of the data gathered.

In Dodoma district, weed resistance and drought tolerance were major preferences. In Arumeru, quality of plant residue and leaf colour were of main concern. Whereas farmers from Mwangi had preferences for seed colours. The study showed strong responsibility of women in cultivation and marketing of cowpea, until it reaches the status of a cash crop. Furthermore, preferences for distinct cowpea types were depicted. The dryer the environment, the more the farmer cultivated a mixture of erect, early-maturing varieties for grain yield mainly and spreading types for repeated leaf harvests as well as grain yield. Although smallholders appreciated cowpea as an additional source of vitamins and micronutrients, many farmers were not satisfied with the germplasm accessible to them.

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The multipurpose use of cowpea as leafy vegetable for human consumption should be further improved by considering traits of local importance. The low intra-specific diversity in cowpea and farmers' demands for improved varieties is an indicator that collaboration among the government, researchers and farmers needs to be strengthened by site-specific selection approaches.

**Keywords:** African leafy vegetable, cowpea, food security, germplasm, malnutrition, multipurpose use, poverty alleviation, Tanzania



# Biotic / abiotic pressure

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## The Responce of Tea Tree Oil as a Biofungicide against Early Blight Disease in Tomato Crop (*Lycopersicon esculentum* Mill.) in Sudan

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The tomato crop (*Lycopersicon esculentum* Mill.) in tropical central and South America. In Sudan, tomato is gaining importance and its consumption has increased, it ranks as the first vegetable crop in Sudan. Tomatoes are subject to a large number of pests and diseases from the time of emergence to harvest. Among these; Early Blight is the most important fungal disease of tomato, induced by *Alternaria* spp. Current research is designed to investigate the potential of Early Blight biocontrol strategy through the use natural alternatives to pesticides with the aim of promoting sustainable agricultural development and economic growth. The antifungal effect of tea tree (*Melaleuca alternifolia*) essential oil against *Alternaria* spp. was studied *in vitro* and *in vivo*. The inhibition effect of four different concentrations (0.5 %, 1 %, 2 % & 3 %) of tea tree oil or melaleuca oil on the linear growth of the pathogen was evaluated in potato dextrose agar. The inhibitory effect of the tea tree oil was examined in the nursery during 2007/2008 winter season using a susceptible open pollinated tomato cultivar Peto 68 and recommended fungicide for early blight disease of tomato Ridomil® Gold MZ 68WP for comparison. The results performed that the antifungal effect of tea tree oil against *Alternaria* spp. was enhanced significantly *in vitro* and *in vivo* with the lease disease intensity of 12.50 % when tomato plants treated with the concentraion 3 % of the tea tree oil when compared to the fungicide treatment 17.88 % and the control (untreated plants) 27.08 % disease intensity. Biocontrol methods based on inhibition of the spore germination of causal agents are achieving significance. Some of the advantages of these methods over chemical methods include absence of residual toxicity, the harmlessness to the nature and costless.

**Keywords:** *Alternaria* spp., early blight disease, *Melaleuca alternifolia*, Sudan, tomato

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## Investigating Inhibition of Nitrification Process by Compounds Released in Root Exudates of *Brachiaria humidicola* Plants

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Precise nitrogen management requires enough knowledge regarding spatial distribution of mineral nitrogen. If plants themselves could precisely manage nitrification, it could offer very important economic and environmental implications. Finding such plants and related physiological and molecular characteristics can help to introduce such highly valuable properties to farming crops. Nitrification inhibition (NI) by climax ecosystems has been suggested for decades, and this inhibitory effect seems to be a feature of wild genotypes rather than commercial cultivars. Many plants particularly grasses were suggested to have NI activity, and recently *Brachiaria humidicola* (BH) showed promising control on nitrification rates through root exudates. So, in this study during a series of nutrient solution experiments, effects of different conditions such as N form ( $\text{NH}_4^+$  vs  $\text{NO}_3^-$ ) and N concentrations (1, 2 and 4 mM N), plant age, light intensity and different collecting medium for root exudates on NI activity of root washings from BH were investigated. The results showed that BH root exudates when collected in distilled water, independent of light intensity, plant age, N-forms, N-concentrations and root exudates collection periods, had no significant inhibition on nitrification. However, when root exudates were collected in a medium containing 1 mM  $\text{NH}_4\text{Cl}$ , there was significant inhibition on nitrification process in a soil bioassay. This inhibition was more highlighted when plants were grown in ammonium rather than nitrate. Freeze dried root exudates instead of drying with rotary evaporator also showed significance NI in plants which were grown in  $\text{NH}_4^+$  under low light, but not higher light intensity, or nitrate nutrition. Measuring electric conductivity of root washings also showed higher conductivity when ammonium presented in root medium, particularly in root exudates collecting medium over extended time (24 instead 6 hours).

**Keywords:** Ammonium, *Brachiaria humidicola*, electric conductivity, nitrate, root exudates

## Interactions between the Mycoherbicide *Fusarium oxysporum* F. sp. *strigae* and Sorghum Roots

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The potential mycoherbicide, *Fusarium oxysporum* F.sp. *strigae* (Foxy 2), expressed high efficacy in controlling the root-parasitic weed *Striga hermonthica* in pot experiments. Preliminary microscopic investigations of *Striga*-free sorghum roots showed that hyphae of Foxy 2 digested root cortical cells but could not cross the endodermal barrier into the central cylinder. However, sorghum roots infected by *Striga* revealed hyphae of Foxy 2 within *Striga* haustoria growing into the central cylinder of sorghum. We performed light and transmission electron microscopic studies to understand this tissue specific reaction. The endodermal barrier of roots was overcome by wounding and were inoculated to observe for possible colonisation. Light Microscopy showed that hyphae had invaded the central cylinder close to the wound but were not found a few centimetres from the wound indicating that they could not grow within the central cylinder. Sorghum therefore manifested a tissue specific reaction (incompatibility) against Foxy 2 within the central cylinder. Furthermore, the action of Foxy 2 in sorghum was compared with a pathogenic strain *F. proliferatum* using the seed coating delivery system. Coated seeds were grown on filter paper and semithin sections of roots showed that both Foxy 2 and *F. proliferatum* colonised and digested the cortical cells but Foxy 2 was slower. *F. proliferatum* invaded and destroyed the cells of the central cylinder three weeks after sowing while the hyphae of Foxy 2 were blocked at the endodermis. Transmission electron microscopic studies revealed that sorghum reacted to the presence of both strains by manifesting osmiophilic material and distorted cytoplasm in cortical cells which was not observed in the control roots. Protein analysis was used to evaluate the possible production of PR (pathogenesis related) proteins by sorghum infected with Foxy 2. Proteins were extracted and analysed for differences in the protein expression pattern of infected and non-infected roots. Results to date suggested that Foxy 2 probably did not cause the production of such potential PR-proteins. However, further investigations are needed to clarify these host-mycoherbicide interactions and to assess potential risks in the application of such biological control mechanisms.

**Keywords:** Biocontrol, *Fusarium oxysporum*, mycoherbicide, sorghum, *Striga*

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## Investigations of Biotic Agents Associated with Dieback Disease of *Dalbergia sissoo* Roxb. in Bangladesh

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The dieback of *sissoo* (*Dalbergia sissoo* Roxb.) is a devastating disease occurring in Bangladesh as well as in India, Nepal, Pakistan and Afghanistan. The dieback symptom complex is characterised by wilting and subsequent loss of side branches leading to stagheadedness, constantly accompanied by gummosis on the trunk. Trees die within short time after the first appearance of symptoms. Fungi, bacteria and insects were reported to be associated with the dieback syndrome, but the causal agent(s) were not yet unequivocally identified. Our studies are focused on the molecular detection and characterisation of putative pathogens in leaf, wood and bark specimens from dieback affected *sissoo* trees, which had been collected at various sites in Bangladesh.

In a first approach we isolated bacteria from dieback-affected and unaffected specimens and started characterisation by sequence analyses including 16S rDNA and typical genes (RNA polymerase, RNase P, gyrase, among others). The sequence data indicated the association with the dieback syndrome of still unassigned bacteria belonging to the genus *Pseudomonas*. Hypersensitivity assays on indicator plants (*Chenopodium quinoa*, *Nicotiana tabacum*) revealed the phytopathogenic potential of several isolates.

On the other hand, the fungal pathogen *Fusarium solani*, which was supposed to be one of the major causes of *sissoo* dieback, was hardly detectable by means of molecular characterisation in our specimens, whereas *F. oxysporum* and in particular *Lasiodiplodia theobromae*, a well known pathogen associated with dieback syndromes of various tropical plants, could be clearly identified.

To make the situation even more complicated, electron microscopic inspection of leaf homogenates revealed the presence of virus-like particles of 60–130 nm in diameter. Preparation and gel electrophoretic analysis of double stranded RNA (dsRNA) allowed cloning and sequencing of cDNA fragments with similarity to viral replicases. Therefore, viral infections are also likely to contribute to the dieback disease.

In conclusion, our data provide clear evidence for a diverse aetiology of the dieback syndrome of *D. sissoo*, and strongly argue for intensive future efforts to the understanding and possibly controlling of this disastrous disease.

**Keywords:** *Dalbergia sissoo*, dieback, DOP-PCR, *Fusarium oxysporum*, *Lasiodiplodia theobromae*, *Pseudomonas*, Viral dsRNA

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## Influence of Biochar-application on the Drought Stress of Plants

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Global warming, increasing desertification of soils, a growing world population and subsequent food shortage force to find innovative solutions for all these threatening problems. The fertile Terra Preta soils of Amazonia contain high amounts of pyrogenic carbon (“Biochar”), humus and phosphorous. Stimulated by these findings an increasing number of Biochar-studies were initiated in the last years predominantly at tropical soils. Thus, the application of Biochar to agricultural soils may be a promising mitigation and adaptation strategy.

To investigate plant-soil interactions and greenhouse gas balances with or without drought stress, a fully replicated pot experiment (pots: 10 cm diameter, 20 cm height) was conducted in a greenhouse. Pots were seeded with the recently discovered drought tolerant cash crop *Chenopodium quinoa*. Three levels of biochar application were used, equivalent to 0, 100 and 200 t ha<sup>-1</sup> ploughed 20 cm deep into the soil.

The ecophysiological plant reaction (such as water relations, water use efficiency, anabolism) was studied and the exchange of trace gases between soil and atmosphere. Application of Biochar increased the water holding capacity (WHC) of the sandy soil and had significant effects on several ecophysiological parameters of quinoa plants. The potential of Biochar for drought-related crop management recommendations will be discussed.

**Keywords:** Biochar, drought stress, global change, quinoa

## A Survey of the Longhorned Beetles Species (Cerambycidae) on *Acacia* Trees in the Gum Arabic Belt of Sudan

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A field study was conducted in 2007 and 2008 in northern Kordofan state in the gum arabic belt (Sudan) on longhorned beetles (Cerambycidae), infesting *Acacia* species (*A. senegal*, *A. mellifera*, *A. seyal*) connected with severe economical losses of gum Arabic yield. The study focused on the assessment of pest species spectrum and infestation characteristics (e.g., number, location and direction of holes of infestation). Environmental and silvicultural parameters were measured to predict the infestation; those are crown size, crown diameter, tree age, tree temperature, tree height and dbh. Spectrum and relative abundance of pest species were determined by catch results of flight interception traps, microclimatic conditions by data loggers, silvicultural parameters of trees by direct measurements.

Longhorned beetle species affecting *Acacia senegal* on the study sites were: *Crossotus subocellatus* (Fairmaire, 1886), *Titoceres jaspideus* (Audinet Serville, 1835), *Crossotus albicollis* (Guérin, 1844), *Coelodon servum* White, 1853, *Doesus telephoroides* Pascoe, 1862, *Tithoes maculatus* (Fabricius, 1792), *Crossotus strigifrons* (Fairmaire, 1886). The results show that all of the *Acacia* tree species i.e. *A. senegal*, *A. mellifera*, and *A. seyal* indicate presence of holes of infestation by the longhorned beetles. Infestation rate of trees ranged between 20 and 100 % on the study sites (n = 6). With the exception of presence of holes in the North direction in *A. senegal*, holes were present in all directions of the tree trunk. *A. mellifera* indicated maximum presence of holes in the trunk, and *A. senegal* in the branches. Infestation rate correlated primarily with the age of the trees.

**Keywords:** *Acacia mellifera*, *Acacia senegal*, *Acacia seyal*, Cerambycidae, gum belt, infestation, longhorned beetles, Sudan



## Differential Response of Low Root Zone Temperature and Drought on Tomato Introgression Lines

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Tomato (*Solanum lycopersicum* L.) is an economically important vegetable cultivated worldwide. It is a thermophilic crop and low temperature can hamper plant growth, development and total biomass production. Sub-optimal temperature also limits the tomato growing season and area and increases the cost for energy inputs especially in greenhouses. Developing a cold tolerant tomato variety with sustainable field performance is a big challenge of modern agriculture. Tomato breeding programs are nowadays concentrating on the detection of dominant quantitative trait loci (QTLs) and evaluating their performance with introgression lines under sub-optimal temperature conditions for tomato production.

The main objective of this study is to reveal the physiological basis of drought stress and chilling tolerance in tomato introgression lines which are supposed to carry QTLs with positive effects on plant vigour under low temperatures. Response of a chilling tolerant introgression line to low root zone temperature will be studied under well watered and drought conditions. We will investigate the effects of low root zone temperatures and drought stress on stomatal conductance, root and shoot abscisic acid content, leaf expansion rate, total green leaf area, percentage of wilted leaf area, biomass accumulation and partitioning.

Tube grafting will be done on four different combinations of genotypes and seedlings will be grown at two different soil temperatures (10°C and 25°C) under well watered condition and drought stress conditions.

**Keywords:** Cold tolerance, drought stress, introgression lines, low root-zone temperature, QTLs, *Solanum lycopersicum*, tomato

## Efficiency of Adaptation Mechanisms of Rice to Diverse Conditions of Iron Toxicity

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Iron toxicity is a nutritional disorder that differentially affects lowland rice as a function of plant development stage and the intensity and duration of the stress. After its uptake and translocation in aboveground plant parts, the physiologically active Fe(II) catalyzes reactive oxygen species which destroy cell membranes and structural components. Tolerant cultivars are considered the most effective approach to cope with diverse iron toxic conditions. Tolerance mechanisms may comprise (1) exclusion of Fe(II) from the root by oxygen release of the aerenchyma, or from the leaf symplast by apoplastic oxidation, (2) retention and immobilisation in physiologically less active tissues and (3) detoxification of reactive oxygen species in leaf tissues. Ten rice genotypes of different origins (*O. sativa* indica/ japonica, *O. glaberrima*, interspecific NERICA) and with known sensitivity or tolerance to Fe(II) were comparatively evaluated in hydroponic culture regarding the effectiveness of the prevailing adaptation mechanism under diverse toxicity conditions. Increasing Fe(II) stress intensities (0, 500, 1000, 1500 ppm Fe(II)) were applied for variable durations (2–6 days) at the seedling, vegetative and early reproductive growth stages (4, 6 and 8–10 weeks old plants). Leaf symptom scoring was combined with Fe partitioning (root plaque, Fe content in root, stem and leaf tissue) and Fe speciation (total Fe(III) by AAS; active Fe(II) by 2,2'-dipyridyl colouration). Within a given cultivar, both the stress tolerance level and the type and effectiveness of the involved adaptation mechanisms changed with developmental stage. Genotype selection must consider the intensity, the duration, and the timing of the iron stress occurrence to effectively counteract iron toxicity stress.

**Keywords:** Rice, iron toxicity, *Oryza sativa*, stress tolerance

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# Influence of Mineral Nutrition and Combination of Mineral and Organic Nutrition at Different Nitrogen Levels on the Root Yield and Nutritional Qualities of a Common Carrot Cultivar from Myanmar

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In Myanmar, low-input agriculture is commonly practised by resource poor farmers using organic manures and land races for cultivation of carrot, where the yield is usually not satisfactory. Nowadays, farmers are trying to introduce hybrid carrot cultivars due to their higher yield and quality. However, hybrid cultivars demand higher amounts of mineral nutrients generally covered by chemical fertilisers. Combined application of chemical and organic fertilisers, therefore, might be an alternative for the farmers to achieve higher yield of better nutritional quality regardless the use of local or hybrid cultivars.

To investigate the productivity and nutritional properties in relation to different types of fertilisation and carrot cultivars, the pot experiment was performed in winter season 2007 in the green house at the Section Quality of Plant Products of the Georg-August University Goettingen, Germany. The experimental design was split-split plot with three replications per treatment. Both mineral and organic fertilisers were used as a source of nitrogen fertilisers, while  $P_2O_5 = 140 \text{ kg ha}^{-1}$  and  $K_2O = 220 \text{ kg ha}^{-1}$  were applied in all combinations in the form of mineral fertiliser. In the main plot, three kind of fertilisers were set: mineral fertiliser (MF), farmyard manure (FYM) + MF (FYM+MF), and Compost + MF (C+MF). Three levels of nitrogen (N1 = 60, N2 = 120 and N3 = 180  $\text{kg ha}^{-1}$ ) were allocated in the sub plot and in the sub-sub plot, a common carrot cultivar from Myanmar (Srup) and a hybrid cultivar from Germany (Fly Away) were grown.

Cultivar Srup was characterised by higher ascorbic acid and nitrate content. Fly Away showed higher yield, dry matter content and total phenolics content. FYM + MF and C+ MF remarkably increased dry matter and total carotenoids content. Moreover, C + MF significantly increased total phenolics content, but decreased the content of nitrate. Total antioxidant capacity was not affected by cultivar difference and type of fertilisation. Levels of nitrogen influenced to a lesser extent on the yield and quality parameters. Generally, use of hybrid cultivar and combined application of mineral and organic fertiliser can be recommended to achieve higher yield and better nutritional quality.

**Keywords:** Ascorbic acid, genotype, low input agriculture, mineral nutrients, total carotenoids, total phenolics

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## The Cost of Invasion Control Measures Subtropical *Ailanthus altissima* (Mill) Swingle in Hesse

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The introduction of species to Europe has a long history but in recent times the invasion of alien species has reach new levels due to globalisation. Vulnerable ecosystems and the increase of invasive alien species (IAS), which are favoured by the human-made climate-change have led to a change in the composition of ecosystems and are endangering local species, communities and biotopes. AIS introduce new pests and diseases previously unknown to the ecosystems.

Alien invasive species introduce pests and diseases, affect agriculture and forestry negatively and damage buildings and roads, thereby raising the costs for management and control. They burden the European economy to an ever increasing degree and therefore can be seen as a major challenge for biodiversity conservation in Europe. In this study we calculate the costs of different measures for controlling the invasive subtropical species *Ailanthus altissima* (Mill.) Swingle.

The genus *Ailanthus* (Simaroubaceae, Quassia family) is a native of India, eastern China, Thailand, Malaysia, Borneo, the Philippines, Sumatra, Java, Indonesia, the Solomon Islands, New Guinea and northern Australia. *A. altissima*, commonly known as “Tree of Heaven”, is today a naturalized and invasive species in disturbed areas in Europe and North America, particularly in metropolitan areas.

During the winters of 2005 to 2007, data about management, salaries, equipment and facilities costs for the control of *A. altissima* in Hesse (Germany) were collected. Park-managers, hospital allergy doctors, private and public garden workers and the vegetation management director of Deutsche Bahn, section Baden-Württemberg and Hessen, were interviewed to obtain further information about investments, local management, new methods, actual researches and strategies used on the control of invasive species.

Especially for Hesse (Germany) it is estimated that the uncontrolled spread of invasive species may cause annual costs of several million of Euros to the public and the private sector.

**Keywords:** Aliens species, cost control, management

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## Removal of Cadmium and Lead by Organo-clay Complexes from Contaminated Wastewater

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Organically modified clay complexes (OMC) were prepared from naturally occurring clay sediment modified by organic cations [L-Cystine dimethylester (cystin), L-Carnitine (carnitin), Thiamine (Thiamin) methyltriphenylphosphonium (MTP), and hexadecyltrimethyl-ammonium (HDTM)] and humic acid (HA), to adsorb heavy metals from contaminated wastewater. Cadmium and Lead were chosen as examples of common heavy metals in wastewater to investigate the adsorption characteristics of the OMC. The most efficient OMC shall later on be selected for wastewater cleaning in Egypt.

The effect of different organic modifiers on the characteristics of the clay sediments was studied by XRD, MIR and total organic carbon (TOC) analysis.

Generally, the total organic carbon (TOC) content in the prepared OMC increased with increasing modifiers concentrations in the following order: HDTM- > MTP- > Thiamin- > Carnitin- > Cystin- > HA-OMC. The Cd adsorption by MTP-, and HDTM-OMC was higher than the adsorption by the un-treated sediment. Carnitin- and HA-OMC showed a lower Cd adsorption than the untreated sediment. Carnitin- and MTP-OMC had the highest adsorption of Pb. HA-OMC showed a similar Pb adsorption as the untreated sediment. Cd and Pb adsorptions on the OMC were pH dependent. Carnitin-OMC had the highest Cd adsorption efficiency (94 % of the initial amount of Cd) at pH 4 to 8. HA-OMC showed a Cd adsorption efficiency of 84–86 % at pH 6 to 8. Carnitin- and HA-OMC achieved Pb adsorption efficiencies between 99.8–99 % at pH 4 to 6. Effect of the equilibrium time and the electrolyte ionic strength on the adsorption process were also investigated.

**Keywords:** Cadmium, lead, organically modified clay, wastewater

## Genetic Characterisation of Resistance Genes against Black Spot (*Diplocarpon rosae* Wolf) in Rose Populations

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Developing resistant cultivars against black spot (*Diplocarpon rosae* Wolf) has been a challenge in breeding garden roses. Genetic characterisation is an important step to identify and utilise new sources of such resistant traits in germplasm collections. This study was initiated to characterise black spot resistance gene(s) in a wild rose species *Rosa majalis*; to determine whether it is identical to the Rdr1, number and inheritance of gene(s) involved, and develop molecular markers and map the position in the genome. Forty-six F1 crosses of *R. majalis* and *R. pisocarpa*, 90 F1 crosses of *R. majalis* and König Stanislaus, 16 control genotypes, and 4 black spot single-spore isolates were used to carry out phenotypic (inoculation) assay, microsatellite marker, ploidy level and sequence analyses. Seven of the 46 segregating genotypes were found susceptible to F004, S009, DortE4 and D002 isolates. However, infection severity with D002 and DortE4 was not high as with the other isolates. In both flow cytometry and microsatellite marker analyses, the resistant parent (*majalis*) and segregating genotypes were found to be tetraploids, while *pisocarpa* is a diploid. Microsatellite marker loci, developed for Rdr1; 69E24Mica\_F1, 29Mica\_F5, 155SSR and Rdr1<sub>-</sub>gener<sup>3</sup>-pp co-segregated with the resistance against F004 and S009. Hence, the resistance gene in *Rosa majalis* could be identical to Rdr1 or a different gene within the Rdr1 cluster. All alleles which were specific to *pisocarpa* were absent in any of the segregating progenies in the *majalis* × *pisocarpa* cross. It suggests all progenies in this cross could be derived from selfing within the seed parent *majalis*. Gene prediction using a 1.7kb region cDNA sequence of resistant segregating genotypes resulted in NBS-LRR type disease resistance gene. Further nucleotide and protein-protein BLAST analyses confirmed that the sequence is part of a putative disease resistance gene in roses. A phylogenetic tree using 25 sequence data of different rose species indicated a closer similarity between the sequence and RGA8 of *R. multiflora*. Chi-square test results of 3:1 in *R. majalis* selfing and 1:1 in *majalis*–König Stanislaus cross segregations suggest a single dominant gene found in simplex (Rrrr) configuration in the parent *R. majalis*.

**Keywords:** Microsatellite marker, *Rosa majalis*, black spot

## Influence of *Bacillus* spp. on Iron Plaque Formation at the Root Surface of Lowland Rice

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Under iron toxic conditions, roots of lowland rice take up excess amounts of ferrous iron, which is translocated via the xylem with the transpiration stream to the leaves. There high concentrations of iron result in the formation of free radicals, damaging cell components, particularly membranes. The rice plant has developed several mechanisms to prevent this nutritional disorder, such as iron storage in different forms and tissues, partitioning among roots, leaves and stems and exclusion at the root surface by oxidising Fe(II) into a root surface plaque of Fe(III) compounds. Albeit the oxygen diffusing through the aerenchyma to the roots is responsible for the oxidation, some bacteria endemic to rice may positively affect the oxidation power of the roots. The aims of this research were to study the effect of 4 root-associated strains of bacillus (*B. megaterium*, *B. pumilus*, and two un-identified isolates of *Bacillus*) on the iron uptake by the plant and on Fe(III) deposition at the root surface.

Seedlings of the iron toxicity-sensitive cultivar I Kong Pao were hydroponically grown for 6 weeks. The root tips of the seedlings were cut (vs. a non-cut control), inoculated with bacteria and subjected to two iron treatments (0 and 1000 mg l<sup>-1</sup> Fe(II)). Nitrogen gas was infiltrated to the cultural solution to maintain reduced conditions. Toxicity symptoms were scored visually; Fe uptake and partitioning within plant organs, and iron plaque formation were determined by chemical analysis.

All four strains improved plant height in plants with intact roots whereas iron plaque formation was more pronounced when the roots were cut. The increased formation of iron plaque could have been due to improved bacterial penetration, facilitated by the cutting of the roots. *B. megaterium* reduced both Fe uptake and leaf symptoms and affected iron partitioning among organs, increasing the share of iron stored in the roots. The results imply that *B. megaterium* is a promising candidate for ameliorating the performance of rice under conditions of iron toxicity. Possible mechanisms of bacterial action related to iron toxicity will be discussed.

**Keywords:** Fe(II)/Fe(III), iron toxicity, *Oryza sativa*

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## Interactions Between Tomato Scion and Rootstock Varieties Regarding Growth and Development under Different Water Supply Levels

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In tomato production water deficit is a major limiting factor for plant growth, since it decreases photosynthesis by reducing leaf area and stomata conductivity. Grafting vegetables onto compatible rootstocks offers different advantages such as (i) resistance to soil pathogens, (ii) yield improvement under low soil temperatures and (iii) greater tolerance to drought and salt stresses.

In this study, different tomato scion (S) varieties were grafted with different rootstocks (R) varieties. As control treatments the S and R varieties were grafted on themselves. Two greenhouse experiments were carried out using 53 L containers. To screen the interactions and morphological plant characteristics, the tomato S varieties of Dirk (Enza), Pannovy (S&G), and Treasury (Semini) were grafted onto R varieties of Vigomax (RZ), Brigeor (Enza), and Maxifort (De Ruit) and examined under well watered (WW) conditions in the first experiment. The pre-selected varieties (S: Pannovy, Treasury; R: Brigeor, Maxifort) which showed highly significant interactions in the screening experiment, were tested in WW and drought stressed (DS) conditions in the second experiment. Early fruit fresh weight, leaf area, shoot and root dry weight, root length (in two soil layers) were measured while the water use efficiency (WUE) referring fruit fresh weight and total plant dry weight were calculated in the final harvests of both experiments.

After grafting, significant positive interactions between S and R varieties were found in the screening experiment and the best performance in total plant dry weight and leaf area was shown with Dirk-Brigeor, whereas opposite results were shown with Treasury-Vigomax combinations. In the second experiment, total root length and dry weight were significantly higher under DS than under WW and higher root length was produced in deeper layer with self-grafted R varieties. Graft combinations with Maxifort were characterised by higher root mass, particularly under DS compared to the control treatments. Treasury-Maxifort showed higher root/shoot ratios under both WW and DS. WUE referring to early fruit fresh weight and total plant dry weight was higher under WW. Under DS, both WUE referring to total plant dry weight and early fruit fresh weight was higher with Treasury-Brigeor compared to the control treatments.

**Keywords:** Drought stress, grafting, *Lycopersicon esculentum*, tomato, water use efficiency

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# Physiological aspects of crops and shrubs

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## Improvement of Germination Rate of Lontar (*Borassus flabellifer* L.) Seed through Physical and Chemical Treatments

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Lontar (*Borassus flabellifer* L.) is a member of the Arecaceae (palmae) family and commonly planted as a home industry plant. The main product from lontar is sap obtained by tapping inflorescences used to make sugar. It contributed to the improvement of the society economic particularly in Sulawesi, Indonesia. Use of lontar woods as construction materials for home building and the use of young fruits as a kind of traditional food are further utilities of lontar. However, the lontar population decreased severally caused by several factors, *i.e.* slow regeneration process caused by a long dormancy phase and a low growth potential. The present study investigated the effect of physical and chemical treatments to improve the germination rate of lontar seeds.

The experiment consisted of a complete randomised design with two factors. First factor: physical treatments (P0 = no physical treatment, P1 = scarification with sandpaper, P2 = seed back sliced by knife). Second factor: chemical treatments (C0 = no chemical treatment, C1 = 24 hours dipped in sterile distilled water, C2 = 24 hours dipped in 0,1 % KNO<sub>3</sub>, and C3 = 24 hours dipped in Gibberelin GA3).

The results show that the combined treatments P1 with C2 or C3 and P2 with C2 or C3 had similar effects on germination rate and grow potency of lontar seeds. In both combined treatments, the germination rate of lontar seed was 13–17 % with a grow potency of about 20 %. In these combined treatments the germination of seeds started at 90 days after treatment, which was 30 days earlier then the control (120 days). The germination potency and grow potency of the control treatment was only 0–10 % . These results suggest that a combined physical and chemical treatment can be used as a the best method to tackle the seed dormancy problems in lontar regeneration process.

**Keywords:** *Borassus flabellifer* L., seed dormancy, seed germination

## Impact of 12 Years of Poplar Cultivation on the Availability of some Soil Nutrients in Safrabasteh, Iran

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Fast growing plantations are likely to provide a huge quantity of raw material quickly and at a relatively low cost. Hybrid poplars, cultivated under Iranian conditions and on suitable soils, offer a high productivity. Thanks to the use of clonal varieties it is possible to obtain homogeneous material with well-known properties. The optimal stand density is 400 stems ha<sup>-1</sup>. The Research Institute of Forest and Rangeland (RIFR) planted many plots of hybrid poplar on the Safrabasteh Poplar Research Station in 1993 (Astaneh, Guilan Province). This study was carried out in order to study the influence of four poplar clone plantation on the available soil nutrients on this research station.

The experimental design was a completely randomised block with 3 replications and four treatments (25 trees in each plot) as: **1.** *Populus euramericana* cv. 214 **2.** *Populus euramericana* cv. 45/51 **3.** *Populus deltoides* cv. 77/51 **4.** *Populus deltoides* cv. 69/55. Some soil properties such as pH, OM, N, P, K, Ca and Mg were determined. The data were subjected to analysis of variance using the ANOVA procedures of the SAS program. Statistical significance was determined at  $p = 0.01$ .

Analysis of variance showed that the effects of different poplar clones are significant on soil parameters. The phosphorous, potassium, magnesium and organic matter contents in the upper layers varied in each plot. The rates of nitrogen and calcium did not change, except N and Ca. Mean comparison showed that the *Populus euramericana* cv. 45/51 had greater effects on the soil parameters than other clones. Thus, it is suggested that suitable poplar clones should be used for future plantations projects.

**Keywords:** *Populus*, soil nutrients

## Description of the Spatial Arrangement of the Physic Nut (*Jatropha curcas* L.) Root System - A Case Study from Madagascar

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*Jatropha curcas* L. (physic nut) is a drought resistant shrub or tree belonging to the family *Euphorbiaceae*. It is increasingly cultivated in Central and South America, Southeast Asia, India and Africa for biofuel production and claimed to grow profitably on marginal or degraded land in arid to sub-humid zones with annual rainfall of 300–1000 mm. Whereas yield and physical properties of the oil have been assessed in several studies, nutrient and water demand of *Jatropha* is not well characterised. Due to the fact that *Jatropha curcas* is often cultivated on marginal land, the efficient acquisition of limited resources may be related to root features, including depth of rooting and spatial distribution around the stele. To be able to evaluate the importance of such features, a study on *Jatropha* root systems was performed on a plantation in Fenoarivo, South-West Madagascar.

The spatial arrangement of roots was investigated in established *Jatropha* stands with a planting density of 1250 plants ha<sup>-1</sup> grown on yellow/red to reddish lateritic soil. The effect of soil tillage was investigated by comparing stands established on ploughed and non-tillage sites. Vertical root distribution down to a depth of 120 cm was analysed with the trench wall method, counting the number of root tips visible on grids. In order to assess the root distribution as a function of distance from the stele, samplings were performed at 20, 40, and 60 cm distance from the trunc on both sides. The data presented allow assessment of the spatial arrangement of the root system of *Jatropha* plants raised from seed as affected by land preparation and plant age. Additional data on root length density and root dry mass in specific soil layers will be used to relate information on spatial distribution to functional root parameters required for the analysis of above/belowground biomass allocation and acquisition of resources such as water and nutrients.

**Keywords:** *Jatropha curcas*, root mapping, water relation

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## Effects of Seed Stratification Treatments on Germination of *Grewia tenax* (Forssk.) Fiori a Wild Fruit Species

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*Grewia tenax* (Forssk.) Fiori is a fruit shrub and grows wild in arid and semi-arid tropics of Asia and Africa. The species is highly valuable for the rural populations because of its multipurpose use. Despite its great ability to withstand drought and high temperature, wild stands of the species are sparse. Seed dormancy is a typical feature of dryland tropical woody species for seed survival under unfavourable climatic conditions. The aim of this study was to define seed dormancy breaking methods for *G. tenax*. Seeds were collected from the wild stand in the surrounding of Dera Ismail Khan (31°48'N, 70°37'E) in Pakistan. The investigation was composed of two successive experiments under controlled environmental condition in the growth chambers of the Institute of Crop Science in Witzenhausen. In the first experiment, treatments were control, constant heat exposure at 40°C, constant cold exposure at 4°C and alternate heat and cold exposure at 4 and 40°C. Seeds were treated for one week before sowing. In the second experiment, seeds were subjected to constant heat exposure (40°C) for 0, 1, 2, 3, 4, 5 and 6 weeks before sowing. The results of the first experiment showed that exposure of seeds to dry heat at 40°C for one week significantly improved total germination up to 42 % as compare to control (20 %). Results of the second experiment displayed a linear increase in total seed germination with increase in time of seed incubation at constant heat. However, maximum total germination (70 %) was achieved, when seeds were incubated for 4 weeks. Seeds exposed to constant heat for 4 weeks also took only 4 and 5 days to reach first and 50 % emergence, respectively as compared to untreated seeds, which took 10 and 14 days to reach first and 50 % emergence, respectively. Emergence spread (duration between emergence of first and last seedling) lasted only 4 days as compare to untreated seeds with 21 days.

Our results indicate that seeds of *G. tenax* possess non-deep physiological dormancy which can be overcome by heat stratification.

**Keywords:** Germination, *Grewia tenax*, seed stratification, wild fruit species

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## Genetic Analysis of Pre-flowering Drought Resistance in Sorghum

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Sorghum production is highly restrained by drought stress and this has led to a world-wide yield reduction. In sorghum, drought stress is being characterised at pre-flowering and post-flowering stages. The present study was conducted to evaluate genetic variation and to identify quantitative trait loci (QTLs) influencing pre-flowering drought stress by considering some drought related agronomic traits such as leaf area (LA) and total root length (TRL) using an F5 recombinant inbred line (RIL) population derived from a cross between the drought resistant parental line 1488 and the susceptible genotype. The RIL-population and the parental lines were evaluated for the listed traits under well watered and drought stressed conditions. Phenotyping results obtained from the experiment showed high variation among genotypes for both traits. LA showed a high heritability of 0.78 and TRL had a heritability of 0.57. Analysis of variance was conducted for these traits using Proc GLM of the software package SAS 9.1. Both traits were statistically significant at a probability level of 0.05. Pearson's correlation coefficient was computed for both traits and the result showed that both traits (LA and TRL) were highly correlated with correlation coefficients of 0.5 under well watered condition and 0.5 under drought stressed condition.

For genotyping diversity array technology (DArT) markers, which is a hybridisation-based technology marker system with high reproducibility that allows quick development of hundreds of markers distributed along the genome, was used. QTL analysis for LA and TRL was carried out following the composite interval mapping method using the PLABQTL software package.

**Keywords:** QTLs, recombinant inbred lines, sorghum

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## Soil Water Availability for Agricultural Use in Small Wetlands in East Africa

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The conversion of wetlands into sites of agricultural production is mostly inter-linked with hydrological alterations (building of raised beds, drainage, irrigation etc.) that might also have negative effects on other system components. Yet, wetland ecosystems require a certain amount of water to maintain the long-term agricultural production potential and the diverse ecosystem services. Our research aims at determining the amount of water required to sustain the wetlands production potential for different wetland types and use patterns to maintain the long-term agricultural production potential of wetlands from a hydrological perspective. Two wetland types — one low-elevation floodplain wetland in Tanzania (350–400 m asl, wetland size 23.5 km<sup>2</sup>, catchment area 3600 km<sup>2</sup>) and one high-elevation inland valley wetland in Kenya (1720–1780 m asl, wetland size 9 ha, catchment area 2 km<sup>2</sup>) — have been selected for in-depth studies. In view of assessing the spatial and temporal availability of water for different agricultural uses, we (1) quantify the seasonal changes in water table (above-ground, within rooting zone, below rooting zone), the water storage capacity in the root zone and soil moisture variations along hydrological gradient; (2) assess the key factors controlling the hydrological regime of the wetlands; and (3) evaluate the effects of different agricultural uses on the storage and the seasonal availability of water. Hydrological parameters (*e.g.* discharge, water table depth, stratified soil moisture contents) and meteorological parameters (rainfall, temperature, relative humidity) are measured during the rainy and dry season as well as during the dry-to-wet season transition period. Soil water balance (HYDRUS 1D) and catchment models (SWAT) are applied to provide a base for the evaluation of scenarios of wetland use. Different use scenarios will be incorporated and model results will contribute for the formulation of recommendations for sustainable resource use strategies for small wetlands in East Africa.

**Keywords:** East Africa, small wetlands, water availability

## Detection of the Extent, Distribution, and Use Patterns of Small Wetlands in East Africa by Remote Sensing

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Small wetlands are estimated to cover some 15–45 million hectares in East Africa. With demographic growth and emerging land shortages, these wetland areas are viewed as potentially productive alternative sites for crop production and are increasingly converted from natural vegetation into agricultural land. Documentation of these resources is crucial because of their role in the ecosystem and for the livelihoods of people. However, their area extent and distribution, and their share under agricultural land use are largely unknown. Surveying and mapping of small wetlands requires high spatial resolution data. Such data are unavailable for the small wetlands of East Africa in particular. We studied all wetlands of <500 ha within four pre-selected 16 km<sup>2</sup> areas, located in the Usambara highlands and the Pangani flood plain in Tanzania, and the Mount Kenya highlands and the Laikipia flood plain in Kenya. Data obtained from aerial photographs, field mapping and Rapid Rural Appraisal were complemented with time series satellite imageries to identify, characterise and detect changes in these wetlands. An automated spectral mixture classification of the landsat data allowed a rough differentiation of pristine wetlands from cultivated areas. A more detailed differentiation of various land use types and crops was achieved by a manual classification based on aerial photographs. The detection and quantification of wetland cover, the current use, as well as land use change and its key driving forces will be presented for selected wetlands. The mapping work on the one hand and the improved understanding of change processes on the other hand is seen to contribute to a decision support for a sustainable use of wetlands.

**Keywords:** Aerial photography, Kenya, land use, Landsat, Tanzania

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## Effect of Water Deficit Stress on Antioxidant Enzyme Activities in Seedlings of Perennial Alfalfa Ecotypes

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Water deficit, with the production of active oxygen species, is an important inducer of oxidative stress that plants have been encountered. Some mechanisms such as antioxidant defense systems in plants are known to reduce destroyer effects of active oxygen species. In these systems, enzymes such as superoxide radicals, polyphenol oxidase and catalase can neutralise active oxygen species. Thus, the study of plant response to drought stress via measuring the enzyme activity levels can help to recognise drought resistant plants for breeding programs and the development of the cultivation in dry and semi dry zones.

The current research was conducted as factorial experiment in a randomised complete block design with three replications. The factors were ten perennial alfalfa ecotypes in combination with three drought stress levels. Data analysis showed that there were significant differences among alfalfa ecotypes, drought stress levels and their interaction for activity levels of the studied enzymes. The moderate drought stress (-4 bar) caused the highest activity level for all tested enzymes, while a higher drought stress reduced the activity levels of these enzymes due to damage to the protein synthesis system. The superoxide-desmotase and peroxidase with absorbance of 780,1 and 8,2 units  $\text{mg}^{-1}$  protein had the most and the least enzyme activity level, respectively. Most ecotypes in this study had the same trend of enzyme level variation at different drought levels, while the trend of peroxidase enzyme activity in foreign ecotypes was different to that in Iranian ecotypes. In foreign ecotypes, the level of peroxidase activity reduced gradually under both moderate and intensity drought stresses, while Iranian ecotypes had high and low enzyme activity at these drought stresses, respectively.

**Keywords:** Alfalfa, antioxidant enzymes, drought stress

## **Seed Coating with Hydro-absorbent Properties as Possible Mitigation Strategy for Unreliable Rainfall Patterns in early-Sown Sorghum**

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Sorghum is staple food for a majority of people in sub-Saharan Africa and is traditionally sown directly after the first rains as a rainfed crop. Its strong photoperiodism allows for a homogenized flowering date so that after the crop is established crop failure is unlikely to occur due to biotic constraints as long as there is sufficient water and nutrients. However, in recent years, farmers have lost substantial shares of their potential yield due to intra-seasonal dry spells and early drought spells, rendering germination of seeds difficult and increasing the loss of young seedlings. Seeds coated with different hydro-absorbing materials may overcome this problem through providing residual moisture to the grain sufficient to sustain early seedling growth during an early drought spell. Germination rates, efficiency of grain reserve mobilisation, and carbohydrate partitioning between roots and shoots were determined for sorghum seeds uncoated or coated with different hydro-absorbers (Stockosorb® and Geohumus®) and a combination of humic acid and biplantol under non-stressed conditions in growth chambers. The most promising combinations were tested under conditions of different drought stress intensities and durations in mist chambers in a greenhouse. Preliminary results show that total germination rate differed with coating material and coat combination. Carbohydrate mobilisation from the grain differed with the percentage share of coating material in the total grain size. Depending on the combination of substances in the coat, the share of coat produced different effects. Drought stress experiments with two sorghum cultivars are still ongoing, however, first results show effects of coat size and coat type on drought stress tolerance. Final results will be shown and discussed in relation to possible technologies rendering early sowing of sorghum more reliable.

**Keywords:** Batros, climate resilience, seed coating, sorghum, super absorber

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## Salt Stress Effects on Cowpea (*Vigna unguiculata* L. Walp) Varieties at Different Growing Stages

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In Cuba approximately 228,000 ha of agricultural soils are affected by salt. This amounts nearly 23 % of the total Cuban area. The cultivation of salt tolerant genotypes is an economical and environmental useful method to mitigate the salt stress effects. Cowpea (*Vigna unguiculata* L. Walp.) is adapted on different environmental conditions, and could be used as an alternative crop for salt affected soils. The objective of the study was to evaluate the salt tolerance of cowpea varieties at different growing stages within three consecutive experiments. The first experience was established under laboratory conditions to determine the response of twelve varieties on different salts levels during germination stage. Seed water absorption, lengths of hypocotyls and radicles and weights of seedlings were measured. The second experiment was established in a green house under semi controlled conditions to evaluate the salt effects on plant physiological and morphological parameters. The length and wide of stem, number of leaves, shoot dry mass, and activities of dehydrogenase and phosphatase in soil were measured.

In the field, cowpea was cultivated to investigate the yield parameters for one non affected soil (1.3 dS m<sup>-1</sup>) and one affected soil (9.8 dS m<sup>-1</sup>).

Differences in varieties response to saline levels were found during the germination. Through a cluster analysis based on euclidian distance, four groups were formed to characterise the tolerance. Among others, IT 86 D-715, Cancarro and Cubanita-666 were classified as tolerant. IT 86 D-386 and IITA-Precoz were found to be most susceptible. A linear negative correlation between the salts levels and the germination parameters was found. In the green house experiment the crop growth were affected negatively by salt. However, the activities of dehydrogenase and phosphatase reacted differently on salt content, and depended more on the varieties cultivated than on the salt effects. In the field IT 86 D-715 was found to be most tolerant to salt stress. Generally, the results showed that the selection of salt tolerant varieties plays an important role to establish salt adapted cropping systems.

**Keywords:** Cowpea, germination, salt stress

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## Effect of Plant Species on Biomass Accumulation, Nutrient Uptake and Water Quality in a Constructed Wetland for Wastewater Treatment in Viet Nam

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So far, biological wastewater treatment in constructed wetlands focused on a reduction of organic carbon compounds in the rizosphere of reed grasses. Particularly in developing countries, it may be of interest to cultivate plant species that can efficiently remove nutrients from wastewater and concentrate them in their biomass. Such approaches are seen to avoid the eutrophication of water bodies, increase the efficiency of wastewater cleaning and to provide a nutrient-rich substrate for use in agriculture. An eight-week experiment was conducted in a horizontal sub-surface flow wetland at Can Tho University, Viet Nam in 2008. The system was supplied with domestic wastewater from a student dormitory at two loading rates. It compared an unplanted control with filter compartments planted to either *Phragmites australis* (standard crop in biofilters) or *Sesbania rostrata* (stem-nodulating legume). At bi-weekly intervals we assessed plant characteristic (biomass, nutrient uptake and nitrogen fixation by  $\delta^{15}\text{N}$  natural abundance method, using *Phragmites* as non-fixing reference plant) and changes in waste water properties (pH, EC, COD, N, and P) at four positions between the wastewater inlet and the filter outflow. The daily nutrient addition was  $900 \text{ mg N m}^{-2}$  and  $4 \text{ mg P m}^{-2}$  in the full and  $400 \text{ mg N m}^{-2}$  and  $3.6 \text{ mg P m}^{-2}$  in the reduced wastewater loading rate.

The N and P elimination from the wastewater as well as its chemical oxygen demand (COD) varied with the type of the species as well as with the plant age and was more efficient with *Sesbania* than with *Phragmites*. Nitrogen depletion from wastewater was significantly higher with *S. rostrata* (90–92 %) compared to reed grass (30–38 %) or the unplanted control (14–20 %). *Sesbania rostrata* accumulated up to  $1.5 \text{ kg N m}^{-2}$ , irrespective of the wastewater loading rate or position in the filter and compensated a reduced N supply from the water with an increasing  $\text{N}_2$  fixation. In contrast to *Phragmites*, *S. rostrata* provided an organic substrate of high and constant quality (biomass, C:N and C:P ratio) in addition to an effective cleaning of the wastewater (COD, Nmin), and may be the preferred plant species for horizontal filter systems under tropical climatic conditions.

**Keywords:** Chemical oxygen demand, nitrogen fixation, *Phragmites*, *Sesbania*

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## Variation of Rice Yields in the Philippines: Impact of Climate Variability and Yield Gap Analysis

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This study describes a combined empirical/modelling approach to assess the possible impact of climate variability on rice production in the Philippines. Rice plays an important role as staple food in the Philippines, and represents 25 percent of the food expenditures of the poorest 30 percent of the population. The assessment of climate-induced variations in yields gains special relevance in-view of projected climate change. In spite of existing uncertainties in regional Climate Change scenarios, all Global Circulation Models agree that climate extremes will become more severe and frequent. However, there is a lack of detailed studies about the current influence of climate variability on rice yield.

We determined the climatic trends during the last two decades (1985–2002) and the influence of climate variability on irrigated rice yield for six provinces of the Philippines scattered along a North-South gradient. Data from the climate information system of NASA were collected, processed, and used as input parameters of the model *Oryza2000*. The simulated yields were compared to recorded actual yields corresponding to official data of the Philippine Bureau of Agricultural Statistics to determine the corresponding yield gaps.

Both simulated and actual yields of irrigated rice varied strongly between years. However, no clear climate-driven trends were apparent for the past 20 years. Also the variability in recorded actual yields showed no correlation with climatic parameters. The observed variation in simulated yields was attributable to seasonal variations in climatic data (differences between dry and wet season) and to differences between provinces. The spatial variation in actual yields could be attributed to soil and management factors and in most cases reflected the farmers' technology level. The resulting yield gap was hence largest in remote and infrastructurally disfavoured provinces with a high production potential as reflected by high solar radiation and day-night temperature differences. They were lowest in central provinces with good market access but with a relatively low yield potential due to near-permanent cloud cover. We conclude that climate variability does not seem to play a primary role in current rice yield trends and that agroecological, seasonal, and management effects are over-riding any possible climatic variations.

**Keywords:** Climate change and variability, Philippines, rice yield, simulation and modelling



## Effect of Soil Water Conditions and Ph on Micronutrient Uptake by Aerobic Rice

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Lowland rice consumes about four times more water than other cereal crops. With emerging water scarcity in many part of the world, the traditional way of lowland rice cultivation can no longer be sustained. New water-saving rice production systems urgently need to be developed. Among different water saving strategies, “aerobic rice” is considered a promising cultivation system for water scarce areas. In the aerobic system, rice is grown with no standing floodwater during the entire growing cycle. The absence of floodwater leads to an elevated soil redox potential and the offsetting of the carbonate buffer system that regulates the pH in flooded soils. Manganese and iron are oxidised and their plant availability is lowered. In the absence of the carbonate buffer, the pH of originally alkaline aerobic soils will increase and further affect the availability of Zn, Mn, and Fe. Such pH increases can also be mediated by nitrification in aerobic soils and the enhanced take up of  $\text{NO}_3^-$  instead of  $\text{NH}_4^+$ , which also causes the rhizosphere pH to increase, concomitantly lowering micronutrient availability. Consequently, micronutrient disorders are seen to be one of the key limiting factors for the production of aerobic rice. This calls for new strategies in managing micronutrients under aerobic rice production system. We evaluate the effect of soil aeration status (Eh) and pH on the availability and uptake of micronutrient (Zn, Mn, Fe) by rice. A greenhouse study comparatively evaluates 5 genotypes (Apo and two aerobic lines from IRRI, and IR72 and CK73 as reference cultivars) at two levels of soil aeration status (aerobic and flooded) and at acidic, neutral and alkaline soil pH conditions. Symptom occurrence, biomass accumulation, and the uptake and partitioning of Mn, Fe and Zn are monitored at different growth stages. This work is seen as a first step towards identifying rice genotypes for aerobic cultivation systems. Such genotypes will subsequently be used to determine adaptation mechanisms to aerobic soil conditions (micronutrient efficiency, rhizospheric pH adjustment, root architecture) and to test soil-specific management interventions.

**Keywords:** Iron, aerobic rice, manganese, *Oryza sativa*, pH, redox potential, zinc

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## Characterisation of Small Wetlands in East Africa

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Small wetlands in East Africa comprise valley heads, inland valley swamps, mountain peat bogs and flood plains. They are highly diverse in terms of their size, hydrologic regimes, vegetation, soils, and geomorphologic settings. They provide diverse ecosystem services and fulfil a wide range of ecological and social functions. There is a need to target further research interventions and to provide advice regarding wetland's conservation or agricultural use. Therefore, a typology of small wetlands (5–500 ha) in Kenya and Tanzania (East Africa) was carried out between February 2008 and June 2008 to classify and group wetlands based on common denominators. Study sites were selected based on geological characteristics, rainfall gradient, altitude, demography and wetland distribution and diversity. A total of 51 wetlands (157 land use subunits) in the Usambara mountains and the Pangani plain in Tanzania and in the Mount Kenya foodslopes and the Ewaso Naroc Swamp in Kenya were surveyed. A data reduction analysis performed on 27 variables using principle component analysis (PCA) indicated that 17 variables, explained most similarities within the wetland subunits. These variables included attributes related to biophysical features and land use (seasonality of flooding, soil C and P contents and texture, vegetation type, drainage patterns, land use of adjacent uplands, the type, duration and intensity of use) and the socio-economic settings of the wetlands (accessibility, population density, market access, and livelihood level). With these variables eight distinct wetland cluster groups were identified. A Discriminant Analysis (DA) showed that 88 % of the variation among the cluster groups were explained by wetland type (inland valley vs. floodplain) soil P content (<10 vs. >10 ppm Olsen-P), soil texture (clay vs. sandy clay) and the hydric regime (permanent vs. seasonal flooding). Based on these results, four wetlands, covering the six dominant out of the eight wetland cluster groups, were selected for further in-depth studies regarding their vulnerability and agricultural use potential.

**Keywords:** Discriminant analysis, flood plains, inland valley, principle component analysis

## Quality and Quantity Responses of Soybean (*Glycine max* L.) Seeds to Water Deficit

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A split-split-plot experiment with randomised complete block design in three replications was conducted in 2004 at the research farm of the faculty of agriculture, Tabriz University, Tabriz, Iran. The effects of limited irrigations on oil and protein accumulation of seeds in two soybean varieties (Zane and Hack) in the field were investigated. Irrigation treatments were assigned to main plot, and two soybean cultivars were allocated to the subplots. Harvest stages were considered as the sub subplots. Irrigation treatments I1, I2, I3 and I4 were defined based on the cumulative evaporation of  $60\pm 3$ ,  $80\pm 3$ ,  $100\pm 3$  and  $120\pm 3$  mm, from pan (class A) respectively. The results indicated that percentages of oil and protein in the seeds were not significantly affected by water deficit at different harvests. However, both oil and protein out put per unit area were significantly reduced, as water deficit increased. By increasing means 100 seeds weight, percentage oil content decreased, but percentage protein content was increased. In general, it was concluded that Moisture stresses during pod fill will not affect both the oil and protein content of soybean seeds. The resulting seed composition is a balance of the reduction is seed weight and the reduction in quantities of oil and protein content per unit area. In this study, the amount and distribution of water were regular and distinctness, resulting in differing effects on seed weight and differing relative effects on oil and protein components of the seed. Irrigation with short time interval and low water volume is better than irrigation with long time interval and much volume in soybean production. In general, it was concluded that soybean oil and protein production per unit area under full and limited irrigation conditions could be improve by increasing seed yield via selection of high-yielding varieties.

**Keywords:** Seed yield, soybean, water stress

## **Evaluation of Irrigation Efficiency at Different Spatial Scales in a sub-Unit of the Khorezm Irrigation and Drainage System Located in the Lower Amu Darya River Basin**

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A study was conducted to assess the irrigation efficiency at different spatial scales in the Shomakhulum Water Users Association (WUA) situated in the Khorezm region, Uzbekistan. Arid climate in the region dictate the need for irrigation of crops using water from the Amu Darya River. Growing overall water deficiency, problems with timely and sufficient water supplies jeopardises crop production and threatens livelihood of the rural population. Among the solutions is an adjustment of the existing network, for which an assessment of the performance of the irrigation system is needed. For the assessment, conveyance losses, application efficiency and the overall irrigation efficiency were estimated in this study. Ponding tests were conducted to assess the conveyance losses, six sites with different soil texture, groundwater levels and the network hierarchy, were selected. The tests showed that the losses in the inter-farm and intra-farm canals were in the range of 2–4 % and 2 %, respectively. The highest losses of 10–18 % were in the field canals. The comparatively low losses in the intra-farm canals are due to shallow groundwater levels in the vicinity of the canals and the siltation in the canal beds in spite of the higher hydraulic gradients between groundwater levels and inter-farm canals' full supply levels. For the field application efficiency, two farms with an area of 14 ha and 10.1 ha were selected. These farms differed in soil texture, groundwater levels and cropping pattern (cotton-winter wheat and cotton). The water losses were higher in the first farm (60 %) compared to the second one (50 %). The irrigation efficiency was estimated in the range of 33–36 %. To calculate the overall efficiency for the whole WUA, the water entering into the WUA was monitored at different inlets. The total inflow supplied to the WUA was 0.03 km<sup>3</sup> versus the requirement of 0.01 km<sup>3</sup> calculated by Surface Energy Balance Algorithm (SEBAL). Thus, the overall system efficiency estimated was 29 %. This study showed that there is a huge scope for water saving within the irrigation system to efficiently cope with current and future water shortages.

**Keywords:** Irrigation efficiency, SEBAL, Uzbekistan

## Upland Rice Adaptation to Variable Water Availability along an Altitude Gradient in Madagascar

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The growing demand for rice and the increasing pressure on irrigated land is leading to the development of upland rice to supplement irrigated rice in Madagascar. In the higher altitude environment, rainfed upland rice can only be planted between October and November due to temperature constraints (cold stress). According to climate change prediction, high-altitude environments are considered to be vulnerable. It is easy to expect positive effects on upland rice production systems such as increasing productivity due to rise in temperature and reducing sterility, considering that other climate change parameters such as rainfall patterns will not have adverse effects and consequently higher demand for water. Generally, crop is very sensitive to even short drought spells during sensitive physiological and phenological periods.

To avoid negative impacts, crop adaptation strategies will be required in terms of varietal development and crop management. The RISOCAS project of the University of Hohenheim for developing rice crop adaptation strategies for climate change in vulnerable environments has selected three different altitude/temperature gradient locations with moderately water-limited conditions, ranging from hot-equatorial conditions to the lower limit of the crop's thermal adaptation (Andranomanelatra 1625 m, Ivory 965 m and Ankepaka 25 m asl) in Madagascar for the upland rice field experiment. The experiment was conducted with two planting dates of 10 contrasting genotypes with three replications in each site. Meteorological data, site-specific soil characteristics, parameters of soil water balance such as soil water content using TDR-based system and bare soil evaporation using mini lysimeters were monitored. Variety specific canopy properties, photosynthesis, stomatal conductance, leaf chlorophyll content, photochemical reflectance index, leaf area index and specific leaf area were measured at regular intervals. Parameters of crop growth, tillering capacity, above ground biomass (stem, leaf and inflorescence separated), grain yield and yield components, harvest index and sterility are monitored to identify valuable traits and ideotype concepts for varietal improvement and adaptation. The first result on potentials and risks of unreliable water availability at different temperature gradient will be discussed and presented.

**Keywords:** Climate change adaptation, phenology, RISOCAS, water use efficiency

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## Temperature Effects on the Phenology of Upland Rice Grown along an Altitude Gradient in Madagascar

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In Madagascar, rice is cultivated on 1.3 Mha of which 29 % are upland rice, growing from the coastal area up to the higher altitude. High altitude rice cultivation is constraint by a short vegetation period due to low temperatures and thus by the time the crop needs to complete its cycle. Climate change is assumed to result in a rise in mean temperatures of 2–5 degrees depending on the simulation scenario. Thus, rice cropping in higher altitudes may become more favourable as long as precipitation is not a limiting factor. In order to match rainy season with crop duration in higher altitudes rice genotypes are needed that possess an early vigour, a short duration and a certain degree of drought resistance. In order to study this problem FOFIFA and CIRAD as partners in the RISOCAS project of the University of Hohenheim, Germany, initiated Mini Rice Gardens (1m<sup>2</sup> plots) with 5 monthly staggered planting dates for 10 contrasting upland rice genotypes on three locations along an altitudinal gradient (Andranomanelatra 1 625 m, Ivory 965 m and Ankepaka 25 m asl) resulting in 15 different thermal environments. At all sites genotypic phenological responses were studied by closely observing the time and temperature requirements to panicle initiation, booting, heading, flowering, and physiological maturity. In addition leaf appearance (phyllochron) and senescence, plant height, panicle exertion, grain yield and yield components, harvest index and spikelet sterility were observed for each genotype and planting date. In all ten varieties crop duration was longer in the higher altitude as compared to lower altitude. The poster shows genotypic differences in crop duration and the effects of planting date on the duration of the different phenological phases. Temperature effects on sterility as well as the effects on leaf appearance will be discussed in order to judge the agronomic fit of a potential upland rice ideotype for higher altitude cropping in a changing climate.

**Keywords:** Climate change adaptation, crop duration, ideotype, mini rice garden, RISOCAS

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## Growth of Sisal Plants (*Furcraea castilla* and *F. macrophylla*) under Flooding Stress

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Flooding is an environmental stress in many ecosystems worldwide. In tropical and subtropical regions, severe crop losses are caused by prolonged seasonal rainfall due to climatic disturbances such as El Niño. This phenomenon creates increased rainfall across the east-central and eastern Pacific Ocean. Excess of water produces anoxic soil conditions within a few hours. Plant roots, consequently, suffer hypoxia or anoxia, which results in an energy crisis affecting the plant growth. Genetic diversity in the plant response to flooding includes alterations in architecture, metabolism, and elongation growth associated with a low O<sub>2</sub> escape strategy and an antithetical quiescence scheme that allows endurance of prolonged submergence. *Furcraea* is a genus of succulent plants belonging to the family Agavaceae, native of tropical regions of Mexico, the Caribbean, Central America and the northern of South America. The present study aims to determine the leaf and root growth of two sisal species (*Furcraea castilla* and *F. macrophylla*) growing under flooding stress in an open field in Tunja-Colombia. Plants bulbils were sown in plastic bags filled with 3 kg of soil. Control plants were watered every four days while flooded plants were watered in a way that the water surface remained 1 cm high over the soil surface and were covered with another plastic bag in order to limit the drainage. In both species, the total dry matter per plant, the specific leaf weight and the leaf area were depressed by flooding; in contrast, the total root length was increased 94,2 % and 74,7 % in *F. macrophylla* and *F. castilla* respectively, compared to controls. The root to shoot ratio was reduced by flooding in *F. Macrophylla*, whereas in *F. castilla* was increased. Although both species were strongly affected by flooding, *F. macrophylla* showed to have a better adaptation to this stress factor than *F. castilla*. The results suggest that farmers should be cautious by selecting and adapting the *Furcraea* species in regions with high rainfall and heavy soils as these conditions limit the oxygen diffusion in soil and consequently plants growth and yield could be reduced.

**Keywords:** Agavaceae, hypoxia, sisal

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# Quantitative aspects of crop production

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## **Efficiency in Rice Production: Evidence from Gogounou District in the North of Benin**

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Despite its high potentiality for rice production, Benin is still importing rice. So, it is important to explore the possibility of improving rice growing for food security improvement. Therefore, the technical, allocative and economic efficiencies of rice growing in the District of Gogounou in Northern Benin have been analysed with the help of a survey carried out among 150 rice producers randomly sampled during the agricultural year 2005–2006. Likewise, factors determining the economic efficiency were identified and their impact on economic efficiency of rice producers was estimated. The data analysis is essentially based on stochastic frontier of production and costs functions as followed various authors. The results show that inefficiency effects existed and were significant. From these, the indexes of technical, allocative and economic efficiency are in average 0.820, 0.859 and 0.701 respectively. Regarding the frequency distributions of the producers according to their indexes of technical, allocative and economic efficiencies, the modal class is (0.8 ; 0.9). Moreover, it is brought out that the level of education, the affiliation to a functional association, the contact with a project agent, the number of years' experience in rice production and access to credit have positive and significant effects on the economic efficiency of rice producers. These different results suggest that the role that must be played project agents to improve management skills of rice producers throughout their visit and training is important. Finally, it's necessary to promote a wideness of rice growing areas for a real rice production development and a sustainable food security in Benin.

**Keywords:** Benin, economic efficiency, rice

## Simulating a Wheat-Maize Intercropping System with the DSSAT Crop Growth Model

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Interspecific competition is not only a survival of the fittest, but can also result in an optimal use of ecological niches. Agriculture can utilise interspecific competition in order to adjust and improve cropping systems, *e.g.* in intercropping systems. Intercropping, defined as growing two or more crops simultaneously on the same field is widespread all over the world. Especially in smallholder farming like in Africa (Malawi: 80–90 of soybean cultivation), India (17 % of arable land) or China (25 % of arable land), intercropping is a common cropping system. In times of climate change, rising food prices, shortage of arable land and food in third world countries and countries with a rapidly increasing population, adjusted traditional cropping systems become more and more important. Relay intercropping, where the maturing annual plant is interplanted with seeds of the following crop, *e.g.* 75 % of wheat is sown in autumn and a few days or weeks before wheat harvest, maize is interplanted, is an example for an optimised usage of scarce arable land. It showed that it is possible to increase grain yields of summer maize without a decrease of winter wheat productivity. But there is an additional summer maize yield because of an elongated growing season. The study is a first approach to model a wheat/maize intercropping system with the DSSAT crop growth model. Field trials were conducted in alternating plots of wheat and maize within a restricted randomised complete block design and four replications. First results of the modelling showed, that intercropped wheat had an increased ability to acquire more nitrogen compared with monocropped wheat. Nitrogen withdrawal from intercropped wheat straw was twice as high as nitrogen withdrawal from monocropped wheat straw. Because of the increased solar radiation, the increased top soil temperature and the higher aggressivity of wheat in comparison to maize, the mineralisation of nitrogen might be favoured. Wheat grain yields increased significantly. Maize suffered at the beginning of the growing season but reacted with a recovery-compensation growth.

**Keywords:** Intercropping, maize, modelling, wheat

## Short Term Effects of Conservation Agriculture on Soil Erosion and Agronomic Parameters of Teff (*Eragrostis tef* (Zucc.) Trotter) on the Vertisols of Northern Ethiopian Highlands

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Agriculture in Ethiopia is dominated by rainfed farming of low productivity. Land degradation in the form of soil erosion and declining soil quality is a serious challenge to agricultural productivity and economic growth. In vertisols, being most vulnerable to erosion, the problem is exacerbated more with the lack of sustainable land management systems. A conservation agriculture (CA) experiment was conducted in 2006 at Gumselasa (Tigray, Ethiopia), one of the areas mostly affected by drought, on experimental plots established on a farmer's field. In the experiments the treatments implemented are (1) CA in the form of permanent raised beds (PB) with contour furrows at 60–70 cm interval combined with residue retention, (2) Terwah system (TERW) consisting of traditional ploughing followed by making every 1.5–2 m contour furrows and (3) the traditional ploughing (TRAD). The objective of the experiment was to evaluate the short term impact of the implementation of CA practices on soil erosion and agronomic components of teff (*Eragrostis tef*). PB reduced runoff volume by 50 % and TERW by 16 % compared to TRAD. PB also reduced soil loss by 86 % and TERW by 53 % in comparison to TRAD. Despite the above improvements in soil erosion, which most probably resulted in higher soil water storage in the PB than in the other treatments, yield, biomass and plant height of teff were significantly higher in the TRAD than in the PB. The significantly high weed dry matter at first weeding in the PB, the types of weeds and water use characteristics of the crop may have caused the reduced yield of teff. Herbicides have to be used while growing teff in CA experiments. Further research should be done to see the impact of the soil management techniques on soil water storage and soil quality. Rainfall intensity measurements should also be performed for complete understanding of soil erosion

**Keywords:** Conservation agriculture, permanent bed, soil erosion

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## Targeting Technical Options to Address Maize Production Constraints in Kakamega, Kenya

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Nutrient deficiencies and weed infestation are the principal constraints to maize production in Western Kenya. Technologies to replenish soil nutrients and mitigate weed infestation in croplands have been introduced and tested, but their widespread adoption has not been achieved. We hypothesised that technical options that consider the site-and system-specificity of the smallholder farming systems could improve the productivity of maize. Hence, the objectives of this study were (i) to quantify site-specific responses of maize to applied technical options, (ii) to assess the capacity of technical options to correct site-specific production constraints of maize and (iii) to target technical options to specific farm types. Field experiments were conducted in Kakamega district during the 2008 and 2009 cropping seasons in five sites with contrasting soil types (Alfisols, Ultisols and Nitisols) and fertility levels. Treatments included farmer's practice (control), clean weeding (CW), farmyard manure (FYM), mineral nitrogen plus phosphorus (NP), seed priming with phosphorus (SP), zero-tillage plus mineral nitrogen and phosphorus (ZNP), zero-tillage plus mineral nitrogen and phosphorus plus *Arachis pintoi* (ZANP) and green manure (GM, incorporation of *Mucuna pruriens*). The agronomic performance and nutrient uptake of maize were evaluated. Nitrogen fixation ( $^{15}\text{N}$  natural abundance technique) by *Mucuna pruriens* and *Arachis pintoi* was quantified. The capacity of the technical options to suppress weeds was also assessed. Soil quality parameters and their dynamics were evaluated sequentially in each cropping season. Preliminary results showed that significant differences ( $p \leq 0.05$ ) exist between treatments for agronomic parameters of maize and weed abundance. Maize biomass accumulation for NP, ZNP and ZANP was tripled when compared to the control. Additionally, 75 % of the weed biomass was accounted for by *Bidens pilosa*, *Ageratum conyzoides*, *Commelina benghalensis*, *Oxalis semiloba* and *Gallinsoga parviflora* and weed infestation was higher at the Ultisol sites than on the Alfisols and Nitisols. Generally, the control recorded higher weed biomass and species abundance in all the five sites. ZANP suppressed more than 50 % of the weed biomass at three months after planting, and, hence, could be a promising technical option to control weeds in the smallholder farming systems of Western Kenya.

**Keywords:** *Arachis pintoi*, *Mucuna pruriens*, nutrient deficiency, weed abundance, *Zea mays*

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## How Does Traditional Harvesting of Young Leaves for Vegetable Use Affect Seed Yields of Cowpea Variety Mixtures in Eastern Uganda?

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Cowpea (*Vigna unguiculata*) is one of the top four leafy vegetables in Uganda grown for both its seed and leaves. Cowpea is usually grown in intercrop with maize, sorghum, cassava or mung bean but sole cropping is also practised. Lack of improved varieties, low soil fertility and insect pests are among the most important constraints to cowpea production in Uganda leading to low seed yields (200–400 kg ha<sup>-1</sup>). Although, young leaves are an essential source of protein and micronutrients for the resource-poor subsistence farmers and their consumption is more popular than of seeds in the eastern and northern districts, leaf yield levels had never been researched and documented. This study was performed within the “ProNIVA” project conducted by the World Vegetable Center (AVRDC) and partners, to improve cowpea’s use as leafy vegetable among other traditional African vegetables. Mixtures containing up to four experimental cowpea varieties with contrasting growth habits and morphology were grown in intercrop with maize during the first cropping season of 2008 at three locations in Soroti (Serere, Kikota) and Kumi (Kogili) districts. Young tender leaves were harvested every two weeks starting at one month until flowering. ANOVA for the leaf and seed yield data was performed using the SYSTAT procedure GLM. The results of these three trials indicated that accumulated dry matter leaf yield from 3–4 harvests and seed yield ranged from 34.7 to 70.9 kg ha<sup>-1</sup> and 33.4 to 551.2 kg ha<sup>-1</sup>, respectively. The leaf-harvesting strategy (25–50 % defoliation) employed by farmers reduced seed yield at Serere and Kogili by 43.4 % and 46.6 %, respectively, but it increased seed yield at Kikota by 8.2 %. At Kikota, cowpeas could develop much more vigorously because the maize suffered severely from drought. Seed yield components (pod number, seeds per pod and 100-seed weight) were not significantly affected by leaf-harvesting. Seed yield of mixtures was less affected by leaf-harvesting, unlike single varieties, possibly due to compensation effect. Overall, harvesting both leaf and seed was superior by 1.34 g DM per plant to harvesting seed alone .

**Keywords:** Defoliation, traditional leafy vegetables, Uganda, variety mixtures

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## Socio-ecological Niches for Technologies to Improve Soil Fertility and Maize Production in Kakamega, Western Kenya

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Farming in Kakamega is characterised by poor productivity due to limiting bio-physical factors, mainly low soil fertility and weeds infestation, together with socio-economic factors, particularly labour shortages and restricted access to capital, knowledge and markets. This situation could be improved by technologies that fit the prevailing socio-ecological conditions. A study on the socio-ecological fitness of technologies recommended to improve soil quality and consequently maize yields was undertaken with the following aims: i) to determine site and system-specific resource requirements and benefits of the proposed technologies; iii) to derive technology-specific fit indicators and; iii) to develop a decision support tool to target appropriate technology for a particular farm type. Five sites were set in three common soils and seven technical options (clean weeding, animal manure, seed priming, mineral fertiliser, zero-tillage with mineral fertiliser application, zero-tillage with cover crop (*Arachis pintoii*) and mineral fertiliser application, green manure (*Mucuna pruriens*) and a control) were evaluated in the predominant soil types (Alfisols, Ultisols and Nitisols) for two growing seasons. Socio-ecological fitness of the technical options was evaluated based on socio-economic characteristics of pre-defined farm types and ecological factors. Socio-economic requirements for each technology were assessed in terms of labour, land, capital and knowledge needs. CERES-maize model was used to establish the gap between potential and actual yields. Benefits were considered in terms of labour- and land-saving, ease of implementation, effectiveness of weed control, as well as changes in maize yield and soil quality parameters. A decision support system will be developed by a multiple regression model that relates the resource requirements and benefits obtained from particular technology to the resources available in a farm type. Preliminary socio-economic results indicate that the cover crop and green manure technologies required 22 % and 20 % more labour than the control, while for animal manure and mineral fertiliser application the inputs were 10 % and 11 % higher, respectively. Most evaluated technologies required higher total capital inputs than the control: zero tillage with cover crop (32 %), green manure incorporation (26 %), mineral fertiliser (13 %) and manure application (9 %). Soil and plant samples are yet to be analysed awaiting the on-going second season.

**Keywords:** *Arachis pintoii*, CERES, *Mucuna pruriens*, nutrient deficiency

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## Plant Liquid Extracts as Low Cost, Fast Release Fertilisers for Vegetable Production in Tropical Countries

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Vegetable production can play an important role in improving livelihoods of small-scale and resource-poor farmers in tropical countries, since vegetables constitute an opportunity for both diet improvement and higher income. In vegetable fertilisation, nitrogen is one of the most important nutrients. However, chemical nitrogen fertilisers are becoming more expensive and often out of reach for smallholders, while common organic fertilisers have a slow nutrient release compared to these. Therefore, there is a need for a quick-acting and cheap N fertiliser suitable for vegetable production. Liquid organic extracts for fertilisation are widely used in many tropical countries, but few scientific studies have been made to understand their efficacy. In some places green papaya - containing papain, a protease enzyme - is used to catalyze N mineralisation, but this process is also under-researched. One aim of the study was to understand the dynamics of N release and mineralisation from plant litters (with and without papain) during the extraction process and to test their fertilising value. Another objective was to better understand the relevance of the use of liquid organic extracts in developing countries and their actual production process and application methods. Laboratory and greenhouse trials were carried out in Italy, while qualitative research was conducted in Cambodia. In Italy, chemical analysis of extracts made from two crop residues showed that the N mineral fraction in solution is mainly ammonium and that papain increases the mineral N release from litters. 25 to 40 % of the litter N was recovered in the liquid fraction after 10 days of extraction. Extracts were used as fertigation on lettuce, and various growth and nutritional parameters were evaluated. However, results were flawed by high levels of salinity causing osmotic stress. In Cambodia, the survey confirmed the relevance of liquid organic extracts as a quick-acting and cheap N fertiliser and information on preparation and use of liquid compost was collected. The use of liquid extracts for fertilisation has good potential for vegetable production in developing countries, but further research is still needed in order to clarify the aspects left unresolved by the present study.

**Keywords:** Fertigation, liquid compost, N mineralisation, organic liquid extracts, papain, tropical countries, vegetable fertilisation

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## Growth of Mycorrhizal Lulo Plants (*Solanum quitoense* Lam. Var. *septentrionale*) Affected by Shading

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Lulo (*Solanum quitoense* Lam. var. *septentrionale*) is an exotic fruit originated and cultivated in the high Andean tropics. The plant exhibits a very low growth rate and the growth period can be extended to up to 2 years. Plants are fragile and must be protected to strong winds and direct sunlight. Plant growth is optimal under partially shade conditions in forestall areas. The present work was carried out under greenhouse conditions to evaluate the response of mycorrhizal and non-mycorrhizal lulo plants to shade conditions in Tunja-Colombia. At transplanting, plants were mycorrhizae inoculated with *Scutellospora heterogama*, *Acaulospora mellea*, *Glomus white* and Mycobiol® (Corpoica) (commercial mixture of mycorrhizae containing *Glomus* sp., *Entrophospora colombiana* and *Acaulospora mellea*). To simulate shading, some plants were grown under a black net that reduced 24,9 % of the sunlight. Plants under shade showed to have an increment of 56,8 % regarding leaf area, however, the dry matter production was 27,3 % lower compared to plants exposed to full sunlight. Mycorrhizal plants showed larger foliar areas compared to non-mycorrhizal plants. *S. heterogama*, *G. white*, *A. mellea* and Mycobiol induced increments in dry matter of 152,7; 131,8; 114,6 and 106,9 % respectively compared to non-mycorrhizal controls. There was a reduction of 37,3 % in the specific leaf weight (dry matter in leaves / leaf area) in plants exposed to shade compared to plants exposed to full sunlight. The relative growth rate (RGR) in dry matter was affected by shade, however, not by the mycorrhiza, hence, the shadow reduced 29,4 % the value of this variable. The absolute growth rate (AGR) was reduced 37,5 % on plants growing under shade, in contrast the mycorrhiza positively affected this variable. An increment of 188,8 % in the AGR was found in mycorrhized plants using *S. heterogama*, 155,5 % with *G. white*, 133,3 %, with Mycobiol and finally 116,6 % using *A. mellea*. The net assimilation rate (NAR) was reduced by 27,5 % in plants growing under shade conditions, however, with respect to control plants, mycorrhiza induced an increase of the value of this variable of 400 % using *S. heterogama*, 328,5 % with *G. white*, 285,7 % with *A. mellea* and 271,4 % using Mycobiol®.

**Keywords:** *Acaulospora mellea*, *Glomus white*, Mycobiol, *Scutellospora heterogama*

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# Organic and mineral fertilisers in cropping

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## Implications of Resource Management on Soil Fertility in Common Farm Types in Kakamega, Western Kenya

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Kakamega in Western Kenya is dominated by a diversity of smallholder farming systems characterised by intense cultivation with little external input use, resulting in declining soil fertility and crop yields. Technologies to counteract these constraints are rarely implemented, as they do not consider the diverse farming systems, their access to and application of nutrients to crops and the resulting influence on soil parameters. Thus, studying nutrient fluxes and balances and their effect on soil fertility after classification of farms is a prerequisite for successful targeting of interventions. In a three-year on-farm study, plot level nutrient balances and resource fluxes between farm components were established in 18 farms of six major types. These ranged from subsistence- to highly market-oriented systems and were located on two soil types. Soil chemical parameters were also determined from some 90 fields under different management.

Subsistence farmers applied little inputs to maize (<9 kg N and 11 kg P ha<sup>-1</sup>) and attained the lowest yields (0.6 kg ha<sup>-1</sup>). Market-oriented farmers, who applied large amounts of animal manure, obtained the highest maize yields. Commercial farmers on Ultisols applied most mineral N to tea, while subsistence farmers applied most organic amendments to home gardens. Consequently, nutrient balances strongly differed between farms and among farm components. Mineral fertiliser use was insufficient to balance nutrient removal by maize, whose fields were strongly depleted (-81 kg N and -86 kg K ha<sup>-1</sup>).

Soil type and nutrient allocation influenced soil fertility attributes. Alfisols contained less N (0.15 %) and C (1.79 %) than Ultisols, which were characterised by low extractable P (<8 mg kg ha<sup>-1</sup>). The poorest soils occurred under maize, irrespective of the farm or soil type, whereas home gardens were more fertile.

Production constraints and nutrient management strategies vary among farm types and components and account for large differences in soil fertility. To be adoptable, soil improvement technologies must address system-specific constraints and fit farm attributes. The combination of a farm typology, nutrient balances and soil analyses are seen to improve the targeting of these technologies to specific socio-ecological niches within Kakamegas diverse farming systems.

**Keywords:** Kenya, nutrient balances, nutrient fluxes, small-scale farming systems

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## Determination of Compost Quality in a Lettuce Crop in the Sabana de Bogotá, Colombia

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Compost and organic fertilisers are used as an alternative for anorganic fertilisers. This way the environmental waste impact of the fertiliser is reduced. The use of these fertilisers in agriculture has increased in recent years, especially in development countries. In Colombia S.A, the Colombian technical standard, NTC 5167/04, includes the requirements and tests that must be done on products that are going to be used as organic or mixed fertiliser. In these tests the physical, chemical and microbiological quality of the fertiliser are highlighted.

In the present study, the quality of animal and vegetal compost and its effect on the quality of a lettuce crop in the Sabana de Bogotá, Colombia was determined. Soil samples were taken before soil preparation and after lettuce (*Lactuca sativa* var. *crispa*) harvest. The treatments were: 10 t compost ha<sup>-1</sup> (control), 30 t compost ha<sup>-1</sup> (T1): T1 outdoors and indoors greenhouse conditions). Presence of *Salmonella* spp. and *Escherichia coli* (as an indicator of fecal contamination) by MPN was evaluated. As agronomical variables, was determined weight, NO<sub>3</sub> contents and heavy metals of final product (plant) and %OM in soil, mineralised N and P, and microelements in soil. As results under site conditions, was not found significant differences ( $p > 0.05$ ) between treatments regarding chemical, physical and microbiological quality. The inability to obtain differences is due to high levels of chemical fertiliser applied, which mask any effect of the application of compost, but was founded high concentration of NO<sub>3</sub> in plant. Metabolized N, *i.e.* organic N in the tissues, represented about 80 % which is good, however, in absolute terms would be a risk according to consume excess nitrate in lettuce, which represents between 2 and 16 % of the total N in different treatments.

**Keywords:** Compost quality, lettuce

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## Response of Home Garden Crops to Organic Amendments in Different Soils of Kakamega District, Western Kenya

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Continuous cropping without external input use or the replenishment of exported soil nutrients has contributed to a low and declining productivity of farms in Kakamega district of western Kenya. The extent of soil degradation and its implications on productivity vary with soil type, which is comprised of clay Ultisols with P deficiency in the South, sandy Alfisols with N deficiency in the North, and potentially productive Nitisols in the Center of the district as well as suitable crop selection. Mineral fertilisers can partially overcome the soil-related constraints, but are rarely applied due to financial constraints of the farmers and are often unavailable. Alternatively, farmers can opt for on-farm available organic sources of nutrients, such as farmyard manure, leaves of *Tithonia diversifolia* and since recently biogas sludge compost. Such organic amendments are valuable and hence primarily applied to the higher value crops in the home gardens. These organic amendments were applied at the rate of 100 kg N ha<sup>-1</sup> on the three soil types, and the response of four home garden crops - *Phaseolus vulgaris*, *Vigna unguiculata*, *Brassica oleracea* and *Amaranthus* sp to each soil-amendment combination was observed for a period of three months for biomass accumulation and yields. Soil samples were collected at monthly intervals for the analysis of the nitrogen mineralisation rate. The decomposition rate of the three organic amendments was determined using the litterbag method. This poster presents the site-and crop-specific suitability of each organic amendment by linking it to Nitrogen mineralisation dynamics and decomposition rates of the three organic amendments.

**Keywords:** Low soil productivity, N-mineralisation dynamics, organic decomposition

## Phytotoxicity and Nitrogen Mineralisation of Composted and Vermicomposted Cotton Residues

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Arable lands in Sudan have been adversely affected by soil fertility decline; this degradation could be maintained with external nutrient inputs. Due to the high cost and availability of the inorganic fertilisers, it is necessary to find alternative sources. Cotton residues are available after harvest and considered as waste materials. Application of decomposed residues maintains soil properties to sustain crop production. Decomposition rate depends on the residue quality, environmental conditions and the decomposer organisms present. Earthworms are widely used because they directly and indirectly modify decomposition.

An experiment was carried out to evaluate the toxicity of cotton residues by biological testing that is of vital importance for screening its suitability for land application. The toxicity of the composted and vermicomposted materials was investigated by seed germination bioassays using cress (*Lepidium sativum* L.). Materials were mixed with water at concentrations of 0 gL<sup>-1</sup> (only water); 8 gL<sup>-1</sup> (0.24 g of material plus 30 ml of water); 16 gL<sup>-1</sup> (0.48 g of material plus 30 ml of water). The extract concentrations did not exert any significant adverse effect ( $p > 0.05$ ) on the measured parameters namely, relative seed germination (RSG), germination index (GI) and root elongation. At all concentrations the percentages of seed germination were greater than 90 %. Treatments resulted in a linear increase in root elongation and quadratic increase of germination index of more than 100 for all extracts.

An aerobic incubation experiment was also conducted in the same materials under controlled conditions (35°C) for 35 weeks to quantify the nitrogen (N) mineralised. The applied materials were equivalent to 4 g N and 8 g N (Urea) per pot. Application of the materials affected the mineralised N concentration ( $p < 0.0001$ ). The treatments contained more mineral nitrogen compared to the control during the whole incubation period. The pronounced mineralisation was observed after 21 and 28 weeks of incubation while no significance was found regarding the other dates. The less mineralised nitrogen was observed after 1 week.

The study objectives were (1) to experimentally investigate the net N mineralisation and (2) to evaluate the toxicity and suitability of the materials used before their application as plant medium.

**Keywords:** Compost, cotton residues, phytotoxicity, N mineralisation, vermicompost

## Losses of Carbon and Nitrogen from Ruminant Manure Storage in Urban Gardens of Niamey, Niger

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Intensive vegetable production in urban agriculture of the West African Sahel is characterised by high fertiliser inputs, resulting in large positive nutrient balances. However, detailed knowledge about the pathways of carbon (C) and nitrogen (N) losses in these systems is missing. The aim of this study therefore was to quantify gaseous emissions of ammonia (NH<sub>3</sub>), nitrous oxide (N<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>), and leaching losses of C, N, phosphorus (P) and potassium (K) from ruminant manure stored in vegetable gardens of Niamey. The cumulative gaseous N and C losses over 3 months were measured during the hot dry and rainy season with a closed-chamber system of a photo-acoustic infrared multi-gas monitor. In the hot dry season N losses were with 0.11 g kg<sup>-1</sup> manure DM highest ( $p < 0.05$ ) in the uncovered control treatment (n=4) and accounted for 1.8 % of total N in the manure. Plastic shading (n=4) and plastic shading with addition of ground rockphosphate (333 g kg<sup>-1</sup> manure DM; n=4) reduced total N losses to 72 % and 50 %, respectively. Carbon losses amounted to 73 g kg<sup>-1</sup> DM in the control treatment and to 92 g kg<sup>-1</sup> DM and 68 g kg<sup>-1</sup> DM for the shaded heaps and the shaded heaps with rockphosphate, respectively. In the rainy season, C losses from the untreated control were highest ( $p < 0.05$ ), averaging 164 g kg<sup>-1</sup> manure DM. Losses were reduced to 77 % and 65 % of the control by shading and shading plus rockphosphate, respectively. During the rainy season leaching losses were only observed for the unshaded control and reached 2.1 g C, 0.05 g N, 0.07 g P and 1.8 g K kg<sup>-1</sup> manure DM. The results show that coverage and addition of ground rockphosphate can significantly reduce nutrient losses from manure heaps and thus enhance resource use efficiency in UPA systems.

**Keywords:** Africa, gaseous emissions, nutrient leaching, rockphosphate, ruminant manure, urban agriculture

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## Impact of Livestock Grazing on the Dry Ecosystems of Southern Madagascar

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The goal of the study was to understand the habitat utilization of livestock and its impact on biodiversity components in different types of spiny forest and grassland in and around the spiny forest ecosystems of National Park of Tsimanampetsotsa, southwestern Madagascar. Transhumance is one of the main forms of land use in this region. The dry forests of the national park are preferred pasture for cattle and goats for large parts of the year with obvious effects on the vegetation. As a consequence Madagascar National Parks (MAP) identified grazing as one of the main threats for the protected ecosystems in the south and one of the drivers for habitat degradation. Specific aims and activities of the present study were: (1) Documentation of vegetation characteristics (species composition, biomass production, regeneration, utilitarian species) in specific vegetation types in and around Tsimanampetsotsa NP; (2) Quantitative documentation of utilization patterns of these areas and plants by livestock; (3) Classification of categories of degradation; and (4) Combining the three to map out transhumance zones for zoning purposes. For this we identified areas of different degrees of degradation. There, we applied standardized methods to measure the floristic composition, vegetation structure, standing biomass of main food plants, their chemical composition and their phenology, as well as vegetation regeneration of annual and woody plants. The results are used to develop a simple tool with the help of Google Earth images which can be applied locally and which will allow zoning of the integrated protected area system and subsequent monitoring of habitat change over time.

**Keywords:** Madagascar, grazing, transhumance, cattle, goats, vegetation characteristics

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## **Livestock: Threat or Natural Resource for the Future?**

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Livestock is frequently brand marked as the responsible factor for deforestation and land degradation. Recent publications, such as the Greenpeace report “Slaughtering the Amazon”, are an example of such an argumentation. It seems to be worthwhile to look behind the process of deforestation and differentiate the message about its relationship with livestock – mostly cattle – production.

Taking the case of the Amazon region as an example, the deforestation process is briefly explained and the determinants for sustainable agro-silvo-pastoral systems are described. The various reasons why sustainable systems are not implemented are discussed. For squatters and smallholders, a better access to services and knowledge is necessary to improve the sustainability of their production systems, including livestock. This would take pressure away from the forest.

The better enforcement of existing laws and the improvement of the governance system based on sanctions, incentives and technical possibilities that promote forest conservation for landlords and companies investing in forest land are needed.

This presentation advocates for a revival of support for sustainable animal husbandry projects and a better and more intensive use of already existing pastures in the agricultural frontier regions. These new projects should be people centred. Moreover, they should not be restricted to production, but follow a comprehensive value chain approach, including an improvement of services (advisory services, veterinary services) and better marketing strategies. The different services can follow different models. The value chain approach should also recognise different value chains from the product to the table, to local and international markets.

**Keywords:** Deforestation, environment, governance systems, livestock, value chain

## The Role of Pasture Management for Sustainable Livestock Production in Semi-arid Subtropical Mountain Regions

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Grazing livestock is an important asset to livelihoods of people in most semi-arid environments, where natural resources cannot be used directly for human consumption. However, overgrazing commonly reduces pasture productivity, therefore threatening people's long-term food security. To study the effect of goats' grazing on the natural vegetation and evaluate possibilities for a pasture management that maintains long-term fodder production, the ligneous and herbaceous vegetation was analysed at grazed and ungrazed sites in the Al Jabal al Akhdar mountains of Oman in August 2006–April 2008. Botanical composition, vegetation cover and biomass production were quantified along transects (n=1–4; length=700–1400 m) at i) a grazed plateau (GP), ii) an ungrazed plateau (UP), iii) a 15-year old enclosure (UE) and iv) a grazed valley (GV), where water availability was higher. Interviews with key informants (n=10) were conducted to determine the extent of village pasture areas and calculate stocking densities.

While foliar dry mass (DM) was 3–6 t ha<sup>-1</sup> at GP, UE and UP and reached 41 t DM ha<sup>-1</sup> at GV, herbaceous yields contributed ≤11 % to total biomass and decreased during the dry, cold seasons, highlighting the restricting effect of the low and variable rainfall. In September 2007, ground cover (%) and biomass yields (kg DM ha<sup>-1</sup>) of the herbaceous vegetation were significantly higher at UP (82±10.5; 629±171) and UE (84±14.2; 505±181) than at GP (55±10.1; 20±8.2;  $p < 0.01$ ). While the botanical composition was similar at UE and UP, unpalatable species were more dominant at grazed than at ungrazed sites. Stocking densities on village pastures were 0.03–0.28 goats ha<sup>-1</sup>, but since construction of roads and housing decreased the available pasture area and pastures of different villages overlap, >0.8 goats ha<sup>-1</sup> graze the natural vegetation near settlements.

Despite the semi-arid climatic conditions, pastures on Al Jabal al Akhdar encompass characteristics of equilibrium systems, where vegetation is strongly influenced by livestock grazing but recovers in its absence. The sustainable use of the natural fodder resources by reserving sufficiently large areas for livestock grazing and by a rotational pasture use coordinated among villages is therefore a valuable alternative to intense supplement feeding or the introduction of zero-grazing management.

**Keywords:** Browse foliage, equilibrium concept, highlands, Oman, rangeland vegetation

## **Socio-economic and Biophysical Conditions for the Sustainable Livestock Management: A Case Study of Nepal**

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Livestock is an integral and important component of Nepalese farming system. Agriculture contributes about 33 % to the total gross domestic product (GDP) whereas livestock contributes about 35 % of the total agricultural gross domestic production, which has been envisaged to increase at 45 % by 2015. In relation to the amount of land per person, the livestock population in Nepal is one of the highest in Asia. However, the productivity of livestock is very low. The livestock production system in Nepal is characterized with harsh agro-climatic conditions, geographic isolation, small holding, degrading soils and diverse socio-economic structures. Nevertheless, livestock products are an important source of supplementing income for more than 80 % of the total farming population of the country.

The analysis of livestock data for the past 14 years in Nepal revealed that the most noticeable change is the significant increase in the buffalo (2.1 % per year) and goat (2.14 % per year) population between 1990/1991 and 2003/04. A mountain/hill household raises, on an average, 6 to 10 livestock, including large and small ruminants. A survey carried out from June to August 2006 to investigate biophysical and socio-economic conditions for sustainable livestock management in Nepal revealed that the herd-size was significantly correlated with the land-size of the household. Milk selling by women was significantly correlated with the household head's education. Year-round forage production was also significantly correlated with the land-size.

In addition to these socio-economic characteristics, biophysical conditions, for example, adoption of the livestock species across different agro-climatic zones, forage digestion ability, existence in low plane of nutritional regime, cold tolerance and relatively smaller body size, were found to be significantly correlated to sustainable livestock management in Nepal. Hence, along with the biophysical characteristics, education, land size and women involvement in milk selling are found to be the most important socio-economic determinants for sustainable livestock management and its improvement in Nepal.

**Keywords:** Biophysical, livestock, Nepal, socio-economic, sustainable management



## Physiology and Genetics of Heat Tolerance in Thai Native Cattle

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Heat tolerance is one of the most demanding challenges for tropical livestock. The objective of this study was to estimate physiological responses and to investigate genes putatively related to heat tolerance in the two Thai native cattle breeds White Lamphun cattle (WL) and Mountain cattle (MT) as well as Holstein-Friesian (HF) cross-bred cattle (more than 82.8% HF genes). Physiological responses were assessed in the afternoon and the next morning (twice a month) for a 3 months period. The average thermo-humidity index (THI) was 87.33 for the morning and 78.79 for the afternoon. The average respiratory rates in WL, MT and HF were 28.68, 33.27 and 36.05 beats sec<sup>-1</sup>, the packed cell volumes were 33.45%, 37.97% and 26.37%. The measured rectal temperatures were 38.75 and 38.75 and 38.46°C. The results showed significantly different respiratory rates ( $p < 0.05$ ) and packed cell volumes ( $p < 0.05$ ) in all breeds, but no significant differences in the rectal temperature. All parameters were significantly enhanced with an increased THI ( $p < 0.05$ ). Tissues were collected for DNA extraction from all animals. A 598-bp long PCR product (spanning exons 6 to 9) of the heat shock protein 90kDa gene (Hsp90) was comparatively sequenced on a panel of 24 animals (8 animals per breed). Three single nucleotide polymorphisms (SNPs) were detected in Thai native cattles (SNPexon 7; G96A and T199C, SNPexon 9; C480T). All three SNPs led to a missense mutation: Glu to Lys, Ile to Thr and Arg to Cys. The present study indicates breed specific different physiological responses to hot climates, which might be caused by Hsp90 polymorphisms. We intend to complete the search for polymorphisms in Hsp90 and to perform then expression studies. Moreover, an extended screening of polymorphisms of this gene in each population will be done. Possible mutations in Hsp90 could make it an attractive candidate for heat tolerance to be used as genetic marker to select appropriate breeds suitable to sustain the worldwide climate change.

**Keywords:** Heat tolerance, physiology, Thai native cattle

## Socio-economic Aspects of Brucellosis in Kuku Dairy Scheme

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Animal diseases act as environmental hazard. Brucellosis is one of the major zoonotic diseases in the world. Human health and welfare depend on the disease situation in animal population. Management and control of this disease contributes to a large extent to sustainable development of animal as well as human resources.

This work aims to highlight the socioeconomic of this disease in Kuku Dairy Scheme - Khartoum State - Sudan. Hence the importance of its control.

The current situation of the disease in both animal and human was determined during 2004. The evolution of the disease was projected up to 2014. Accordingly the cost and the burden of the disease were estimated in two scenarios, in the first one animal growth rate was estimated according to the existing parameters. In the second scenario the number of animals was held constant. The prevalence rate was found to be 24.9 % and 11.3 % for animals and humans respectively. The total cost of the disease in both dairy and health sectors was found to be 67 126 953.8 SD equivalents to 268 507.8 US\$

In the baseline year the burden of the disease was found to be 7.1 and 14.1 DALYs if the disease is associated with 0.1 and 0.2 disability weight respectively.

The total cost of the disease was found to be 1 022 123 020 SD (745 547 286 SD in PV) equivalent to (4 088 492 US\$) over the 11 years period (2004–2014) in the first scenario. The total loss of healthy years during this period will account to 52.6 years (0.1 DW). And 105.2 years (0.2 DW).

In the second Scenario the total cost of the disease in both dairy and health sectors was found to be 1 414 827 570 SD (101 505 075 in PV) equivalent to 5 655 170.142 US\$ over the 11 years period. The total loss of healthy years over the 11 years will account to 82.1 years (0.1 DW). And 164.1 years (0.2 DW). Most of the producers (80 %) are well informed about the disease and its zoonotic nature, (53 %) are well acquainted with the economic importance of the disease. All of them support the idea of disease control.

**Keywords:** Brucellosis, economic analysis, Kuku scheme

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## Performance of Mehsana Buffalo Calf Raising

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Nine Mehsana buffalo calves about 4 weeks of age were divided into 3 groups to feed with 3 kinds of milk namely buffalo milk, cow milk and milk-replacer. This experiment was conducted at Mae Tha Nhua Royal Project Development Centre, Mae On district, Chiang Mai province. The average initial weight for the buffalo calves fed with buffalo milk, cow milk and milk replacer were  $41.7 \pm 1.89$  kg,  $39.0 \pm 3.61$  kg and  $40.0 \pm 4.24$  kg, respectively. The study on growth performance of 3 groups of calf, the results has shown that an average daily gain (ADG) for the calf fed with buffalo milk was equal to the calf fed with cow milk ( $0.56 \text{ kg day}^{-1}$ ) and higher than the calf fed with milk replacer ( $0.34 \text{ kg day}^{-1}$ ) ( $p < 0.05$ ). For body weight gain the result shown that the calf fed with buffalo milk and cow milk ( $47.3 \pm 3.69$  and  $47.0 \pm 5.57$  kg, respectively) were significant higher ( $p < 0.05$ ) than the calf fed with milk replacer ( $28.5 \pm 0.71$  kg). Milk intake was significant lower in the calf fed with buffalo milk than the calf fed with milk replacer and the calf fed with cow milk ( $254.5 \pm 8.32$ ,  $425.50 \pm 71.42$  and  $444.3 \pm 24.50 \text{ kg head}^{-1}$ ), respectively ( $p < 0.05$ ). When consider about cost, the calf fed with milk replacer was lowest ( $4,882.91 \text{ baht head}^{-1}$ ), the calf fed with cow milk ( $8,197.86 \text{ baht head}^{-1}$ ) was higher than milk replacer but lower than buffalo milk ( $9,794.37 \text{ baht head}^{-1}$ ) ( $p < 0.05$ ). In conclusion for this study, cow milk could be replaced for buffalo milk fed to the calves without any adverse affect to the calf on growth performance. Moreover, they could completely replace for the buffalo milk in order to reduce feed cost of weaned buffalo production.

**Keywords:** Buffalo calf, buffalo milk, cow milk, Mehsana buffalo, milk replacer

## Development of Urgently Needed Improved Diagnostic Test for CBPP, a Devastating Cattle Disease in Africa

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Contagious Bovine Pleuropneumonia (CBPP) is a lung disease of cattle caused by the bacterial pathogen *Mycoplasma mycoides* ssp. *mycoides* small colony type (MmmSC). CBPP severely affects cattle stocks in Africa and consequently, a large proportion of the livestock-dependent population. While the disease has been eradicated in most parts of the developed world, it is still present in many countries of sub-Saharan Africa due to ethical reasons, a lack of money, fragmentation of veterinary services, uncontrolled cattle movement, poor vaccine efficacy, and poor sensitivity of current diagnostic tests. A diagnostic test able to detect all infected animals would be a key tool in controlling CBPP. By having such a test, farmers, cattle traders and veterinarians would be able to test their cattle stock for CBPP, separate infected animals, and ensure that only CBPP-free animals are traded, which would not only help to secure a constant income from trade but also lead to an increased livestock productivity. A systematic search to find the best possible immunogenic antigens has never been carried out. We used two approaches namely (1) two dimensional gel electrophoresis, immunoblot combined with mass spectrometry and (2) a phage library and panning with sera to identify novel candidate antigens. By doing so we identified a number of candidate antigens, some of which have been individually characterised in enzyme-linked immunosorbent assay and immunoblot experiments, employing sera from experimentally infected cattle. Further work is needed to design an optimal combination of diagnostic antigens. We will present an outline of the steps needed to translate our current research results into a product and improved policies for control of CBPP.

**Keywords:** CBPP, diagnostics, immunogens

## Participatory Assessment of Institutional and Organisational Challenges Confronting Dairy Goat Management in Kenya

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Institutional Analysis and Development Framework (IAD) is applied in the investigation of a range of actors, organisations and drivers influencing dairy goat management in Kenya. Information was elicited using participatory appraisal exercises. Venn diagrams and focus group discussions were used to map out key institutions and organisations, assessing their importance and links with the economic development of dairy goat producing households (and with each other). Different stakeholder groups in the public (e.g. government ministries and research organisations), participatory (e.g. farmers, farmers organisations, Kenya Stud Book-KSB and development agencies) and private (e.g. financial organisations) sectors were identified and their relative rankings quantified for the three projects Dairy Goat Association of Kenya (DGAK), Higher Education Links-Egerton University Community Dairy Goats Project (HEL-EUCDGP) and Heifer project International (HPI), each represented by the regions Nyeri, Nakuru and Bomet districts, respectively. The private sector was the least represented with only one stakeholder (i.e. the banks) while majority of the stakeholders in the participatory sector were ranked higher and had a strong affiliation with the economic development of dairy goat keepers. Non-farmer group households were ranked first by participants in all the three regions followed by the farmer groups. Research organisations, banks and KSB had the lowest ranks in most locations. Non-farmer group households, farmer groups and breeders associations had the strongest influence and inter-linkages on the dairy goat sector. They also occupied key positions in the Venn diagrams, implying that a strong affiliation exists between these stakeholders and the economic development of dairy goat keepers. The diagrams also revealed weak and distant inter-linkages with the ministry of livestock, development agencies and the KSB. Research organisations were considered weak and distant to goat breeders and separated from the institutional network and had virtually no relationships with other stakeholder groups. Collective action by farmers can be argued as the preferred organisational option, but it has to be institutionalised, supported technically and policy-wise, and networked with key stakeholders while clearly defining their respective roles.

**Keywords:** Dairy goat projects, institutions and organisations, participatory appraisal, stakeholders

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## **Impact of Forage Fodder Bank Adoption on Labour Use for Feeding Cattle of Smallholder Households in Prey Chhor District, Kampong Cham Province, Cambodia**

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Prey Chhor is low-lying district in Kampong Cham Province, where most of the agricultural land is flooded during the raining season. Most of the land is planted with paddy rice during the rainy season and there are only small pockets of higher-lying land. In the cropping season, farmers need to travel long distances and spend many hours each day to find enough grass to cut for feeding their cattle. From 2003–2005, the Livelihood and Livestock Systems Project introduced forage fodder banks to smallholders in an attempt to improve feed supply. In October 2008, an impact study was conducted to measure the impact of forage fodder banks on labour use. Using a structured questionnaire, a total of 143 households were interviewed. Respondents fell into three groups: (i) adopters, (ii) non-adopters (exposed) who lived in the same village as adopters and knew about forages but had not adopted, and (iii) non-adopters (not-exposed) from similar, nearby villages and who had not been exposed to forage fodder banks.

Average farm size and household membership was 1.4 ha and 5.5 people, respectively. On average, each household raised 4 cattle. The average size of forage fodder banks was 485 m<sup>2</sup>. Despite this small forage area, adopters spent significantly ( $p < 0.05$ ) less time on feeding and managing cattle than non-adopters (exposed and non-exposed) throughout the year. In the dry season, adopters spent 5.1 h d<sup>-1</sup> feeding and managing cattle, as compared to 7.3 h d<sup>-1</sup> for non-adopters (exposed) and 6.6 h d<sup>-1</sup> for non-adopters (not-exposed). In the early wet season, adopters spent 4.2 h d<sup>-1</sup>, as compared to 6.0 and 5.8 h d<sup>-1</sup> for non-adopters (exposed and not-exposed), respectively. This difference in labour use increased further during the flooding season when adopters spent 1.7 h d<sup>-1</sup> while non-adopters (exposed and not-exposed) spent 3.7 and 4.6 h d<sup>-1</sup>, respectively.

In conclusion, forage fodder banks significantly reduced amount of time needed to feed and manage cattle in all season, but the greatest benefit was in the flooding season when households who had adopted forage fodder banks saved at least 2 h d<sup>-1</sup>.

**Keywords:** Cambodia, fodder banks, labour saving, smallholders

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## Willingness to Pay for Breeding and Production Services: Application of a Contingent Valuation to Dairy Goat Breeding Programmes in Kenya

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A household survey was conducted with 311 farmers participating in three dairy goat projects in Kenya i.e. the Dairy Goat Association of Kenya (DGAK), Higher Education Links-Egerton University Community Dairy Goats Project (HEL-EUCDGP) and Heifer Project International (HPI), to assess farmers' willingness to pay (WTP) for provision of breeding and production services. A Heckman's two-step model was estimated to identify factors affecting the probability that a respondent was willing to pay for provision of services; veterinary services (VS), extension services (ES), marketing services (MS), and performance recording (PR), and the factors affecting the effectiveness of applying these services in dairy goat production systems in Kenya. The second-step, Ordinary Least Square (OLS) estimates were used to make inferences about factors affecting farmers WTP for these services because the inverse mills ratio (IMR) was not statistically significant. This means that there was no sample selection bias resulting from using the non- zero data (only farmers willing to pay). Farmers were significantly willing to pay more for provision of VS than any other service. Variables such as satisfaction with project activities, system of production, social benefits, flock size, participation in the projects, farm visits, market linkage and information, and experiences on the services significantly ( $p < 0.05$ ) influenced the WTP. The decision to pay or not was not necessarily affected by those not willing to pay because of the inter-linkage probabilities with the ability to pay. Effective provision of reliable and affordable support services for breed improvement is of much significance to the dairy goat keepers if these programmes are fitting to their social and economic circumstances. Provision of these services also necessitates public investment to develop capacities of service providers and establish markets for these services. Creating a system consisting of public/private provision linked to community-based approaches is therefore vital. Support is necessary for the poor farmers to avoid undesirable practises or the services being restricted only to those who can afford to pay.

**Keywords:** Breeding and production services, contingent valuation, dairy goat projects, Kenya, willingness to pay

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## **The Characteristics and Performances of Sonok Compared to Karapan Cows as Important Consideration for Conservation of Madura Cattle**

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Madura cattle are a prominent example of local cattle in Indonesia. These cattle were formed from crossing of Bali, Ongole and Javanese cattle in Madura island, Indonesia, starting around 1 500 years ago. The uniformity of the breed was developed through tuft selection by the people in Madura. The social and cultural values of Maduranese embedded with the existence of Madura cattle. There are two cultural activities that involve Madura cattle, there are Sonok and Karapan. These are identify markers of the Maduranese throughout Indonesia.

Sonok is a heifer/cow contest for which good heifers and cows are selected based on their exterior performance. Karapan is a colourful male cattle race held every year after harvest season. Karapan cattle are mostly produced in an isolated district, where Madura cattle are conserved pure. The cattle here are threatened by inbreeding. While Sonok cattle are produced in other districts, where crossbreeding with exotic breed also occurs.

The aim of this study was to explore the characteristics and reproduction performances of Madura cows that produce progeny for Sonok and Karapan cattle.

Twenty five heads of cows which produce Sonok cattle and 39 heads of cows which produce Karapan cattle were measured and judged of their exterior performance. A total of 55 Sonok and Karapan cow owners have been interviewed to obtain the reproduction performance of the cattle. The officials in the Sonok contest and Karapan race have been interviewed to reveal the criteria applied to select cattle used for those activities.

In general, body size of Sonok cows was bigger than that of Karapan cows. The differences on the body size of Sonok and Karapan cows can be explained by several factors, such as selection within breed and management by farmers. Selection criteria for Sonok emphasize on exterior performance, while for Karapan, only on their speed of running. Reproduction performances of Sonok and Karapan cows are relatively high. Cultural practices in keeping Sonok cattle and criteria applied to select it, can be considered for conservation Madura cattle.

**Keywords:** Cattle, conservation, Madura cattle, Sonok cattle, Indonesia

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## Analysis of the Provision of Artificial Insemination (AI) Services Across the Organisational Structure in Bangladesh: Development of Sustainable AI Service Structure

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An empirical study was conducted in four districts (Comilla, Brahmanbaria, Narayanganj and Mymensingh) of Bangladesh from March till May 2006 with objective of analysing existing public, private and autonomous service provision to livestock farmers in the study areas towards the development of sustainable Artificial Insemination Services. The data were collected from 165 farmers with the help of a standard questionnaire by face to face interview. A stratified-purposive sampling technique was chosen for this study. Therefore, each of the farmers had an equal option of using at least one of the three AI service provisions. The services provided by the District Artificial Insemination Centre (DAIC), sub-centre and points were considered as public service whereas the services provided by the Bangladesh Rural Advancement Committee (BRAC) and Bangladesh Agricultural University (BAU) Artificial Insemination Centre were considered as private and autonomous service, respectively. The data collected from the survey were subjected to statistical analysis by SPSS version 12.0. The descriptive statistics were done to know the frequency and intensity of provision of AI services. The results indicate that public services are available in all study areas whereas autonomous services are only in Mymensingh district. The services provided by the private organisations are increasing but the access to the services by the remote farmers is not increasing. The results also showed that there is more demand for the services but the existing organisations are not able to provide the service which is a threat for the long term sustainability of AI service provision services across the organisational structure. From this study, it is recommended that farmers' needs should be translated in such a way that they get satisfaction and also has access to their required services, which entail that, public and private organisations are obliged to increase their service provision for sustainable Artificial Insemination Service development.

**Keywords:** Artificial insemination service, institution and organisation, service provision

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## **Pro Poor Risk Reduction Strategy for Hpai Control in Backyard Poultry in Indonesia: A Situation Overview and Approaches Used**

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Considering that Highly Pathogenic Avian Influenza (HPAI) in developing countries is not solely a veterinary problem, especially in backyard flocks, and an acceptable control can only be successful with the involvement of those small holders a research agenda was developed by an international expert team in collaboration with national partners from four African countries (Nigeria, Kenya, Ethiopia, Ghana) and Indonesia. The team includes veterinary and economic scientists. Despite significant scientific advances made towards understanding of HPAI, knowledge gaps remain on e.g. disease epidemiology and economic impact of HPAI and its control with specific emphasis on the effects of alternative mitigation strategies on livelihoods. Moreover, there is a limited understanding of the institutional arrangements most suited for disease control in different production systems.

To address the knowledge gaps several components were developed and implemented in all five countries consisting of (a) Risk assessment, (b) Livelihood and (c) Institutional analysis. A planned cross-country analysis will allow to identify similarities and differences in HPAI control and its success between the project countries.

The submitted paper will present used approaches for each research component with special emphasis on implemented activities in Indonesia, a country where HPAI is considered to be endemic in many parts of the country and conventional control measures have failed to limit substantially the spread of the disease. Beside of this a situation overview on HPAI will be provided.

**Keywords:** Chicken influenza, backyard poultry, Indonesia, pro poor control measures

## Constraints of Camel Meat and Milk Marketing and Strategies for its Improvement in the Arid and semi-Arid Northern Kenya

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A survey to identify constraints along the camel milk and meat value chains and, to design strategies to address the challenges in order to increase profits for the chain players was conducted in northern Kenya and Nairobi. The methods used included Participatory Integrated Community Development (PICD), Focus Group Discussions (FGD), Key Informants Interviews (KII), Direct Observations (DO) and Informal Interviews (II). The PICD, FGD, KII and direct observations were conducted in all the study sites while informal interviews were used for individual chain players in Nairobi and Laikipia. The KII were used on opinion leaders, DO in markets and slaughter facilities.

In a second step, field testing of the intervention on milk hygiene at market level and meat processing at household level was carried out for one year in Garissa and Bangali. Results indicated that about 50 % of marketable camel milk was not sold, 30 % (about 7.5 million litres) of marketed camel milk per annum was sold in sour state at 0.13\$ lower than the price of a litre of fresh milk; processed meat got spoiled along the chain and, producers experienced difficulties marketing their camels due to poor infrastructure, distant markets, limited value addition and hygiene problems. Annual economic losses associated with milk spoilage were estimated at US\$ 961,538. Proposed interventions include; training producers, bulking & market agents and transporters on milk hygiene, management of milk related diseases, training milk and meat sellers on business skills, introducing simple value addition technologies, promotion of value added products, among others. Preliminary findings indicated that an additional 3 million litres of camel milk was sold in fresh state, giving an annual saving of US\$ 384,615. Increased profitability of up to 60 % compared to 30 % before the intervention was reported among nyirinyiri processors. In conclusion, economic potential of the camel could be fully exploited by facilitating adoption of proposed interventions at all levels of the camel milk and meat value chains.

**Keywords:** Camel milk, Camel meat, Kenya

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# Livestock husbandry systems

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## Fluid Milk and Butter Production and Marketing Systems in Fogera District, Amhara Region, Ethiopia

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This study was conducted to characterise milk production and marketing systems and to provide options for more market-orientation in Fogera district, Amhara Region, Ethiopia. Twelve rural Kebeles and 480 households that practice milk production were used for the study. About 98.8 % of the households used traditional husbandry and indigenous breeds, mainly the Fogera cattle. Communal grazing and crop residues are the main feed resources. Communal grazing area covered 9602 ha; out of which 3,418 ha (35.6 %) were infested by a noxious weed, *Asra-cantha longifolia*. Seasonal flooding from Lake Tana and movement of animals from adjacent districts during the dry season have exacerbated the feed shortage. Parasitic diseases are major threats. Three dairy production systems, namely rural small-scale mixed, peri-urban and urban were identified based on use of inputs, location and access to markets. The average number of milking cows per household was  $1.59 \pm 0.04$  and ranged from 1.18 to 2.08, while the average pastureland holding was  $0.18 \pm 0.09$  ha. Across the three production systems, 20.4 % of the milk produced was used for home consumption, 66.3 % processed (mainly into butter and ayib), and only 13.3 % was marketed. In the rural small-scale mixed system, most milk is processed into butter, due to lack of market access to fluid milk. About 16.5 liters of milk were required to produce a kilogram of butter and about 104,193 kg of butter were marketed annually. This translates to an estimated 1,719,184 liters of milk per annum. In the peri-urban and urban production systems, the total amount of milk produced per day was 1,316 liters; out of which 278 liters (21.1 %) were used for household consumption, 702 liters (53.3 %) were processed into butter, and 337 liters (25.6 %) were marketed. The critical constraints to dairy development were feed shortage, high disease prevalence, shortage of improved dairy breeds, poor extension, artificial insemination and veterinary services, lack of working capital and marketing. Technologies and knowledge on improved butter production and marketing systems would enhance the benefits to smallholder dairy farmers if major urban centres such as Bahir Dar city and its surroundings and the export market open up new opportunities.

**Keywords:** Butter, cattle, Ethiopia, fogera, marketing, milk, production

## Effect of Feeding of Fat-tailed Sheep and Manure Treatment on Nitrogen Fluxes in the Soil-plant System

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Alternative feeds used in sheep production in dry areas often contain bioactive ingredients. The impact of applying manure from these feeding systems on the nitrogen (N) flux in the soil-plant system has not been investigated. Fresh (frozen) feces and composted manure composed of feces, urine and straw (10:2:1 of fresh weight) were obtained from ten sheep diets including agricultural by-products, crop residues, Atriplex and traditional feeds. All manure treatments were added to soil at a rate of 90 mg N/kg dry soil and their effects were tested on i) microbiological and chemical soil properties in a soil incubation experiment over 12 weeks and ii) on dry matter (DM) yield of barley (*Hordeum vulgare*, var. *harmal*) grown in pots for seven weeks. Simultaneously, fresh olive mill waste was applied to soil in four rates in addition to ammonium-sulfate fertilisation and non-amended soil. Contents and evolution of mineral N (ammonium and nitrate) in the soil clearly differed among treatments. Net mineralisation in the non-amended soil during incubation was 15 mg N/kg soil. The effect of fresh manure treatments on soil mineral N content ranged from net immobilisation to net mineralisation. In contrast, all composted manure treatments resulted in net N mineralisation. Olive waste manure decreased mineral soil N by 20 mg N/kg soil compared to the non-amended soil, irrespective of the application rate. The ongoing analysis of soil microbial biomass N and chemical properties will clarify the role of microbial immobilisation versus antioxidative and/or binding effects of polyphenols on soil N dynamics. The mineral N contents in the soil were reflected in barley DM production. Only two out of ten fresh manure treatments increased shoot DM production, while this was the case for nine compost treatments. Still, none of the manure treatments reached the 2.4 g shoot DM per pot obtained from ammonium sulfate fertilisation. Fresh manure from olive waste significantly depressed plant productivity ( $\leq 0.4$  vs. 1.2 g DM per pot in the non-amended soil). Barley tissue N will be analysed to calculate N recovery in the plant and to relate plant N uptake to N flux in the soil-plant-animal system.

**Keywords:** Composting, dry areas, manure, N fertilisation, N mineralisation, sheep feeding

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## Resource Use Efficiency in Urban and Peri-urban Livestock Enterprises in Niamey, Niger

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Urban livestock (UL) systems are often criticised for their poor management and low nutrient use efficiency. In Niamey, Niger, 13 representative sheep/goat and cattle keeping, low (LI) and high input (HI) UL enterprises were subjected to a comprehensive nutrient management monitoring during 11/2005–01/2008. Nutrient inputs through feeds and outputs through faeces were quantified through regular weighing and sampling, accompanied by regular weighing of animals. In the HI sheep/goat system, daily offers (TLU<sup>-1</sup> basis) of feed nitrogen (N), phosphorus (P) and potassium (K) were highest during the cool dry season, averaging 208.7 g N, 35.8 g P and 169.1 g K. Although these offers exceeded N, P and K requirements of fattening sheep/goats 2.9-, 4.4- and 7.9-fold, a live weight gain of only 104 g d<sup>-1</sup> was achieved. During the hot dry and rainy season, weight gains in the HI sheep/goat system were 86 and 53 g d<sup>-1</sup> and exceeding those of the LI system 1.2- and 2.4-fold. In the HI cattle system, daily offers of N, P and K exceeded the maintenance requirements of beef cattle in all seasons. However, cattle lost 651 and 232 g d<sup>-1</sup> in the hot dry and rainy season while they gained 33 g d<sup>-1</sup> in the cool dry season. In the LI cattle system, weight changes of +714, +300 and -914 g d<sup>-1</sup> were obtained in the cool dry, rainy and hot dry season. Partial nutrient balances (per TLU<sup>-1</sup> d<sup>-1</sup>) amounted to +110.8 g N, +8.0 g P and +85.7 g K in the HI sheep/goat system versus +4.4 g N, -6.2 g P and +1.0 g K in the LI system ( $p < 0.05$  for all). Balances averaged +28.6 g N, +2.5 g P and +21.5 g K in the HI cattle system and +2.2 g N, -0.6 g P and +4.3 g K ( $p > 0.05$  for all) in the LI system. The combined poor feed conversion and highly positive partial nutrient balances point to the severity of inefficient nutrient use in Niamey's UL enterprises and call for an analysis of the environmental consequences resulting from there.

**Keywords:** Cattle, live weight changes, partial nutrient balance, roughage, small ruminants, West Africa

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## Smallholder Cattle Production in Northern Mountainous Viet Nam in Relation with the Poverty Status of the Household

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In Viet Nam, cattle are mainly raised in household farms. The potential for beef production is assumed high in uplands. The government aims to improve beef production in the North. The northern uplands have the highest poverty incidence, particularly in remote areas. Ethnic minorities live there in less productive areas with poor infrastructure and low accessibility to market and off-farm work. The aim of the study is to investigate the relation between poverty level of household farms and beef cattle keeping and production.

This study was conducted in 20 villages, both lowlands and highlands, in the mountainous Yen Chau district, Son La province. Data on livestock production of randomly selected 299 households of different ethnic groups were collected by using standardised questionnaires. The relative poverty status of the household was assessed using terciles based on accurate indicators of their wealth status. Analysis of variance with SAS software version 9.1, PROC GENMOD, was used to process quantitative data.

Investigated farms were grouped into cattle keeping and non-cattle keeping farms. Cattle keeping farms comprised 44 % of the total investigated households and had bigger family and farm sizes compared with non-cattle keeping farms. Cattle keepers consisted of more farms of the richest and middle terciles than of the poorest (41 % and 37 % compared to 22 %, respectively). Among cattle keepers, farms keeping less than 3 cattle (an average of 1.4 cattle per farm) were representative for the small farms, with the medium farms keeping from 3 to 12 cattle (an average of 4.8 cattle per farm). The medium farms consisted mainly of the richest and middle terciles (91 % of the total), while 83 % of the poorest farmers keeping cattle were presented in the small farms. Cattle keeping was more prevalent among households with advantages in providing family labour and crop residues for cattle rearing. The poorest households kept no cattle at all or a small number of cattle mainly for working force.

**Keywords:** Cattle production, household farm types, mountainous regions, poverty rate, Viet Nam

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## Supplementation of High Quality Forages Could Improve Growth Rates of Bali Cattle Grazing Native Pasture in the Wet Season

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Liveweight gain of grazing Bali cattle (*Bos javanicus*) on native pastures in the wet season in West Timor, Indonesia is believed not to be limited by forage quantity and quality. However, studies showed that the growth rate in this breed of cattle under such condition was  $>0.3 \text{ kg d}^{-1}$ . The present experiment aimed at assessing the effects of providing high quality forage as supplements to Bali cattle grazing native pasture in the wet season.

Twenty four Bali heifers with a mean liveweight of  $85.4 \pm 3.8 \text{ kg}$  were allotted to four treatments. The treatments were grazing only, grazing + *Gliricidia sepium* leaf, grazing + *Acacia villosa* leaf, and grazing + *Lannea grandis* leaf. The heifers grazed together on a 25 ha *Bothriochloa timorensis*-dominated pasture during the day (0700 h to 1700 h) in wet season, and supplements were provided at night. The supplements were given to achieve 30 % refusal. Total intake was estimated by marker technique ( $\text{Cr}_2\text{O}_3$ ). Liveweights were recorded twice a month. Data were subjected to statistical analysis based on general linear model suited to a completely randomized design.

The results showed that growth rates of Bali heifers grazing native pasture during wet season in Timor was low ( $35 \text{ g d}^{-1}$ ), and providing high quality forages as supplements at night significantly improved LWG by up 205 %. Yet, the magnitude of LWG response varies according to type of forage, with the best result achieved by heifers given *Gliricidia sepium* leaf.

It is concluded that growth rates of Bali cattle on native pasture in the wet season is low due to low inadequate nutrient availability from grazing forage, thus providing high quality forages as used here will improve growth rates.

**Keywords:** *Bos javanicus*, browse species, heifers, life weight gain

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## Trypanosomosis and Cattle Health Management in Three Regions of Burkina Faso

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Trypanosomosis is an important disease affecting humans as well as animals. Despite several methods applied for many years, the control of this disease remains a big constraint to livestock productions in tropical areas. The objective of this study was to assess the importance of trypanosomosis among diseases in cattle in Burkina Faso, mainly in tsetse challenged areas and to capture information how farmers apply methods to control the disease. A survey has been carried out in 3 regions of Burkina Faso, one tsetse free region in the North and 2 tsetse challenged regions in the South-West and the West. 134 Cattle breeders were interviewed individually with a questionnaire consisting of open and closed questions. The results indicate that among the 16 diseases mentioned by cattle breeders, trypanosomosis is the most important one in tsetse challenged areas. More than 50 % of breeders in the South-West and the West ranked trypanosomosis in the first position. Pure Zebu cattle are much more susceptible to the disease than the taurine Baoule cattle or Baoule × Zebu crosses. Zebu cattle are preferred by cattle breeders for their body size and draft power. Chemoprophylaxis/chemotherapy is widely used as a control method as well as insecticides to fight the flies. Farmers feel that the effects of some common trypanocidal drugs are less good than they used to be. Blood samples have been collected from cattle during the survey to state the level of admixture of Baoule breed and frequencies of alleles in trypanotolerance candidate genes. Crossing susceptible breeds with the trypanotolerant ones like the Baoule cattle can help to reduce trypanosomosis occurrence in cattle. This can then be used as part of an integrated control method.

**Keywords:** Baoule, Burkina Faso, cattle, trypanocide, trypanosomosis, trypanotolerance, Zebu

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## Effect of Machine-milking Regimes on Lactation Performance and Oxytocin Release in Syrian Shami Cattle

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Two different machine-milking regimes were used to evaluate the lactation performance and Oxytocin (OT) release in primiparous Syrian Shami cows. For this purpose 12 Shami cows were investigated and divided randomly into two equal groups. Six cows were milked in the presence of the calves (PC) and subsequently suckled, whereas the remaining six cows were exclusively machine milked without the presence of their calves (WC). Milk yield and milk composition were measured each week from day 7 until day 91 of lactation during two milkings (morning and evening).

Blood samples were taken during the two milking times from each individual cow between days 43 and 65 of lactation. A day before blood sampling, cows were catheterized in jugular vein. Sampling was performed before, during and after milking. Blood samples were anticoagulated with K3-EDTA, cooled on ice, centrifuged at 3000 g for 15 min. Plasma was separated and stored at -20°C until used for radioimmunological determination of OT concentration. The degree of udder evacuation was determined by the succeeding removal of residual milk

For statistical evaluation, analysis of variance was calculated based on least-square means using the MIXED procedure of SAS (SAS, 8.1). Results are presented as means  $\pm$  SEM.

PC released OT during the milking process, whereas in the WC group no OT release was detected throughout the milking process. Consequently, the residual milk fraction was much lower in PC than in WC (11 v. 58 %,  $p < 0.05$ ) and daily milk yield until day 91 post partum was higher in PC than in WC ( $12.6 \pm 0.3$  v.  $7.1 \pm 0.4$  kg,  $p < 0.05$ ). In conclusion, Syrian Shami cattle are not suitable to be exclusively machine milked without the presence of their calves.

**Keywords:** Oxytocin, residual milk, suckling, Syrian Shami cattle

## Comparisons of Beef Buffalo and Beef Cattle Farming in Northeastern Thailand

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The number of cattle in Thailand increased between the years 1996 and 2005 whereas the number of buffaloes declined during this period. The objective of this study was to analyse the main reasons for this development. Therefore 121 farmers in the Nakhon Ratchasima province were interviewed with a semi-structured questionnaire between October 2007 and May 2008. Beef buffaloes were usually kept in a simple and rough housing compared to beef cattle. Moreover, beef buffalo farms were rarely supplied livestock facilities by the farmers compared to the support of the beef cattle keepers. Farmers mentioned high drought and heat tolerance, high favourite meat and attractive appearance of the animal as favourable traits for beef cattle, while high fertility, properly feeding behaviours (neat and low selective grazing), high feed intake, good body condition, large body size, high meat production, friendly temperament and high animal price were mentioned as favourable traits for beef buffaloes. Management difficulties including more selective grazing, quick walk, trend to damage cropping and hard to handle were the main constraints for beef cattle farming stated by 67 % of the keepers, while lack of public water resource for reducing heat stress by lying in mudholes was the main constraint for beef buffalo farming mentioned by 57 % of the farmers. Farmers (63 %) also perceived the lack of public water resource as the most important reason for the decrease of the buffalo population.

Although beef buffaloes are relatively easy to manage and have many satisfactory traits compared to beef cattle, their production is suffering from the very serious constraint. This needs to be taken into consideration by the government in order to sustain the regional buffalo meat production.

**Keywords:** Beef buffaloes, beef cattle, farming constraints, favourable traits, water resources

## Methodological Approach to Analyse the Efficiency of Animal Recording Practices

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Animal recording is an interactive process that involves collection of data on identified animals in the production units and processing these data into information that can be used for decision making. Efficiency of recording is essential to ensure utility of outcomes necessary for sustainable participation. Most evaluation approaches define efficiency in economic terms with little regard to institutional issues affecting utility of the outputs. In animal recording systems where there are no direct economic benefits, efficiency evaluation based on utility derived from the records would be more laudable. In that case, a system is considered efficient when outcome-utility dependent participation is sustained. Approaches for evaluating efficiency based on utility of the outputs are however unavailable. The study presents an approach for evaluating efficiency of the animal recording based on output utility using institutional analysis and development framework. The approach considers animal recording as an action arena with various actors in three action situations namely animal identification and registration, pedigree and performance recording, and animal evaluation and information utilisation. The variables include the positions occupied by actors, their actions, the outcomes associated with the actions, level of control over choice, available information and the cost and benefits of engagement. As an interactive process, animal recording has rules that order relationship between actors. It also exists within a biophysical system and community whose attributes jointly with the rules influence the actions and outcomes of recording. These are evaluated by looking at rule formation structures, enforcement and compliance, and the level of interaction between the recording system and other biophysical characteristics and the community for their effects on outcomes, their utility and sustainability of recording. Participatory tools; Stakeholder matrix and Venn diagrams are used to identify the variables, quantify their interactions and link them to outputs. The approach evaluates efficiency by incorporating institutional issues influencing the operations of the system and its outcomes. It may therefore be used to evaluate efficiency of systems whose outputs do not have direct market value and in situation where quantitative market information is scarce.

**Keywords:** An approach, animal recording, efficiency evaluation, institutional analysis, participatory tools

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## **Constraints for Cattle Production of Small-scale Farmers in Kampong Cham Province, Cambodia**

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Almost all cattle raised in Cambodia are produced by small-scale farmers in rural areas. Small-scale farmers commonly use native grasses and crop residues as feed for their animals. Feed resources for cattle have become a constraint as the cattle population and area cultivated with crops have increased; this has resulted in low animal productivity. Suggested alternative: Nutrition has been identified as the single most important constraint to cattle production in Cambodia. Increasing demand for red meat has meant that cattle production represents an important opportunity for Cambodian farmers. This study reports a survey which was conducted to identify constraints to cattle production of small-scale farmers in Cambodia. Sixty randomly selected households raising cattle in Kang Meas and Tbong Khmum districts in Kampong Cham province were interviewed in late 2008.

Most (80 to 90 %) household income was derived from the farm (only 10 to 20 % of income was from off-farm sources). Cattle production represented 20 % of farm income, on average. The mean number of cattle per household was 5. Overall cattle production was assessed as very low, with average inter-calving interval estimated at 18.3 months and mean growth rates of non-lactating animals at less than 100 g d<sup>-1</sup>. Farmers reported that cattle were mainly used for draught, breeding and selling. This is a significant shift from the traditional approach of using cattle for draught and breeding only, indicating that farmers were responding to market demands.

Farmers rated feed availability as the most important constraint to cattle production, followed by diseases. In the survey villages cattle production was severely constrained by the lack of feed resources which caused low animal productivity. Providing locally available feed (natural grasses and crop residues) for cattle is a major challenge for farmers, requiring high labour inputs. Planting alternative feeds such as forage grasses is an attractive opportunity for small-scale farmers to improve their cattle production.

**Keywords:** Animal productivity, cattle production, crop residue, feed resource, grasses, small-scale farmer



## Screening of Tropical Plants Possessing a Low Methane Formation Potential and High Ruminant Digestibility *in vitro*

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The awareness of global warming due to accumulation of greenhouse gases, including methane, has increased in recent years. The livestock sector especially in the tropics is known for its high contribution in form of extensive methane emission. Ruminant husbandry in tropical regions depends on the availability and the quality of plant fodder especially during dry season. In the present study, an *in vitro* screening of various tropical plants was conducted in order to detect plants characterised by a low methane formation potential but a highly digestibility in the rumen. Therefore leaves from 27 tropical plant species, obtained from the area of Bogor, Indonesia, were incubated *in vitro* using the Hohenheim gas test. Approximately 200 mg dry matter of each plant was incubated with 30 ml of ruminal fluid/buffer mixture (1:2; v/v) for 24 h at a constant temperature of 39°C. Each plant was incubated four times, represented by two incubation units per experimental run. Variables measured were total fermentation gas production by reading of the scale on the syringes, and methane concentration by using gas chromatography. Organic matter digestibility was calculated from total gas production. The plants were analysed for their chemical composition i.e. crude protein, ether extract, neutral detergent fiber, acid detergent fiber, acid detergent lignin and total phenols. The results showed that most of the plants tested had contrasting profiles regarding their digestibility and methanogenic potential in the artificial rumen system; they had either high digestibility combined with a high methane formation or low digestibility with low methane formation. This pattern was shown to be correlated with the total phenol contents in the plant. Nevertheless, several plants revealed methane formation below average (12.7% of total gas) but a ruminal digestibility above average (39.9%). These plants were *Artocarpus heterophyllus*, *Leucaena diversifolia*, and *Leucaena leucocephala* and showed methane proportions in total fermentation gas of 11.3%, 11.5%, and 12.4%, respectively, and a ruminal digestibility of 45.1%, 43.1%, and 46.4%, respectively. Further research using larger collection of tropical plant species is needed to obtain more promising plants possessing a low methane formation potential combined with a high digestibility in the rumen.

**Keywords:** Digestibility, *in vitro*, methane, tropical plants

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## Effect of Ensiled Pineapple Waste with Rice Straw as Roughage Source on Rumen Fermentation Products

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Four ruminal fistulated crossbreed (Holstein-Friesian × Native) heifer with average body weight  $458 \pm 19$  kg were used to determine rumen fermentation products (pH, volatile fatty acids and ammonia nitrogen) at 0, 2, 4 and 8 h after feeding based on Latin square design. The animals were randomly fed with one of the four total mixed rations containing different roughage sources. Treatments consisted of (1) ruzi silage, (2) ensiled pineapple waste, (3) ensiled pineapple waste with 10 % rice straw and (4) ensiled pineapple waste with 15 % rice straw. Each animal was fed at a ratio of roughage and concentrate of 50:50.

After ensiling the physical characteristics of rice straw were changed: softer, with a lactic acid odor and a light yellow colour. However, supplementation with rice straw increased dry matter content of the silage but decreased its crude protein content. Rumen pH, total VFA and  $\text{NH}_3\text{-N}$  were not significant different among the treatments. The highest amount of total VFA was found at 2–4 h after feeding. But  $\text{NH}_3\text{-N}$  concentration was the highest at 2 h after feeding. The highest amount of VFA found in the rumen fluid was acetic acid (206.75, 176.60, 198.63 and 198.50  $\text{mM l}^{-1}$  for the four treatments respectively), followed by propionic acid and butyric acid. Animals fed with ensiled pineapple waste tended to have a lower ruminal pH but higher in  $\text{NH}_3\text{-N}$  (25.05, 20.75 and 24.21 mg % for treatment 2, 3 and 4, respectively) when compare to ruzi silage group (12.86 mg %). Moreover, the ratio of acetic : propionic : butyric (C2:C3:C4) was not significant different between the treatments (54:24:22, 55:22:23, 52:25:23, 53:24:23 for the treatments 1, 2, 3, and 4, respectively). In conclusion, ensiled pineapple waste with 10–15 % rice straw could be used as roughage source for ruminant feeding.

**Keywords:** Ensiled pineapple waste, rice straw, roughage source, total mixed ration, volatile fatty acids, ammonia nitrogen

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## Pastoralists' Perspectives on Multi-functional Role of Small Ruminants in their Production Systems in Arid Areas of Northern Kenya

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Pastoral systems in sub-Saharan Africa are characterised by a high temporal and spatial variability of resource availability. Livestock is the only production asset of pastoralists and has thus to fulfil a broad range of functions for the household. We generated descriptive data on the different functions of the eight age and sex classes of sheep and goats respectively in northern Kenya. Using semi-structured interviews, we interviewed 22 and 33 Gabra and Rendille livestock keepers, respectively. We further used six group inquiries to get explanations of the different functions and their ranks. In both communities, animals of the different age and sex classes have a number of different functions. They are geared either towards fulfilling household needs and cultural and social obligations or towards maintenance and reproduction of the flock. Pastoralists have preference for animals of specific age and sex classes for selling or slaughtering for nutritional or financial reasons, respectively. Yearling ewes and rams are slaughtered more often than reproductive ewes and sheep castrates. Especially, the old goat castrates are sold during periods of high household financial requirements. Besides milk and meat, especially sheep fat is used for a variety of uses that include human therapy and skin beauty. The old sheep castrates are valued for supplying fat when required in large quantity. The young castrates are a preferred source of curative fat. Also for cultural functions, animals of specific age and sex classes are used. For instance, ewes are used during the *almado* ceremony which does not involve the slaughtering of an animal. The old ewes are slaughtered during a camel blessing ceremony called *sorio harafa*. Sheep and goats in the studied systems have partly different and rather complementary functions in the system. In the meeting of household food needs, sheep are for example relied for meat while goats for milk. Furthermore sheep are used more often for the ceremonial functions than goats. By assigning different functions to the different species and especially to different age and sex classes, pastoralists make strategical use of diversity to obtain more options and thereby increase resilience of the production system.

**Keywords:** Cultural use, goats, Kenya, multi-functional, pastoralists, sheep, small ruminants

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## Management of Awassi Sheep Flocks in Syria

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Sheep in Syria are considered an essential component of the livelihood system of poor farmers. Sheep are distributed over the country, but mostly concentrated in the areas receiving less than 250–300 mm average rainfall annually (app. 55 % of the total country area) mainly including steppes and pastures. About 21 million heads of Awassi sheep (the only sheep breed kept) contribute 76 %, 31 % and 100 % of the country's total red meat, milk and wool production, respectively. Awassi is a multi purpose animal and well adapted to the harsh environmental conditions. A first step to develop breeding programs for Awassi sheep in Syria is the understanding of the production system and objectives. One part of this step is to have clear view about flock management. The objectives of this study are to describe the management practices of Awassi sheep keepers in Syria. A study was carried out during summer 2006 and 2007, involving 105 sheep keepers of four different eco-zones. Individual questionnaire interviews were used. The flock owner is the decision maker, and only 23 % of sheep keepers hire people as shepherd. Grazing is most important source of fodder, supplementation with concentrates became very necessary to maintain feeding levels of the animals during summer. Seasonal east-west movements looking for good rangelands and pastures were recognised. The application of a governmental immunisation programme against prevalent diseases (Enterotoxaemia, Pasteurellosis, Brucellosis, Sheep Pox and Foot and Mouth disease) differs between the regions, all sheep keepers in southern, middle and eastern areas immunize there animals while this is done in only 60 % of the flocks the northern area.

Awassi ewes have a long breeding season (end of May to early September) with a breeding peak occurring between June and August. Because rams are always with the flock, few out-of-season mating may occur. Age of the lambs is the main factor for weaning. Breeding animals are selected based on the individual experience of the sheep keepers (76 % of all flock owners) and 24 % ask another sheep keeper for advice. Almost all sheep keepers (98 %) use performance characteristics as selection criteria.

**Keywords:** Breeding program development, traditional sheep hearing, health care, Syria

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## Socio-economic Sustainability of Dairy Production Systems in Bangladesh

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Dairy production in Bangladesh is growing fast but faces problems of high input prices and low milk prices leading to a low productivity of dairy cattle. This poses the question whether dairy production systems are economically and socially sustainable. The concept of sustainable dairy production systems covers economic, social, technical and environmental dimensions. This paper mainly focuses on economic and social sustainability of dairy production systems based on the methods developed by the International Farm Comparison Network (IFCN) and D'Haese et al., (2007). The objectives were to analyse indicators which reflect economic and social sustainability using entrepreneur's profit, return on investment, farm income, competitiveness of the product market and competitiveness of the factor market. The social capital (trust and associability), age, education, gender, wage rate of the region compared to other sectors and cultural habits were used as social sustainability indicators.

The results related with economic indicators showed that small farmers have much lower entrepreneur's profit as compared with large farmers which implies that currently only larger farmers are able to recover their full economic costs and consequently are more sustainable. Small farmers have lower labour and land productivities than large farmers. Regarding the social indicators, lack of trust and associability was observed in the milk production chain especially between small farmers and processors which is a threat to sustainability. Smallholders have a lower knowledge about the farming system as measured in terms of years of formal education received and the years of experience in dairying. This increases their disadvantages in a dairy system with growing competitiveness. The overall result indicates that the smallholder dairy production system will not sustain unless and until the productivities are improved. From the findings it is recommended that entrepreneur's profit and farm productivity should be increased by providing a conducive policy and institutional framework targeted at smallholder dairy farmers needs in order to improve on sustainability of smallholder dairy systems.

**Keywords:** Bangladesh, dairy production, sustainability,

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## **Farmer Innovation and Market-oriented Livestock Production in Ethiopia: Key to Sustainable Natural Resources Management**

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Developing countries have been trying to develop feed resources for livestock production through numerous natural resource management projects, with the hope that these feed resources would be utilised by livestock in a sustainable manner. However, lessons have shown that such a technology push approach alone resulted neither in improved livestock production nor in sustained natural resources management. Recognition of farmer innovation, community participation and mobilisation with a focus on a market-oriented livestock production are key elements for generating demand for and uptake of technologies and sustainable management of the natural resource base. The interventions should address constraints of a particular commodity along the value chain with innovation systems perspective. Technological interventions coupled with appropriate organisational and institutional arrangements are critical factors for successful fodder development to optimise livestock dependent income. This approach was tested by the Improving Productivity and Market Success (IPMS) project in two ecologically contrasting districts in Ethiopia; Atsbi district in Tigray Region in the highlands of northern Ethiopia and Mieso district in Oromiya Region in the lowlands of eastern Ethiopia. The targeted livestock species for market-orientation were sheep production in Atsbi and cattle and goat production in Mieso. Systematic and step-wise procedures were employed to assess the production system and the implement the interventions in the value chain of market oriented livestock production. The main activities were identification of pilot intervention sites, documentation of farmer innovations, targeting the interventions, community mobilisation and participation, capacity building through visits and training and constant demonstration and follow up, as well as linking livestock keepers to credit facilities and markets. Targeted technological interventions included natural pasture improvement, backyard forage introduction and development, integration of forage legumes into cereal production systems and various forms of utilisation of feed resources for livestock production. The paper explains the approaches, methods and processes used to introduce various feed technologies and describes the link between feed resources development and market-oriented livestock production for sustainable management of the natural resource base. The lessons learned provide valuable information for scaling up to other areas with similar potential for market-oriented livestock development.

**Keywords:** Ethiopia, feed resources, livestock, natural resources management

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## Feed Efficiency and Feed Cost in Holstein Friesian Dairy Herds Worldwide

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Feed is the largest single cost component associated with milk production worldwide. Unfortunately, in many developing countries, feed cost is high, while the feed efficiency (FE) and the performance of the herds are low. Consequently, it becomes very important to assess the current feeding strategies on dairy farms world-wide. The objective of this study is to understand the variations in FE and feed cost, and to show how the economic improvement of FE can improve farm profitability. Feed data obtained from typical Holstein Friesian dairy herds in twelve countries (seven developing and five developed countries) were analysed and compared using TIPI-CAL (Technology Impact Policy Impact Calculations model).

Feed intake on dry matter basis was highest in Mexican farms (24.5 kg day<sup>-1</sup>), and lowest in New Zealand (8 kg day<sup>-1</sup>). FE expressed as kg of milk produced per kg of dry matter feed consumed showed wide variations among the farms; it was highest in the United States (1.7) and lowest in Bangladesh (0.17) while it was 1.08 in China. Feed cost on total cost was lowest in China; 16 % compared to 86 % in Jordan and 66 % in Spain. In terms of efficiency, the New Zealand and American dairy herds were more efficient in converting nutrients into milk at lowest costs of 24 % and 20 % respectively, with milk yields of 4252 and 7100 kg Fat Corrected Milk (FCM) per lactation per animal, compared to other countries in the study. As conclusion, in the developing countries improving FE is a tool for better utilisation of feed and land resources as feed cost per kg of milk is quite high compared to developed countries. Under low milk price scenarios, a reduction in feed cost on-farm would lead to substantial improvement of feed efficiency of dairy herds in these countries to a comparable level with those of the developed countries, which will maintain farm profitability without compromising milk production or herd health.

**Keywords:** Milk production, developing countries, milk price scenarios, economic modelling



# Aquaculture

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## **Fisheries in the Small Reservoirs of Northern Ghana: Opportunities and Constrains of a New Natural Resource**

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An increasing number of extreme climatic events such as droughts and floods pose threats to rain-fed agriculture, the traditional and most important livelihood strategy in northern Ghana. Hundreds of small reservoirs were built during the past 50 years to help the rural population to deal with the difficult environmental conditions by enhancing their flexibility and diversifying income sources. Fisheries in these reservoirs was assumed to be a rather incidental benefit. However, in many communities in northern Ghana, where poverty and malnutrition prevails, fisheries developed into an important supplement to income. The steadily increasing demand for fish further shows that fish is a very welcome addition to the menu as well. Fisheries activities in four communities were studied and provide good examples for local responses to uncertainty resulting from climate change. Unfortunately, the growing popularity of fishing results in massive fishing pressure without accompanying management of this comparatively new natural resource is poor.

The few attempts of science and policy to increase fish production focused on technical solutions to increase fish production and neglected problems of implementation. A look into history shows that clashing traditional, governmental, and participatory management strategies as well as generation conflicts overtax the capacities of the communities to cope with management responsibilities. Organisational problems and difficulties in the implementation of even the simplest, well-known management rules, such as compliance with the ban on small meshed nets or close season, are some of the consequences. If cooperation between science, politics and local stakeholders can be established to overcome the disenchantment with management, fisheries in small reservoirs has a great potential to support the adaptation of the rural population to climate change.

**Keywords:** Fisheries management, livelihoods, northern Ghana, technical options

## **Growth, Mortality and Spawning Stock Biomass of Red Mullet *Mullus barbatus* in the Egyptian Mediterranean Waters**

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In Egypt, Mediterranean sea supports a large fishery that harvests about 50 thousand tonnes per annum. Red mullet is one of the most important demersal target species of the commercial fisheries in the Egyptian Mediterranean and contributes a mean annual catch of 2 000 tonnes. This paper presents the first assessment of the *Mullus barbatus* resource using per-recruit analysis as a suitable stock assessment tool for data-limited Egyptian fisheries. Age-based growth, mortality and sexual maturity parameters necessary for the per-recruit models were determined. Age and growth parameters were estimated for red mullet, *M. barbatus*, sampled from commercial landings of the trawl fishery using otolith's reading technique. *M. barbatus* has longevity of 3 years, but about 75 % of fish were less than 2 years old. The growth parameters estimates were  $K = 0.66 \text{ yr}^{-1}$  and  $L = 27.1 \text{ cm}$ .

Natural mortality ( $M$ ) was  $0.46 \text{ yr}^{-1}$ , fishing mortality ( $F$ ) was  $0.85 \text{ yr}^{-1}$  and exploitation ratio was 0.65. Length-at-50 % maturity was estimated at 13.3 cm TL, while the length at first capture was estimated at 10.4 cm TL. The length ( $L$ ) -weight ( $W$ ) relationship was estimated as  $W = 0.0077 L^{3.1095}$ . It is shown that the red mullet resource in the Egyptian Mediterranean waters is over-exploited with spawner biomass-per-recruit at 26 % of pristine levels. SSB analysis showed that effort reduction and/or establishing temporal closures for trawlers, trammel nets and gill-nets during the period of maximum spawning are strongly recommended. Also, a minimum legal landing size of 15 cm should be enforced to avoid the risk of recruitment overfishing. Per-recruit analysis revealed that  $F$  should be reduced by about 30 % to achieve the maximum  $Y/R$ . All approaches point to the need of drastic reduction in fishing pressure of about 30–50 % in the Egyptian Mediterranean fisheries.

**Keywords:** Egypt, management, mortality, *Mullus barbatus*, reference points, spawning stock biomass

## Earthworm Powder as Potential Protein Source in Diets for Common Carp (*Cyprinus carpio* L.)

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Earthworm culture is developing in many regions nowadays. Earthworms can be produced by simple methods from many kinds of organic materials. Products of earthworm can be used as an alternative protein source for many cultured animals such as pig, poultry, and fish and shrimp. However, the utilisation of earthworm powder as protein source in aquafeeds is poorly studied, and data on the digestibility of earthworm powder in carp and the resulting protein utilisation are missing so far.

An experiment was conducted to evaluate the potential of earthworm powder in replacement of fish meal and its digestibility. Triplicate groups of fish were fed a control feed (fish meal based protein), or experimental diets in which 30 % (EW1), 70 % (EW2), or 100 % (EW3) of fish meal protein were replaced by worm powder. The experiment was set up in a recirculation system at a constant temperature of 25°C for 8 weeks. 5 fish were stocked in each aquarium (40 l) and fed at feeding rate of 5 times of maintenance requirement. Fish growth was monitored weekly after 24 hour of starvation. At the end of experiment, fish were sacrificed, length and weight of intestine, weight of liver and chemical composition of the body were determined. Proximate composition and gross energy (GE) of fish and feeds were analysed according to AOAC (1990) standards and by bomb calorimeter respectively. The amino acid contents of the feed ingredients were determined according to EU standard methods 98/64/EG and 2000/45/EG.

Fish fed on earthworm containing diets had similar (EW1, EW3) or higher (EW2) growth rate, protein efficiency, energy retention than the control group. Protein digestibility in EW1, EW2 and EW3 was higher than in the fishmeal-based control diet. The viscera indexes did not show any significant difference which could give indication to nutritional stress. However, complete replacement (EW3) resulted in significantly lower lipid conversion compared to the control feed, the reasons for this and the effect of small supplements of earthworm powder to plant-protein based diets need further evaluation.

**Keywords:** Alternative protein sources, aquafeeds, common carp, digestibility, earthworm

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## **Fishing for Expertise — The Role of the Private Partner in Public-private Partnerships in Aquaculture and Fisheries**

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In the discourse on development, we can find arguments that that collaboration between public agencies, business and civil society in Public-Private Partnerships (PPP) are able to mobilise additional financial resources, capacities and expertise and increase the efficiency and sustainability of development. These arguments are based on the assumption that it is actually the private sector that primarily drives the economic growth. Unfortunately the necessary characteristics of these private actors are often underspecified: Is every private actor equally capable of partnering with the public? In our presentation we will argue that private partners need to be of a certain economic size to create efficient and fruitful partnerships, especially in sectors which require knowledge and capacity.

We will draw our empirical examples from an increasingly important business sector: Aquaculture. While it is a traditional farming sector, it also requires a certain amount of knowledge, capacity and investment. It is a growing business for professionals, and also helps to deliver food security and livelihood for many people in poor countries, particular for small scale farmers. With ongoing development towards intensification and global networking aquaculture creates an increasing demand for infrastructure and supporting public services.

Within a GTZ funded project, our research team reviewed 53 aquaculture and fisheries PPPs in Africa (18 %), Asia (73 %) as well as some additional cases in South America (8 %). We analysed how public and civil institutions and development organisations use PPPs as tools to accommodate the demand for sector specific public service needs. Data and information were obtained through document analysis, semi-structured interviews with key informants, and an email survey.

**Keywords:** Aquaculture, fishery, infrastructure, public services, public-private partnerships, small scale enterprises

## Detoxified *Jatropha curcas* Kernel Meal: An Excellent Fish Meal Replacer in Common Carp (*Cyprinus carpio* L.) Diet

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*Jatropha curcas* (L.) is a multipurpose and drought resistant tree, widespread throughout the tropics and subtropics. Its seeds are rich in oil and protein. It is being promoted as a biofuel plant. *Jatropha* kernel meal obtained after oil extraction is an excellent source of protein. However, presence of toxic and antinutritional constituents restrict its use in fish feed. *Jatropha* kernel meal was detoxified. A 16-weeks experiment was conducted to evaluate the nutritional quality of the detoxified *Jatropha* kernel meal (DJKM) in common carp. Carp (36) with an initial average body weight of  $22 \pm 0.12$  g were randomly distributed into three treatments with four replicates and fed iso-nitrogenous and iso-energetic diets (crude protein 38 %, crude lipid 10 %): Control (fish meal based protein), J50 and J62.5 (50 % and 62.5 % of fish meal protein replaced by DJKM). Body mass gain (374–588 %), specific growth rate (1.4–1.7 %), metabolic growth rate ( $6.8\text{--}8.8 \text{ g kg}^{-0.8} \text{ day}^{-1}$ ), feed conversion ratio (1.7–2.2), protein efficiency ratio (1.2–1.6), protein productive value (21.9–26.5 %), and apparent lipid conversion (30–43 %) did not differ significantly among the three groups. Energy retention; dry matter, protein, lipid and energy digestibilities; and digestive enzyme (amylase, protease and lipase; U/g protein) activities were highest in control group, followed by J50 and J62.5 groups; all being significantly different. The ranges for energy retention and digestibilities of dry matter, protein, lipid and energy were 13.4–20.1 %, 70–75 %, 79–86 %, 80–86 % and 73–82 %, respectively. The relative intestinal length ( $\text{mm g}^{-1}$ ) was in the order: J62.5 > J50 > control; all being significantly different. Red blood cells (RBC) count and hematocrit were highest in control group, followed by J50 and J62.5 groups; all being significantly different, while creatinine level in blood had the opposite trend. RBC count, hematocrit and creatinine level in blood were  $1.32\text{--}1.52 \times 10^6 \text{ cells mm}^{-3}$ , 30–45 % and  $0.20\text{--}1.55 \text{ mg dl}^{-1}$ , respectively. White blood cells count, hemoglobin, alanine transaminase, alkaline phosphatase, glucose, total bilirubin, urea nitrogen, albumin, globulin, total protein, calcium, phosphorus and sodium in blood did not differ significantly among the three groups and were within the normal ranges, suggesting no clinical toxicity. In conclusion, DJKM is a promising fish meal replacer in carp diet.

**Keywords:** Common carp, fish meal replacer, *Jatropha curcas*, kernel meal, protein source

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## Masculinisation of Nile Tilapia (*Oreochromis niloticus*) Fry by Immersion in $17\alpha$ -methyltestosterone

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This study was conducted to develop a short-term immersion procedure for masculinisation of Nile Tilapia (*Oreochromis niloticus*) by using  $17\alpha$ -methyltestosterone at 100, 200 or  $400 \mu\text{g l}^{-1}$  for 3, 6 or 12 h. Fry were immersed two successive times with 3 days interval period. The highest percentage of male *Oreochromis niloticus* ( $96\pm 4\%$ ) and the lowest gonado-somatic index of female *Oreochromis niloticus* ( $1.89\pm 0.02$ ) were obtained by immersion of fry in  $17\alpha$ -methyltestosterone at the level of  $400 \mu\text{g l}^{-1}$  for 6 h. However, survival rate of *Oreochromis niloticus* Fry during hormone treatment period did not differ significantly from survival rate in the control group.

Tilapia culture is widespread all over the world. The problem of overpopulation in fish ponds caused by uncontrolled reproduction is a major constraint to the further development of the Tilapia culture industry. This problem could be overcome by culturing all-male populations of Tilapia. One of the most common techniques for producing all-male populations of Tilapia is androgen-induced-sex-reversal by using androgen-treated feed. However, the immersion of fry is not fully developed for practical usage. Feeding androgen carries some potential disadvantages as in efficiency in masculinisation. Immersion of Tilapia fry in androgen solutions may be an alternative to oral administration of androgen, this technique is well developed in salmonid culture; however it remains largely experimental in Tilapia culture.

The objective of this research was to develop short-term immersion procedure for the masculinisation of Nile Tilapia by using  $17\alpha$ -methyltestosterone and evaluating the most proper dose concentration and hormone treatment period.

**Keywords:** Androgen, males, methyltestosterone, *Oreochromis niloticus*, sex ratio, sex reversal, tilapia



## Utilisation of by-Catch and Processing Wastes from a Marine Fishery in Feeds for the Organic Aquaculture of *Litopenaeus vannamei* in Costa Rica

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In shrimp aquaculture one feasible way to reduce shrimp production costs and increase producers' profitability is the use of feeds with low fish meal levels or alternative protein sources with the aim of an organic certification. The main problem in realising organic shrimp aquaculture is often the lack of suitable protein sources. Our protein source derives from deep-sea shrimp fishery in Costa Rica certified as sustainable. Also important is the trading of the produced organic shrimps. In our case certifier for organic aquaculture of marine shrimp the German certifier "Naturland" guarantees the selling of every organic produced shrimp. Regarding their guidelines fish meal content of the experimental diets is limited to a maximum of 20% of the total mass.

This study was carried out on a marine shrimp farm in Jicaral, Costa Rica and had the goal to test the possibility of using a locally available resource that is currently being wasted. A 48-day feeding trial was carried out to compare two test diets to one commercial control diet (Nicovita 35% protein). The two experimental feeds were prepared with fish meal of *Physiculus talarae*, *Pontinus cf sierra* and *Hippoglossina bollmani*, three common species that form part of the normal by-catch of the deep-water shrimp fishery in Costa Rica as well as shrimp head meal from *Heterocarpus vicarius*, integral wheat meal, sunflower oil and a vitamin and mineral premix.

Pacific white shrimp, *Litopenaeus vannamei*, were used to test both diets in comparison to the above mentioned commercial feed.

Test diets were fed to shrimp with an initial weight of  $10.8 \text{ g} \pm 0.56$  to evaluate their growth and feed utilisation parameters: size and weight gain, feed consumption, Feed Conversion Ratio (FCR), survival, Protein Efficiency Ratio (PER), Body Weight Gain (BWG) and Specific Growth Rate (SGR). At the end of the experiment, average weight was  $16.7 \text{ g} \pm 0.7$  in the control diet,  $16.6 \text{ g} \pm 1.6$  and  $16.7 \text{ g} \pm 0.4$  in the two experimental diets, suggesting that by-products and processing wastes from marine shrimp fisheries can efficiently be used in feeds for *Litopenaeus vannamei*.

**Keywords:** Costa Rica, *Litopenaeus vannamei*, organic aquaculture, protein sources

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## Evaluation of Protein-rich Feed Ingredients for the Organic Production of Freshwater Prawns *Macrobrachium rosenbergii* by Smallholders in the Inlands of Costa Rica

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In Costa Rica are many freshwater bodies unused for aquaculture purposes so far, although they are particularly suitable for the cultivation of freshwater prawn *Macrobrachium rosenbergii*. Such cultivation would be a possibility for raising the income of smallholders especially in case of ecologically produced prawns that are high-value-products. The aim of this study was to remove the lack of appropriate feeds by testing and comparing regional feed components for semi-intensive production of freshwater prawns considering the ecological background.

We evaluated two different test diets with a total maximum amount of 20 % fish meal according to the guidelines of “Naturland” (Verband für ökologischen Landbau) as a potential certifier. The used fish meals and additional shrimp head meal were regional by-catches and processing wastes. Diet 1 contained 15 % fish meal (*Physiculus talarae*) and 10 % shrimp head meal (*Heterocarpus vicarius*) and diet 2 contained 20 % fish meal (15 % *Pontinus* cf *sierra* and 5 % *Hippoglossina bollmani*) and 5 % shrimp head meal (*Heterocarpus vicarius*). Further ingredients were integral wheat meal, sunflower oil, vitamins/minerals and gelatin. The test diets were compared to (1) a control feed used for the cultivation of marine shrimp (Nicovita) and to (2) a pellet feed for horses used in the only existing prawn farm in Costa Rica. A grow-out experiment was designed to determine the effect of the diets on growth performance and feed utilisation parameters of *Macrobrachium rosenbergii*. We used a randomised set-up of three natural ponds, each with four net cages of 2 m<sup>2</sup> for 28 days. The monitoring of the water quality parameters dissolved oxygen and water temperature showed no significant difference between the ponds. The highest weight gain (5.7 g ± 3.8) was achieved by diet 2 followed by the control feed Nicovita (4.4 g ± 2.8) and diet 1 (4.0 g ± 1.9). The lowest weight gain was observed by the pellet feed for horses (0.6 g ± 0.5).

These results indicate that the test diets used in this study are suitable feeds for *Macrobrachium rosenbergii*. Further research is needed to evaluate these feeds in different life stages of prawns and to optimise processing.

**Keywords:** Costa Rica, feed ingredients, prawns, organic production

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## Can We Still Improve Aquaculture Production in Viet Nam? Aspects of Freshwater Fish Production in Mountain Areas of Northern Viet Nam

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Aquaculture production in Viet Nam is one of the main economic activity of the country. Presently the production after rapid growth rich 2.2Mt year<sup>-1</sup> in 2007. Despite this there is still demand on fish products in local market and consumption of fish is increasing yearly. The fish consumption is traditionally high representing 19.4 kg person<sup>-1</sup> year<sup>-1</sup> in 2007 including marine fish. In the provinces of Lang Son and Cao Bang in northern Viet Nam was initiated project within the official development cooperation between the Czech Republic and Viet Nam represented on the Czech side by the Czech University of Life Sciences Prague and on the Vietnamese side by the Research Institute for Aquaculture No. 1 located in Tu Son (Bac Ninh). Northern provinces of Viet Nam are situated in mountains with restricted land area for aquaculture activities. Moreover northern provinces are inhabited by several minorities that carry on their own habits and traditions. Both provinces are known for their natural resources especially metals that are also exploited and that can have negative environmental effect. The objective of the project is to increase fish production in both provinces from reservoirs that were constructed for irrigation purposes. The suggested methods are selected with respect to application of environment risk assessment. Two types of aquaculture were chosen: culture based fisheries and cage culture. Optimal fish stock for culture based fisheries is calculated for individual reservoirs according to biotic and abiotic characteristics. For cage culture fisheries was identified local fish species *Hemibagrus guttatus* which has high economic value and its production could improve income of cooperatives created close to reservoirs. There is cooperation with 5 selected cooperatives; two of them are located in Lang Song province and three in Cao Bang province. The part of the study is oriented to evaluate the socio-economic characteristics of minorities living in mountain areas. Promoting effective harvesting methods in the reservoirs are another activities of the project.

**Keywords:** Aquaculture, environment risk assessment, ethnic minorities, mountain areas, Viet Nam

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## **Economic Efficiency of Shrimp Farms in Thailand under Good Agricultural Practice System**

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The main purpose of this study is to measure and investigate factors affecting economic inefficiency of shrimp farms in Thailand under Good Agricultural Practice System. In the first stage, to estimate efficiency scores, the data envelopment analysis (DEA) approach is applied to farm-level cross-sectional survey data of shrimp farms in two districts of two provinces in the Eastern Region of Thailand. In the second stage, in order to examine the effect of farm-specific socio-economic and management factors on farm efficiency, a regression model is estimated where the level of inefficiency from DEA is expressed as a function of these factors. Then, Tobit estimation is used in this study. Previous studies have investigated economic efficiency and its components at both the farm and aggregate levels in Thai agriculture. However, this study, to the best of our knowledge, has been the first application of DEA in order to measure and explain economic efficiency and its components of shrimp farms in Thailand. The empirical results suggest two important findings. First, the economic efficiency scores of some farms were considerably low. Second, there is confirmation that farm size, the considerable variability of concentrated feed used have influenced the economic inefficiency of shrimp farms while the differences in producers' age, education and experience, the number of farm visits per year and belonging to farmer groups do not have different impacts on economic efficiency in Thai shrimp production in different farms. The results indicate advantages in ready mixed shrimp feed used by producers and small farms in Thai shrimp production. Therefore, the development policies of the above areas should be used to increase the cost efficiencies of these inefficient farms in Thailand.

**Keywords:** Data development analysis, economic inefficiency, good agricultural practice system, socio-economic factors, management factors, Thai shrimp farms, Tobit regression

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## GIS Mapping of Pond Aquaculture Potential in Southern Malawi, Africa

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Smallholding aquaculture in Malawi is gaining popularity, particularly with the promotion of pond-fish culture within integrated agriculture-aquaculture (IAA) systems. These systems benefit poor farm households through enhancing food security and supplementing farm income. Location-specific successes of IAA need to be out-scaled to benefit more farm households. However conditions favouring adoption do not occur uniformly over geographical space.

GIS modelling techniques were used to identify and map the potential for smallholding pond aquaculture systems to aid aquaculture planning and management. A resource evaluation framework was adopted and implemented for the Southern Region of Malawi.

Through literature review, consultations with aquaculture specialists and local experts, and carrying out multiple regression analysis, we identified five groupings of the key determinant factors and their indicators that are quantifiable and mapable. These factors include water availability, land conditions, market structures, knowledge inputs and labour and finance which were then weighted and mapped for the current and a future scenario of pond aquaculture development in Southern Malawi.

For the convenience of target users, we developed the Suitability Analysis and QUery for Aquaculture (SAQUA) open source software package which can be used for multi-criteria evaluation modelling, for conducting drill-down queries, and for filtering multiple map layers.

**Keywords:** GIS, infrastructure, Malawi, markets, multi-criteria evaluation, pond based aquaculture, resource management



# Monogastric livestock

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## The Civet Cat and Smallholder Civet Producers in Ethiopia

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Ethiopia is the world's main supplier of civet musk with international export share of 90 percent and it has also a long-lasting history in trading of musk for perfume industry. This product is collected from Civet cats which are more related to mongoose and classified among mammalian species. Their habitat is mainly savannahs and forests of South and Central Africa and rarely found in arid regions. Even though, African viverrids tend to be carnivorous; they show a feeding habit of omnivores. They are nocturnal. They have been kept in captive for hundreds of years in Ethiopia and most Civet farmers keep 10 - 15 civets in individual cages. Polyestrous African Civets has age at sexual maturity of around 1 year and average life span of 15 - 20 year. More commonly, litter size varies 2 - 3 per year with 1 - 6 kits per litter. Despite its importance in the livelihoods of smallholder producers, mistreatment of civets at captivity has raised a welfare question. Moreover, increasing tendencies of perfume industries towards the use of synthetic fixatives, poor husbandry practice and the decline in wild population threatens the prospects of civet industry. However, opportunities also exist as musk is among rare commodities, the synthetic is not perfectly replacing the natural product and the product is currently in short of supply as it only covers 22 percent of the international demand. Besides it is identified among potential investment opportunities in Ethiopia. Hence this literature review work tries to pinpoint some possible recommendations to improve the allover husbandry practice and tradability of the product through integrated development and research works by taking the traditional knowledge as a core player.

**Keywords:** Civet cat farming, Ethiopia, musk production, musk trading, welfare

## Production Efficiency of Crossbred Pigs in Cho Han Kyu's Natural Farming System in Northern Thailand

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The Korean natural farming system 'Cho Han Kyu' is currently widely applied small pig farms in Northern Thailand. The main idea of this system is to use indigenous microorganisms (IMOs) and to utilise local resources. To optimise the system's efficiency, appropriate breeds have to be chosen. Four crossbreds (Duroc × Large White × Landrace, DU × LW × DR; Pietrain × Large White × Landrace, PT × LW × LR; Pietrain × Thai native, PT × NT; Duroc × Meishan, DU × MS) and a group of Thai native pigs (NT) (10 animals per group) were fed with fermented animal feed according to Cho Han Kyu in the fattening period between 30 to 60 kg live-weight. The comparison of production efficiency between the animal groups revealed significantly ( $p < 0.05$ ) higher average daily gains (ADG) and average daily feed intake (ADFI) in NT (0.7098 g and 1.9397 kg d<sup>-1</sup>) compared with DU × MS (0.5176 g and 1.5728 kg d<sup>-1</sup>). The production efficiency was, however, not significantly different between the further breeds. The PT × NT crossbred had a significantly higher total feed intake (TFI) than the crossbreds DU × LW × LR and DR × MS as well as the group NT (139.39, 74.97, 92.79 and 64.01 kg, respectively); no significant differences existed compared to the PT × LW × DR crossbred (127.12 kg). Contrary to that the feed efficiency (FE) and feed conversion ratio (FCR) values were not significant between any of the investigated groups of animals ( $p > 0.05$ ). The production efficiency of the crossbred DR × LW × LR in the commercial system (n=10) compared to the natural system (n=10) was improved in terms of higher ADG, TFI, ADFI, FE and better FCR ( $p > 0.05$ ). We conclude finally that NT is well adapted to the natural farming system and poor feedstuff in the period of 30 to 60 kg live-weight. The study will be continued to assess the parameters in the fattening period between 60 to 100 kg. The break-even point will be analysed to meet the efficiency economic criteria for small pig holders in northern Thailand.

**Keywords:** Natural arming, Thailand, pig production efficiency

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## Natural Farming for Small Pig Farms in Northern Thailand

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The commercial pig production is nowadays the prevailing system in Thailand. Natural farming systems using local resources are, however, probably the better choice for small pig holders. We investigated in this study different animal feedstuffs to assess their efficiency in the Korean natural farming system Cho Han Kyu. Animals were kept at three smallholder farms in the provinces Chiangmai and Lumphun. Pigs were raised from 12 to 60 kg weight. The protein supplements were coarse soya bean meal (Crude Protein = CP of 12.97 %), kitchen scraps (CP = 18.06 %) or fermented feed with dried leucaena leaves (CP = 10.18 %). No significant differences were found between the groups of pigs for the traits growth rate, feed consumption and feed conversion ratio (FCR).

In addition, a total of 30 crossbred animals (starting at 12 kg weight) were kept in three groups of 10 animals each. The aim was to assess possible differences in the production efficiency with respect to the farming system (natural versus commercial farming) and the type of feed:

- a) Group 1 (natural housing and fermented feed according to Han Kyu Cho's formulation; CP = 12.97 %);
- b) Group 2 (natural housing and commercial feed without antibiotics; CP = 10.51 %);
- c) Group 3 (commercial housing and commercial feed; CP of 22.96 % to 14.80 %).

The pigs were slaughtered at about 100 kg weights. There were no significant differences in the growth rate between the three groups. The highest average back fat thickness (2.8 inches) was recorded for group 2. The lowest carcass length (68 cm) was documented for animals belonging to group 1.

Blood and faeces samples were taken at four natural farms and at one commercial farm. No parasites or protozoa were detected. The complete blood count (CBC) was physiological for all investigated samples. Therefore, the composition of the litter was also investigated on the natural farms. Samples were taken before and after raising the pigs. The percentage of nitrogen and organic matter increased, but the percentage of phosphorus decreased during the raising on the four natural farms. However, the litter samples met the quality of good compost.

**Keywords:** Natural farming, Thailand, pigs

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## Efficiency of Indigenous Fungi for Controlling Pathogenic Bacteria in a Swine Natural Farming System

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Indigenous microorganisms such as fungi are often used in natural farming systems to reduce the rate of both air and water pollution. Different kinds of fungi are therefore added to the bedding to support the production of organic fertilizer. Fungi synthesize enzymes, lactic acid and antibiotics that might inhibit the growth of pathogenic bacteria. Indigenous fungi were collected under bamboos at several places located in five provinces in Northern Thailand (Chiang Mai, Lamphun, Lampang, Chiangrai and Phrae) to investigate the genus or species of the microorganisms. A total of 13 fungi were purified and identified by slide culture. These results indicated that the majority of fungi belonged to *Geomyces* sp. and *Rhizopus* sp. The origin of the further fungi remained unknown. Antibacterial performance studies using *Salmonella* spp., *E. coli* and *Staphylococcus aureus* revealed that three of the 13 fungi affect bacterial growth (23.1%). The fungi collected at Lamphun (Maung isolate) and at Chiangmai (Mae-Sarp and Khun-Sarp isolate) hold the power to inhibit bacterial growth at 61.5%, 38.5% and 38.5% of all bacteria tested, respectively. Co-culture experiments revealed that all fungi strains were capable to inhibit *Salmonella typhimurium* at bacterial concentrations of less than 10<sup>6</sup> CFU/ml. Growth rates of *Salmonella* spp. taken from pig faeces were inhibited at a concentration of 10 CFU/ml ( $p < 0.01$ ). The results clearly demonstrate the inhibition of bacterial growth by the fungi at a low bacterial concentration. A high efficiency to degrade cellulose has been found in isolates collected in Phrae (Rong-Kwang isolate), Chiangrai (Mae-Fah-Luang isolate), Chiangmai (Saraphi isolate), Lampang (Maung isolate), and Lamphun (Ban-Hong isolate) ( $p > 0.05$ ). The fungus extracted from the Ban-Hong isolate showed the highest cellulase activity ( $0.344 \times 10^{-5}$  U/ml). The lowest activity was found in the Viang-Pa-Pao isolate (Chiangrai) ( $0.065 \times 10^{-5}$  U/ml). The Mae-Rim (Chiangmai), the Rong-Kwang (Phrae) and the Saraphi isolate (Chiangmai) ( $0.326 \times 10^{-5}$  U/ml,  $0.319 \times 10^{-5}$  U/ml and  $0.279 \times 10^{-5}$  U/ml) demonstrated moderate activities ( $p < 0.05$ ). In addition to the gained basic knowledge about indigenous fungi, we will start to characterize these species on the molecular level. The final goal will be to assess their potentials to be used in the swine natural farming system.

**Keywords:** Indigenous fungi, Natural farming, Pathogenic bacteria, swine

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## ***In vitro* Ensilability of Jack Bean (*Canavalia ensiformis*) and Cowpea (*Vigna unguiculata*) Grains Sole or Mixed with Sorghum (*Sorghum bicolor*) Grains: An Alternative for Low Input Pig Feeding Systems**

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Local food sources are an alternative to conventional feedstuffs for pig feeding in the tropics. Jack bean (*Canavalia ensiformis*), cowpea (*Vigna unguiculata*) and sorghum (*Sorghum bicolor*) grains are suitable, and ensilage of those grains is seen as an option for conservation.

Ripe grains were chemically analysed and ensilability was tested by the Rostock Fermentation Test (RFT). Cowpea showed a low content of water soluble carbohydrates (WSC) of 2.3 % DM, whereas in jack bean no WSC were found. Starch contents were similar (38.7 resp. 35.9 % DM). With a buffer capacity (BC) of 8.9 g lactic acid (LA)/100 g DM compared to 6.3 g LA/100 g DM in cowpea an inferior ensilability of jack bean was expected. Sorghum showed the lowest BC (3.1 g LA/100 g DM) and the highest starch content (73.9 % DM). RFT was performed in triplicate per treatment: control, molasses (4 % of fresh matter), *Lactobacillus plantarum* (LAB,  $3 \times 10^5$ , cfu g<sup>-1</sup> fresh matter), molasses+LAB. Also sorghum was mixed with legume grains. Hereby advantage should be taken of reducing BC and using the possibility to combine ensilage of two grains, forming a complete ration without the necessity to dry sorghum before feeding. Grains were milled (4 mm mesh size) and 50 g were mixed with 200 ml of distilled water and additives (30°C incubation temperature). At 0, 14, 18, 22, 26, and 38 h pH was measured and filtrates were analysed after 38 h.

In jack bean the application of LAB led to a fast pH decrease (at 14 h), but no significant differences were observed among all variants at 38 h. LAB variants of cowpea showed a significant pH decline  $\leq 4.0$  at 38 h. Cowpea+LAB and cowpea+LAB+molasses showed the highest LA production and the lowest levels of acetic and butyric acid as well as ammonia. Only in jack bean+LAB+molasses the LA production was similar to cowpea. According to RFT, LAB inoculation is necessary to achieve sufficient acidification. Furthermore, addition of molasses as a source of WSC is needed to expect a good ensilability of jack bean. Mixed silage is an option to be used.

**Keywords:** *Canavalia ensiformis*, cowpea, *in vitro* ensilability, jack bean, pig feeding, *Sorghum bicolor*, *Vigna unguiculata*

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## Nutritional Evaluation of Cowpea Seedhulls Using Different White Rot Fungi

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An experiment was conducted to determine the nutrient composition of cowpea seedhulls subjected to three different white rot fungi (*Aspergillus niger*, *Rhizopus stolonifer* and *Trichoderma viride*) at different fermentation periods for possibility of inclusion in poultry diets. 30 grams of the seedhulls were inoculated with 107 spores of *A. niger*, *R. stolonifer* and *T. viride* separately at 30°C for periods of 0, 7 and 14 days. The substrates were analysed for proximate and mineral compositions before and after fermentation at the end of each period. Fermentation with the inoculum of *A. niger* caused an increase from 14.11 % to 29.68 % in crude protein (CP) content of the seedhulls after 14 days compared to an increase from 14.11 % to 21.45 % and 14.11 % to 28.10 % with the spores of *T. viride* and *R. stolonifer*, respectively over the same time period. The crude fibre content decreased from 30.0 % to 18.0 % in day 14 when the hull was fermented with *A. niger*, while 26.00 % and 20.00 % crude fiber were determined for *R. stolonifer* and *T. viride* respectively. Calculated metabolisable energy values increased in the different treatments as follows: 13.51 %, 12.54 % and 12.27 % for *A. niger*, *T. viride* and *R. stolonifer*.

Fermentation with inoculum of *A. niger* resulted in 22.15 %, 23.45 % and 26.15 % reduction in Acid Detergent Fibre (ADF), Neutral Detergent Fibre (NDF) and Acid Detergent Lignin (ADL) contents, respectively, in day 14, compared to 18.86 %, 22.22 % and 38.46 % with inoculum of *R. stolonifer*. The results also showed significant ( $p < 0.05$ ) reductions in the cellulose and hemicellulose contents of the hull. These results indicate that cowpea seedhulls could be used for possible inclusion in poultry diets. However, the level of cowpea seedhulls in poultry diets needs to be determined in future studies .

**Keywords:** Cowpea seedhull, fermentation, fungi biodegradation, inoculum

## **An Economic Analysis of the Market Channels and Factors Influencing Indigenous Chicken Marketing in Kenya**

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This study looked at the economics of indigenous chicken (IC) marketing in Kenya. It specifically identified and investigated the existing marketing channels, the level of profitability as well as the constraints and opportunities facing the indigenous chicken marketing. The study was carried out in three regions of the country: Western, South Rift and North Rift regions of Kenya, with two districts selected from each region. Data were collected by individual interviews using structured questionnaires. A total of 469 respondents participated. The target population consisted of traders in different markets in the selected divisions within the three regions. Data analysis was done using statistical tests in which descriptive statistics were used. The results of Ordinary Least Squares (OLS) regression analysis on the factors influencing the profits indicates that costs of marketing and the numbers of birds and eggs and their selling prices, are some of the factors that are significant in assessing the profits to traders. The study also found out that more men than women participated in marketing of indigenous chicken and eggs in the existing markets both in rural and urban areas. Apparently, consumer demand for indigenous chickens and eggs was not adequately met by traders. The IC business was also found to be profitable but was mostly constrained by high transaction costs. In this respect policies and actions need to focus on reducing transaction costs by improving market information and as well on increasing production of IC and egg output. This would assist in increasing productivity of IC farmers and as a result profitability of IC marketing.

**Keywords:** Constraints, indigenous chicken, Kenya, marketing, profits

## Local Fodder Resources in the Feeding Management of Smallholder Pig Producers in Northern Viet Nam

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Due to unfavourable agricultural production conditions and land scarcity in the uplands area of northern Viet Nam, livestock husbandry in general and pig husbandry in particular appear as an important opportunity to sustain livelihoods for smallholder farmers. Widely varying management practices of small-scale pig producers are leading to different levels of pig performances. With the increasing utilisation of improved local as well as exotic breeds accompanied by new husbandry management practices, smallholders increasingly rely on external inputs. Due to the uncertainty of future resource availability, the use of local fodder resources and management practices adapted to the specific small-scale farm production conditions are necessary to optimise resource utilisation.

The seasonal availability of fodder resources and their utilisation were evaluated applying a seasonal calendar. Data were collected by group discussions in nine villages belonging to three production systems differing in production intensity, remoteness and ethnicity.

A high number of different feedstuffs are used in pig feeding in all systems. The most important fodder components are maize, cassava, banana stem and sweet potato leaves. Throughout the whole year smallholders of all systems supply also concentrate feed to the pigs and little seasonal variation was observed. The utilisation of local fodder resources shows a higher variation caused by system and season.

While maize and cassava compete for use as human food, animal feed, and for marketing, banana stem and sweet potato leaves are agricultural by-products with no or low opportunity costs. However, fodder ranking reveals a high importance of maize and cassava in all systems.

It was concluded that the feeding management of pigs in different systems applied by small-scale farmers in the uplands shows a high variety. In particular farmers of the resource driven system are highly dependent on local fodder resources due to financial constraints to purchase supplement fodder. However, there seems to be scope to improve the pig feeding management of smallholders by optimising the utilisation of farm produced crops and alternative local fodder resources.

**Keywords:** Local fodder resources, pig, smallholder farming, Viet Nam

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## Genetic Identity of Native Pig Breeds in Northern Thailand Evidenced by Microsatellite Markers

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At present, most of the northern Thai native pigs are still traditionally raised by hill tribes or smallholders due to customs, religion and for use in ritual sacrifice. Moreover, starting 20 to 30 years ago, many native pigs have been increasingly mated with European commercial breeds (*e.g.* Duroc; DR, Large White; LW, Pietrain; PT) as well as with the Chinese Meishan to improve their performance for economically important traits. Thus, Thai pigs are nowadays on the risk to lose their genetic identity, especially as only a limited number of studies have been conducted to investigate their genetic composition. In this study we performed a survey of the molecular identity of Thai pigs as well as their genetic relationship within and between pig populations in northern Thailand. A total of 162 animals representing two native breeds (Thai indigenous pigs; TIP and wild boars; TWB) and five commercial breeds or their intercrosses (DR, LW, PT, Duroc×Meishan; DRM and Pietrain×Native; PTN) were investigated for 18 FAO recommended microsatellite markers. The mean number of alleles per locus, the mean effective number of alleles per locus, the mean observed and expected heterozygosity per locus as well as the mean polymorphic information content of the overall population were 12.56, 5.93, 0.69, 0.82, and 0.79. The respective values were higher in native pigs (12.05, 6.31, 0.69, 0.82, and 0.80) compared to commercial pigs (8.11, 4.20, 0.68, 0.73, and 0.69). Our study indicates a high genetic diversity in Thai native pig breeds. Based on the phylogenetic tree obtained from Nei's genetic distances, most native pig populations have been distinctly different from commercial pigs (59.18%), but some of them are similar (40.82%). Our results provide valuable information for the preservation and utilisation as well as the further genetic improvement of Thai pigs.

**Keywords:** Genetic identity, microsatellites, native pigs, northern Thailand

## Nutritional Evaluation of Cassava by-Products and Shrimp Waste Meal in Diets for Growing Pigs

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Sixteen Large White crossbred male pigs of 30–35 kg body weight were used to evaluate the digestibility of cassava by-products and shrimp waste meal as cheap alternatives to the increasingly extensive commercial feeding stuffs. Employing an incomplete-block-design at the Teaching and Research Farm, University of Agriculture, Abeokuta, Nigeria, two pigs per diet, housed individually in metabolic crates, were fed each one of the following eight experimental diets: Basal diet (BD), BD+cassava leaf meal with or without enzyme (CLM±E), BD+unfermented cassava peel with or without enzyme (UCP±E), BD+fermented cassava peel (FCP) and BD+shrimp waste meal with or without enzyme supplementation (SWM±E). The BD consisted of 79 % maize, 18 % soybean meal and 3 % vitamin-mineral premix. 300 g dry matted (DM) of each of the test ingredients SWM, CLM, FCP and UCP were added to 1000 g DM of BD; the enzyme Rovabio(R) was added to the diets at 100 mg kg<sup>-1</sup> DM. The feed was offered in wet mash form (water: feed=2:1) in two equal meals at 08:00h and 16:00h. Water was supplied ad libitum. Each of the three trial periods consisted of 14 days adaptation followed by 7 days of faeces and urine collection. Faeces and urine were collected twice daily and frozen. Dry matter (DMD) and energy digestibility (ED) for UCP±E and BD were higher ( $p < 0.05$ ) than for CLM±E, FCP and SWM-E, among which there were no significant differences. Acid detergent fiber digestibility followed the trends of DMD and ED. However, neutral detergent fiber and crude fiber digestibility of UCP±E and BD were not different ( $p > 0.05$ ) from those of SWM±E and CLM±E, but higher ( $p < 0.05$ ) than those of FCP. Nitrogen retention (NR) for UCP-E and UCP+E (71.3 %, 71.6 %) was similar to that of BD (73.6 %). NR was higher for SWM-E and SWM+E (79.8 %, 82.1 %), CLM-E and CLM+E (79.2 %, 77.4 %), and lowest for FCP (69.2 %). Period of trial and enzyme supplementation did not significantly affect the results. It can be concluded that SWM, CLM and particularly UCP can be utilised effectively to reduce pig feeding costs.

**Keywords:** Fibrous diet, Nigeria, nitrogen retention, nutrient digestibility, pigs

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## Reproductive and Growth Performance of the Indigenous Small Ear Pig from Southwestern China

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Xishuangbanna, a prefecture located in the southernmost part of China, formerly was a remote and self-subsistent area between Laos, Viet Nam and Burma. Presently it benefits from one of the world's largest infrastructural programs. In conjunction with economic benefits for a majority of the region's inhabitants, this development also implies massive destruction of the formerly highly diverse natural resources. The rising demand for livestock products in the prefecture's capital Jing Hong is met by import of pig meat from remote towns, while Xishuangbanna's local upland pig farmers do hardly participate in this new market. Their resource-driven smallholder production systems are characterised by poor management and poor access to improved fodder and veterinary services. They raise the so-called Small Ear Pig (SMEP), which is one of 9 registered native pig breeds of southern China. The breed is regarded as a local speciality food and renowned for its good taste, easy handling and disease resistance. No data about growth and reproductive performance of this breed is available in global farm animal genetic resource databases yet. Therefore, progeny history records for 219 littering sows were collected during January - April 2009, and the growth performance of 150 pigs is monitored from April 2009 to March 2010. By using the species-independent herd model PRY, reproduction parameters and growth performance records obtained under the current management system are evaluated, and their response to improved breeding and feeding management will be tested through scenario design and assessment. Preliminary results show that under the current conditions, female SMEP reach 60 kg live weight after more than one year of growth, are early maturing (4 months), have long intervals between subsequent litters (> 12 months) and yield an average litter size of 5.6 ( $\pm 2.13$ , n=423 litters). The relatively high variation of the so-far analysed data supports the assumption that strategies for improvement of SMEP reproductive performance can be identified in order to support local efforts to improve the livelihoods of Xishuangbanna's upland farmers.

**Keywords:** Bio-economic modelling, litter size, littering interval, pigs, progeny history records

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## Yield and Nutritive Value of Maize-amaranth Mixtures for West African Dwarf Sheep

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Inadequate supply of quality forage during the dry season is a major cause of low productivity among ruminants in Nigeria. Conserved maize and amaranth fodders have great potentials to bridge the gap in forage supply during this period.

In an agronomic study, the effects of intercropping and fertiliser application on yield and quality of maize and amaranth fodders, and land use efficiency were evaluated in two growing seasons. Nutritive value of conserved maize, amaranth or maize-amaranth fodders for ruminants were estimated in a digestibility and animal growth study using male West African dwarf (WAD) sheep. Fertiliser application improved the dry matter yield of sole crops and intercrop mixtures. In the two seasons, maize crop showed a higher response to fertiliser application than amaranth or maize-amaranth mixtures. With fertiliser application, dry matter yield varied significantly ( $p < 0.05$ ) between sole crops and intercropped mixtures. Fodder yield varied from 7.1 to 12.6 t ha<sup>-1</sup> during the first season and 6.9 to 11.3 t ha<sup>-1</sup> in the second season. Crude protein content of whole plant fodder varied from 9.9 to 22.7%. Fodder yield reduced with increasing proportion of amaranth in the mixture while protein content of total forage increased. Dry matter digestibility of sun-dried maize (SDM), sun-dried maize-amaranth (SDMA), sun-dried amaranth (SDA), ensiled maize (EM), ensiled maize-amaranth (EMA) and ensiled amaranth (EA) was 71.8, 60.7, 57.3, 73.7, 55.3 and 52.6% respectively. Daily weight gain of WAD sheep fed SDM, SDMA, SDA, EM, EMA and EA was 82.6, 71.3, 65.3, 83.8, 52.2 and 44.1 g day<sup>-1</sup> respectively.

Although intercropping improved fodder yield and land use efficiency compared to sole amaranth, it had no yield advantage over sole maize. Protein content of total forage increased when maize was intercropped with amaranth but this did not translate to improved digestibility or improved performance of sheep fed the mixed fodders. The superior yield and nutritive value of fodder maize in this study suggests that sole maize is a better option than maize-amaranth mixtures as dry season fodder for ruminants in southwest Nigeria.

**Keywords:** Amaranth, dry season, fodder, maize, sheep

## Development and Productivity Indicators of Goat Herds on Al Jabal al Akhdar, Northern Oman

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Goat husbandry is the main livestock activity in Oman's Al Jabal al Akhdar Mountains, supplying food and income to farm households. The low nutritional quality of the natural vegetation appears to limit the animals' production in the traditional systems, but outputs might differ according to herd management.

This study therefore determined key indicators for the productivity of goat herds in the traditional mountain oases systems. Progeny history interviews on n=206 female goats were conducted in the villages Masayrat ar Ruwajah (1070 m a.s.l.), Qasha' (1700 m) and Ash Sharayjah (1980 m) in the central Al Jabal al Akhdar mountain range in winter 2007/08. Baseline data on farm structure and activities were used to classify goat keepers into two groups, namely (I) farmers regularly marketing goats and (II) farmers keeping goats for subsistence purposes. To calculate reproductive parameters, model the goat herd development and calculate the total output per animal per year, the bio-economic herd model PRY was applied.

Herd sizes were larger for group I than for group II farmers, averaging 41.8 (SD 14.6, n=5) and 22.9 (SD 10.17, n=11) animals. Both types of farmers offered dried fish and dates to their animals, with quantities per goat and month of 0.8 (SD 0.3) and 5.7 (SD 1.5) kg dry matter (DM) in group I and 0.7 (SD 0.5) and 7.9 (SD 3.95) kg DM in group II. In group I and II, respectively, age at first parturition was 20.3 (SD 7.3) and 23.9 (SD 7.1) months, the parturition interval averaged 12.0 (SD 7.0) and 15.1 (SD 6.0) months and litter size was 1.05 (SD 0.3) and 1.1 (SD 0.5) kids per kidding. Kid mortality was 2.1 % in group I and 7.5 % in group II. The potential annual herd expansion rate at a maximum female cull age of 84 months was determined at 25 % and 21 %, the annual monetary output per animal averaged 91€ and 77€ in group I and II.

Goat management of group I farmers who sold animals was more professional and resulted in a better reproductive performance and higher productivity of goat herds compared to farmers keeping goats for subsistence purposes.

**Keywords:** Arabian Peninsula, bio-economic modelling, reproductive performance, goats, mountain agriculture

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## Improving Milk Yield with *Canavalia brasiliensis*

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When cattle has to rely on maize stover and weeds for feeding in the dry season as is often the case in Central America, the milk production drops significantly. To improve the nutrient offer the intercropping with forage legumes is seen as a viable option. Here, an on-station experiment in Colombia with both *Canavalia brasiliensis* and *Vigna unguiculata* as supplement is described in the following.

Three plots of maize, 1 ha each, were established in April 2008 in Santander de Quilichao, Cauca, for the treatments: 1) control (maize only), 2) maize - *Canavalia*, 3) maize - *Vigna*. The maize-legume plots were subdivided by three each. *Canavalia* was sown between the maize rows on 13 May, 27 May and 10 June, whereas *Vigna* seeding started on 19 May, followed on 2 June and 16 June, both at a seeding rate of 20 kg ha<sup>-1</sup>. The grazing trial started at the end of August with three groups of 2 cows (Holstein × Zebu) each, having 153 days of lactation on average, in a 3 × 3 latin square design with 5 days of adaptation and 5 days of measurement per period. At the beginning of the trial *Canavalia* was 13 weeks old, whereas *Vigna* was 12 weeks old. Milk quantity and quality was measured and feed protein content analysed.

The maize had a crude protein content of around 4.4 % in dry matter, *Canavalia* 16 % and *Vigna* 14 %. The fat corrected milk yield cows was significantly higher with *Vigna* (8.2 kg d<sup>-1</sup>) and *Canavalia* (7.5 kg d<sup>-1</sup>) supplement than with maize stover alone (6.1 kg d<sup>-1</sup>). No significant difference was found in the milk fat (4.1–4.6 %) nor in the other contents (7.7–8.3 % non-fat solids, 16.7–18.5 mg dl<sup>-1</sup> milk urea nitrogen).

The inclusion of *Canavalia brasiliensis* in the grazing diet can increase the milk yield per cow by 1 kg d<sup>-1</sup> in the dry season compared to the offer of maize stover alone which is usually practised in Central America.

**Keywords:** *Canavalia brasiliensis*, Central America, maize stover, milk production, *Vigna unguiculata*

## Effect of Pasture vs Concentrate Feeding on Carcass and Meat Characteristics of Finishing Swamp Buffalo (*Bubalus bubalis*)

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Swamp buffalo were an important source of draught power for small scale farms in Thailand until their major replacement through machines. However, the consumption of buffalo meat increased over the past years because of its high protein and low fat content. The aim of this study was to measure the impact of feed on carcass and meat quality of Thai swamp buffalo. Therefore twenty-four swamp buffaloes, aged one year old were used in this experiment. The animals were randomly divided into four equal groups, one group of buffalo was grazed on a pasture of pure Guinea grass (T1) whereas the second group was grazed on Guinea grass mixed with the legume *Stylosanthes guianensis* (T2). The other two groups, were raised in pens and fed with concentrate (based on dry matter) either 1.5 % (T3) or 2.0 % (T4) of their body weights, respectively. All buffaloes were slaughtered at an age of three years (average live weight of  $385 \pm 15$  kg). Longissimus dorsi muscles were used for meat quality determination. Body weight development was not significantly different between the groups. Hot and chilled carcass, dressing percentage and carcass length of animals of group 3 was significantly ( $p < 0.01$ ) higher than in the other groups. Meat descending from animals fed 1.5 % concentrate (T3) was redder ( $p < 0.01$ ) in colour (higher  $a^*$ ) than meat from animals fed on pasture. Water holding capacity (WHC) in terms of drip and thawing losses were significantly different. However, the cooking and grilling losses were not significantly different between the groups. In conclusion, concentrate influenced carcass composition and favour meat quality.

**Keywords:** Carcass, meat quality, pasture, swamp buffalo, guinea grass, *Stylosanthes guianensis*

## Within the Bounds of Economic and Ecological Possibilities – Prospects for Pastoralism in Azerbaijan

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Pastoralism is one of the major land uses in Middle and Central Asian transformation countries. After the dissolution of collective or state farms pastoralists now have to act under market conditions to generate income. The institutional framework has changed nearly totally, but the carrying capacity of pastures remains the same. How did pastoralism develop under market conditions and what can its future look like? This study addresses overgrazing in grasslands of Azerbaijan from an economic point of view.

Azerbaijan has a traditional transhumant sheep farming sector, which is recently growing in terms of livestock numbers. But national statistics show, that agriculture regarding the share of GDP, generated incomes and employment is strongly underdeveloped, compared to other, rapidly growing sectors of economy. Therefore, rural development is needed for poverty reduction and economic growth in rural areas. However, excessive growth of livestock numbers leads to problems of overgrazing and erosion, which are already reported for mountainous regions in Azerbaijan.

In this study, we address the following questions:

1. Which forms of farm organisation emerged after the dissolution of collective farms in transhumant sheep farming? How is their present economic performance?
2. Which paths of development are feasible in the future?
3. How can an ecologically sound and welfare enhancing development of sheep farming be facilitated?

Data collection took place in two transhumant regions in Azerbaijan. Interviews were conducted with farm managers and representatives of administration, covering current farm organisation, costs and revenues as well as the institutional framework for transhumance. Economic performance was assessed in cost revenue calculations.

Analysis revealed comparably large-scaled management units of approx. 600 ewes with high levels of market integration. Farms are organised as family farms or cooperatives, with an increasing share of absentee owners. Addressing research question 3, scenarios were developed, aiming at enhancing the ecological condition of pastures, while maintaining or even increasing income levels of the affected farms. Scenarios comprise alterations in management as well as in institutional framework.

**Keywords:** Azerbaijan, livestock economy, overstocking, pastoralism, scenario analysis

## Edaphic and Topographic Factors Explaining *Canavalia brasiliensis* Production in the Nicaraguan Hillsides

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In smallholder farming systems of the Nicaraguan hillsides, intensification of land use resulted in soil nutrient depletion and a decrease in agricultural productivity. Nitrogen (N) is considered as the most limiting nutrient in the traditional maize-bean-livestock system. Furthermore, farmers lack forage of good quality for their livestock especially in the dry season. We are testing the hypothesis that the underutilised and drought tolerant cover legume *Canavalia brasiliensis* (canavalia) can be introduced into the traditional mixed system to overcome productivity decline. To test the performance (dry matter production, symbiotic N<sub>2</sub> fixation) of canavalia on farm, we implemented field trials on six farms located at different altitudes across the landscape. Three fields were located in the bottom of the valley, two at a medium level and one on the top of a hill. On each field, twelve 100 m<sup>2</sup> plots were established. Chemical and physical soil properties were assessed at 0–10 cm depth, and topographic characteristics were defined for each plot. Soil profiles were described for groups of plots with common properties, including canavalia root mapping. Farmer's individual management per site (tillage and fertilisation) completed the data set. During two consecutive years, canavalia was cut four months after planting. The above ground biomass production varied between 0 and 5700 kg dry matter/ha. Canavalia fixed between 8 and 70 kg N/ha, with on average 62% of N derived from the atmosphere. Unconstrained multi-dimensional scaling was used to structure the data set and determine gradients of soil properties between the plots. Multivariate multiple regression was applied to detect significant topographic and edaphic factors explaining above ground biomass production of canavalia, as well as the effects of soil properties on N uptake and N fixation by the legume. Final results will be available by October 2009.

**Keywords:** *Canavalia brasiliensis*, edaphic factors, multivariate analysis, Nicaraguan hillsides, on-farm trial, topography

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## Changes in Forage Biomass and Cattle Live Weight under Three Different Cattle Stocking Densities in Subtropical Mountain Wooded Pastures in Tarija, Bolivia

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In the subtropical mountain forests in south-eastern Bolivia, cattle are of economical importance for local people. The production system is based on a high annual utilisation of the grasslands and forests close to the villages in the Salinas valley at high stocking densities during the rainy season. In this study forage yield and utilisation and changes in animal live weight were assessed in 2006 and 2007 under three stocking densities (0.8, 1.3, 2.2 animal units ha<sup>-1</sup> (AU=300 kg live weight) using paddocks of 3 ha each (about 25 % of grassland, 75 % forest). Biomass yield was measured before and after the grazing period (85 days, March-May) and cattle live weight was measured weekly. By source of forage, the herbaceous plants from the grassland accounted for 72.3 %, herbaceous plants from the forests to 15.1 % and the woody plants to 12.5 % of total forage production. As expected, the difference between forage biomass (grassland, herbaceous and woody vegetation) measured before and after grazing was generally largest ( $p < 0.05$ ) with high stocking density. In this group, even the grassland biomass initially available in the second year was lower as a carry-over effect, but not in the other groups. During the first 3 weeks of the grazing period in 2006 and 2007, live weight increased in all groups, but especially ( $p < 0.05$ ) at low compared to high stocking density. Until the end of the experiment live weight gains decreased or live weight was even lost approaching the end, being more severe in 2007 than 2006. The live weight loss was lowest at low stocking density during the last 3 weeks (+3.5 kg head in 2006, -8 kg head in 2007), and more critical in the other stocking densities suggesting feed scarcity and quality. The low performance in terms of live weight gain can be attributed to the generally low quality of forage in the grassland at the end of the rainy season even though at low stocking density forage was found to be available in sufficient amounts. The general trend of a lower forage yield in 2007 may also have resulted from less favourable climatic conditions compared to 2006.

**Keywords:** Pastures, Bolivia, Criollo cattle, transhumance

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## Spatial and Temporal Changes in Biomass Production of Rangelands on Al Jabal al Akhdar, Northern Oman

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The semi-arid rangelands of Al Jabal al Akhdar mountains in the northern Hajar range of Oman are valuable wildlife and plant habitats and serve as extensive grazing grounds for livestock. However, the productivity of these rangelands is spatially and temporally highly variable, and the increasing grazing pressure as well as climatic changes threatens the vegetation resource. Numerous reports indicate a decrease in the vegetation cover and biomass production of rangelands during the last decades. But the extent of these degradation related changes as well as the spatial distribution of biomass production has not yet been quantified.

To quantify the productivity of the different plant communities on the central Jabal al Akhdar region (60 km<sup>2</sup>), a combination of destructive and non-destructive biomass measurements was conducted based on a systematic sampling design. Life-form specific allometric equations were used for grasses, herbs, subshrubs and weeds (unpalatable species) and combined with existing biomass data of phanerophytes. Additionally, remotely sensed vegetation indices (VI) were calculated from actual satellite images and their suitability for the cover and biomass estimation was evaluated. Following a geostatistical interpolation method, the spatial distribution of Annual Net Primary Production (ANPP) was modelled based on the biomass samples. Ordinary kriging and co-kriging with the VI values as covariates were used processed with the geostatistical extension of ArcMap 9.1. The predicted biomass map was tested by cross-validation. To determine the temporal changes in vegetation cover and biomass production from past to present, the VI was calculated for a series of Landsat satellite images from 1990 to 2009. Selected for this analysis were images captured at the peak vegetation growth as derived from corresponding rainfall data. The results of the time series in vegetation cover were related to climate data and additional socio-economic statistic.

Generally, the rangelands are characterised by a relatively low density of ground vegetation with a high fraction of bare soil patches. The ANPP differed significantly between the life forms and the different plant communities. A remarkable decrease in vegetation cover was detected during the last 20 years as a result of climate change combined with increasing livestock numbers.

**Keywords:** Annual net primary production, Climate change, Co-kriging, Degradation, Ordinary kriging, Vegetation indices

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## Impact of Expanding Rubber Cultivation and Increasing Mechanisation on the Buffalo Population in the Nabanhe National Nature Reserve, Yunnan Province, P.R. China

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Due to expansion of rubber (*Hevea brasiliensis*) and increasing mechanisation of agriculture, the buffalo population is decreasing in the Nabanhe - Nationalm - Nature - Reserve (NNNR), Yunnan Province, Xishuangbanna Prefecture, China. This study analyses the current use of buffalo for field work and recent developments in the region's buffalo population, based on interviews of 60 buffalo keeping farmers.

Farms of the NNNR were assigned to 3 classes (C) which differed mainly in two characteristics: altitude and area used for rubber cultivation. C1, C2 and C3 are found at an altitude of 400–1200, 801–1200 and 1201–1600 m asl and have on average 58 %, 14 % and 5 % of their crop land under rubber cultivation.

At present, farmers of C1, C2 and C3 keep on average 1.6, 2.2 and 2.4 buffaloes and crop 2.2, 2.8 and 2.5 ha of land. In C1 75 %, in C2 100 % and in C3 97 % of the farmers stated to use their buffaloes for field work, but only 28 %, 45 % and 57 % of the farmers' crop land is ploughed by buffaloes. The area ploughed by buffaloes remained constant over the last 10 years, although the area of crop land managed per farmer increased. In 1999, the cultivated area of C1, C2 and C3 farms was only 1.2, 2.0 and 1.5 ha, of which 54 %, 75 % and 78 % were ploughed by buffaloes. The decreasing importance of buffaloes is also reflected by the decrease in the number of animals kept: 38 % of C3 farmers kept less buffaloes in spring 2009 than in 2007, for C1 and C2 farmers the respective numbers were 33 % and 25 %. Nevertheless, 14 % (C3 and C2) and 17 % (C1) of the farmers kept more buffaloes in spring 2009 than in 2007.

C2 and C3 farmers plant less rubber and dependent more on crop production and buffaloes' work force than C1 farmers, who mainly cultivate rubber and are highly mechanised already. Although buffaloes are still of importance to C2 and C3 farmers, a further substitution of buffaloes by tractors is anticipated and therewith the loss of an additional meat source for the rural population and of local farm animal genetic resources.

**Keywords:** Swamp buffalo, land use, mechanisation, Xishuangbanna, rubber

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## Shall the Animals Graze? - Analysing the Efficiency of Traditional Goat Husbandry in the Al Jabal Al Akhdar Mountains of Oman

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Pastoral goat husbandry supplies meat and income to farm households in villages of Al Jabal al Akhdar, Oman. The pasture vegetation significantly contributes to goats' feed intake, but its low nutritive value appears to limit the animals' growth and production.

To quantify goats' daily weight gain, animals of twelve farmers were weighed every five weeks during November 2006 — October 2007 and progeny history interviews were conducted on does ( $n=114$ ) of 14 households to determine age at first parturition (AFP, months), kidding interval (KI, months) and litter size (LS,  $n$ /parturition). Data was analysed using the herd model PRY to estimate annual output (€/animal) and feed use efficiency (€/kg dry matter intake) of goats under traditional management (TR). To evaluate the potential of an improved supplement feeding of goats or the introduction of a zero-grazing system, output and feed use efficiency were also simulated, assuming AFP, KI and LS to be 18 months, 10 months and 1.2 kids for a semi-intensive (SI) and 14 months, 8 months and 1.3 kids for a zero-grazing (ZG) management. Metabolizable energy concentrations in the SI and ZG diets were set to 10 MJ and 11 MJ  $\text{kg}^{-1}$  organic matter.

While AFP ( $22\pm 9.7$ ), KI ( $12\pm 4.3$ ) and LS ( $1.0\pm 0.26$ ) and post-weaning weight gain of TR bucks ( $73\pm 34.6\text{g d}^{-1}$ ) and does ( $48\pm 25.7\text{g d}^{-1}$ ) resulted in a low annual output (38€) and feed use efficiency (0.05€), both increased for SI goats (54€, 0.08€) and ZG goats (61€, 0.14€). However, considering feed intake of goats on pasture to be 50 % (SI), 60 % (TR) and 0 % (ZG) of their daily feed intake, feed use efficiency was higher in SI goats (0.16€) than in TR (0.11€) and ZG (0.14€) goats.

The pasture vegetation is an important source of fodder in Oman's pastoral livestock systems, increasing the benefits derived from the traditional goat husbandry and rendering livestock keepers more independent from the purchase of expensive, often imported feed stuffs. Nevertheless, improved homestead feeding of goats in addition to grazing can increase reproduction performance, feed use efficiency and overall herd productivity.

**Keywords:** Feed use efficiency, grazing, growth rates, reproductive performance, small ruminants

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## Characterisation of Livestock Production Systems in the Naban He National Nature Reserve, Yunnan Province, China

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China developed from a huge, but economically less important country to an important global player within the last years. The southwestern part of the country, formerly being a remote, self-subsistent area between Laos, Viet Nam and Burma, and one of the world's major biodiversity hotspots, is presently subjected to a huge infrastructural program. Nevertheless, in rural areas of Xishuangbanna, a mountainous prefecture at the Lao border, farmers still run their traditional crop livestock systems. Focusing on livestock, this study aims at characterising the production systems in the regional Naban He nature reserve, in order to identify priority farmer groups for livestock intensification trials. Data were obtained by applying PRA tools, key informant interviews and a structured quantitative survey addressing the demographic characteristics of 204 farms, farm assets and farming practices. Data was collected from 12/2007 to 05/2008 and was subjected to cluster analysis using SPSS 17 software. Only interval scaled variables were considered in the analysis, tested for auto-correlation and transformed to binary values. The squared Euclidean distance served as distance measure and Ward's method was used as merging algorithm. Three distinct farm classes were identified, located at altitudes of 1686 m, 1032 m and 694 m above sea level. Production assets are more diverse on highland (H) and midland (M) farms than on lowland (L) farms. Tea plantations (in mu, H: 16.1 ±44.5; M: 12.7 ±27.7; L: 0.8 ±2.1), paddy fields (in mu, H: 27.6 ±26.7; M: 11.6 ±7.9; L: 6.7 ±8.3) and pigs (H: 5.0 ±3.5; M: 4.75 ±3.5; L: 2.5 ±1.9) are more important in classes H and M, while rubber-tree cultivation (*Hevea brasiliensis* (Willd.)) dominates on lowland farms. Class L has better access to extension services and a more intense pig management, although pigs are kept for self consumption only. On farms H and M the local pig breed is extensively reared in order to be sold but farmers lack appropriate access to markets and extension services. Especially class M farmers would like to intensify their pig production but identify lack of labour as a major constraint.

**Keywords:** Cluster analysis, highland systems, pigs, rubber

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## How Does Grazing Intensity Affect Different Vegetation Types in South African Semi-arid Rangelands? Implications for Conservation Management

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The Knersvlakte in the Succulent Karoo Biome (South Africa), which is known for its high diversity and endemism, has been subjected to domestic livestock grazing for centuries. In the course of establishing a conservation area there, it became relevant to assess the suitability of alternative future landuse practices. Thus, we investigated the effects of grazing on the vegetation of the Knersvlakte in terms of species diversity and composition as well as plant size and reproduction of selected species. Data were sampled on four adjacent farms, one of which was ungrazed, one moderately and two intensively grazed. Plant community and population data were collected on 27 quartz and 24 non-quartz plots, representing the two major habitat types of the region. Within each of the 1000 m<sup>2</sup> plots, 100 subplots of 400 cm<sup>2</sup> size were sampled. ANOVAs revealed that the species richness and abundance of endemic species on quartz fields was only slightly reduced through grazing. An association of plant strategy type and grazing intensity could not be detected. Ordination and fidelity analyses indicated that species composition differed between grazing intensities and that the ungrazed and moderately grazed plots both contained unique locally endemic habitat specialists. Reproduction of the endemic dwarf shrubs *Drosanthemum schoenlandianum* and *Argyroderma fissum* (both *Aizoaceae*) was increased through moderate grazing, which in the case of *D. schoenlandianum* was ascribed to overcompensation for experienced biomass losses. From the nature conservation point of view, either the ungrazed or the moderately grazed plots showed the most favourable status in most of the parameters. In the Knersvlakte, both ungrazed areas and moderately grazed areas therefore seem to be important for the conservation of the existing plant diversity, vegetation pattern and their underlying processes.

**Keywords:** Biodiversity, compositional shift, herbivores, quartz fields, South Africa

# Forest management and perennial crops

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# Forest management

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## **Forests, Land Use Change and Climate Change**

WULF KILLMANN

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The situation of the world's natural and planted forests is touched upon. Land use change, resulting deforestation and its causes are described. The role of forests in climate change mitigation is explained, and the challenge discussed to at the same time reducing deforestation and coping with demographic changes and climate change impacts on agricultural productivity.

**Keywords:** Climate change, deforestation, land use change

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## **Vigorous Tree Growth in a Flooded Environment: Diversity and Flood Adaptations of Amazonian Floodplain Forests**

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In Amazonian floodplain forests, more than one thousand tree species are adapted to the prolonged periodical flooding and grow vigorously. The main growing period is the terrestrial low-water phase. In the aquatic phase, water columns reach heights which can exceed 10 metres. The trees are subjected to periods of flooding with freshwater which last up to nine months every year and which occur very regularly and predictably. Flooding causes drastic changes in gas exchange, in the bioavailability of nutrients, concentrations of phytotoxins, and anoxic conditions prevail in the rhizosphere. Trees do not only persist in a dormant state, but grow vigorously during most of the year. These extreme conditions are tolerated because of a large variety of adaptations to flooding, starting at the seed stage with hydrochory and ichthyochory as main means of dispersal, followed by fast germination and high tolerance to complete submergence in seedlings, and ending in a not yet completely apprehended number of adaptations in adult trees, at phenological, physiological, morphological and anatomical levels. Morphological adaptations of the root system comprise hypertrophy of lenticels, formation of adventitious roots, plank-buttressing and stilt rooting, development of aerenchyma, and the deposition of cell wall biopolymers such as suberin and lignin in the root peripheral cell layers. Water loss and gas exchange in the flooding period are effectively reduced by alterations in vegetative phenology and water storage. Since also these forests, as most wetland ecosystems, are threatened by human overpopulation and overexploitation, the challenge to understand and thus maintain this ecosystem increases every decade.

**Keywords:** Adaptations, increments, submergence, tree growth, waterlogging



## Promoting Utilisation of two Light Broad-leaved Lesser-used Timber Species

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Myanmar has been practising a selective logging system since 1856, which has creamed forests for years, resulting in dwindling growing stock of commercial timbers. With scarcity of such valuable species and ever increasing timber demand, teak has been intensively planted throughout Myanmar to meet local requirements. Teak plantation has, however, deleteriously affected site quality and productivity, which impedes sustainable development of teak.

On the other hand, there still exist many lesser-used timber species in extensive forests of Myanmar. Augmenting demand for lesser-used species will lead to sustainable forest management. Two timber species *Bombax ceiba* and *Bombax insigne* characterised by their abundance and rapid growth occur throughout Myanmar and are economically and ecologically important for their flosses and conspicuous flowers. *Bombax ceiba* is superior to teak in its flourishing growth in dry areas and will become one of the most important species in rehabilitating central dry zones of Myanmar. However, their timbers are presently under-utilised.

To promote their utilisation, physical and mechanical properties of these timbers at green and 12 % moisture content (MC) were investigated as basic requirements to marketing feasibility. Both species shrink on average by 2 % in radial and 5 % in tangential direction from green to oven-dry condition. *Bombax ceiba* swells by 2.3 % (radial) and 5.7 % (tangential), and *Bombax insigne* by 3.6 % (radial) and 7.0 % (tangential) from oven-dry to water-saturated condition. Their MCs are very high as measured after soaking in water. With modulus of rupture (MOR) of 28 N mm<sup>-2</sup>, modulus of elasticity (MOE) of 4018 N mm<sup>-2</sup>, maximum crushing strength (MCS) of 15 N mm<sup>-2</sup> at 12 % MC and basic specific gravity of 0.23, *Bombax ceiba* is best suited to production of wood composites. *Bombax insigne* is also a light timber with basic specific gravity of 0.33. Its MOR is 60 N mm<sup>-2</sup>, MOE 6880 N mm<sup>-2</sup> and MCS 28 N mm<sup>-2</sup> at 12 % moisture content. It is strong enough to use in window and door frames, siding and furniture. Both timbers are nondurable, but their service life can be extended through environmentally friendly modification processes like impregnation with melamine resins, which also results in longer carbon storage as well.

**Keywords:** Basic specific gravity, mechanical properties, moisture content, shrinkage, swelling

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## Adaptation of Tropical and Subtropical Pine Plantation Forestry to Climate Change: Climate Proofing Seed Material of *Pinus patula* and *Pinus tecunumanii*

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*Pinus patula* and *Pinus tecunumanii*, two pines native from Mexico and Central America are important plantation species for the forestry sector in the (sub)tropics. In the last decades members of the International Tree Conservation & Domestication Program (CAMCORE), North Carolina State University, have established large multi site provenance trials for these pine species. The data provide valuable information about species and provenance choice for plantation establishment in many regions with different climates. However, since climate is changing rapidly, it might become increasingly difficult to choose the right species and provenance to plant. The aim of the study is to test the suitability of seed material under changing climate of two *P. patula* varieties, *P. patula* var. *patula* and *P. patula* var. *longipedunculata*, and two *P. tecunumanii* ecotypes (highland and lowland). For each variety and ecotype, a site growth model was developed that statistically relates growth with environmental factors and couples the predictions to the average 2020 climate prediction of four general circulation models. Three developed models were significant and robust. Provenances of *P. tecunumanii* from lowland areas in Central America are expected to be most productive in 2020 because of their promising performance under rather hot and wet climates. Intraspecific diversity did matter in the case of *P. tecunumanii* growth. Provenances from the low area populations grew faster than those from high altitudes, and especially outperformed *P. tecunumanii* high altitude provenances and *P. patula* provenances when the climate becomes warmer and wetter. The results also show that in some regions the most suitable planting material today is not necessarily the most suitable in 2020, around the time of harvesting.

**Keywords:** Climate change impact predictions, height growth, management decision support tools, provenance trials, site growth modelling

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## Latitudinal Gradient in Woody Species in Western Burkina Faso

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Understanding plant species distribution patterns and the underlying factors is a crucial step for the conservation and management of plant communities in the savannah-woodland ecosystem. Anthropogenic disturbances (agriculture, livestock, fire, wood cutting) and environment heterogeneity (climate, soil) have a positive or negative effect on woodland dynamic, species richness and diversity. The latitudinal gradient of diversity is ultimately dependent on the historical, geographic, biotic, abiotic and stochastic forces affecting the geometry, internal structure, and location of species ranges in ecological or evolutionary time. Latitudinal is not ecologically meaningful, but correlates with variation in ecologically meaningful variables such as climate, area and soil. The primary explanatory variables for latitudinal gradient are likely to vary continuously from the low latitude to the high one mirroring the special variation in species richness.

We describe the species composition, structure and diversity of woody species at four sites along a latitudinal gradient: North Sahelian sector, South Sahelian sector, North Sudanian and South Sudanian sector in western Burkina Faso. We did a survey to identify the woody species on 82 sample plots of 50 × 20 m. Density, dominance, frequency, species and family importance values were computed to characterise the species composition. Some diversity indexes were calculated to examine the heterogeneity of each site and the similarity between sites. Precisely, we calculated, Shannon's diversity index ( $H'$ ), Simpson's diversity index ( $D$ ), Simpson's Evenness ( $E$ ), Jaccard's similarity index and Horns' modification of Morisita's index.

A total of 74 species were found. A low similarity in tree species composition between sites was found, which indicates high beta diversity and reflects differences in habitat conditions, topography and between sites distances. The site-specific difference accentuates the importance of landscape-scale approaches to understand species distributional pattern, composition, structure and diversity as well as to undertake restoration and conservation measures which promote total basal area and diversity in these ecosystems.

**Keywords:** Biodiversity, conservation, environmental relation, fragmented landscape, Sahelian zone, species richness, Sudanian zone

## Socio-economic Determinants of Forest Conservation in Botswana

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In Botswana, due to the pervasiveness of the arid and semi-arid conditions over the country, the conservation of forest and protected areas is crucial to the maintenance of ecosystem services, support income generating activities and livelihoods of the nation. Consequent on these conservation practices are the socio-economic characteristics of dwellers around the forest reserves in the country. This study examined the socio-economic determinant of forest conservation in Kasane forest reserve, Chobe district. A simple random sampling technique was used to select 237 households and a structured questionnaire with a reliability coefficient of 0.85 was used to elicit information on socio-economic characteristics of people living around the forest reserve and data were collected on their socio-economic characteristics and involvement in conservation practices. The data collected were described using frequency counts and percentages and a probit regression analysis. The results show that showed more females 61.2% living around the forest, 78.1% were aged between 20 and 49 with 44.3% of the respondents having secondary education. About 67 percent of the respondents were involved in conservation practices by setting aside the forest for tree and animal protection. The paper concludes with suggestion for the right combination of policies, public awareness and appropriate conservation approaches in order to sustain KFR preservation. Significant variables include education ( $t = 6.37$ ), occupation ( $t = -4.26$ ), years of residency ( $t = 5.87$ ), place of origin ( $t = 2.42$ ), and income ( $t = 2.68$ ). There is therefore need for public awareness and appropriate conservation approaches among the dwellers around the forest.

**Keywords:** Botswana, forest conservation, forest reserves

## A Study about the Use of Forest in the Bufferzone of Limpopo National Park, Mozambique

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In the course of a GTZ internship in Mozambique in 2008 a field study has been made. The internship occurred within the GTZ Advisory Service on “Sustainable Forest Management and Conservation”, which cooperates with the Limpopo National Park in Gaza district in south-western Mozambique.

The study examines the use of forest in the bufferzone of Limpopo National Park, specifically in the village Mkumbe. It focuses on the use of forest trees and shrubs and shows the diverse and extensive ways in which the inhabitants of Mkumbe use the forest. Sixty-five tree and shrub species have been identified as well as three grass species, two liana species, two palm species and two succulent species. Twelve amongst the sixty-five trees and shrub species are very important species, as are one grass and one agave species. Men and women were asked to evaluate the importance of the respective trees hierarchically. The results showed no significant differences between the sexes. But differences appeared when it came to the question of how men and women used the trees. Women use non-wood forest products, mainly fruits. They further use branches as fire wood for cooking. Men use trees primarily as a building material and to fabricate items of practical use. Nearly all parts of trees have a purpose. People use the roots, bark, fibres, rosin, fruits, leaves and wood of the trees. They use them as medicine, fire wood, food, building material and a base for drinks as well as to sell for profit and for rituals and ceremonies. This study illustrates the life-saving function of the forest for the inhabitants of Mkumbe and how it contributes to their livelihood.

The qualitative study contains four group interviews and twenty-six individual interviews. They were realised during a period of seventeen days of permanent presence in the selected community within the bufferzone of the Park. A bachelor thesis resulted from the field trip.

**Keywords:** Gender, Limpopo National Park, livelihood, Mozambique, non-wood forest products, use of forest

## Small Scale Reforestation of Five Native Timber Species in a Nutrient Rich Várzea of Central Amazon

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Our study aims to enhance the experience in reforesting endangered timber species in white water floodplains (várzea) of Central Amazon. Between 1 November and 6 December 2008 mixed plantations of *Cedrela odorata*, *Piranhea trifoliata*, *Schizolobium amazonicum*, *Calcophyllum spruceanum* and *Ocotea cymbarum* were established in the Mamirauá Sustainable Development Reserve. Two to six months old saplings were planted in 18 forest gaps of high and low várzea (less or more than 3 m inundation height during the high water period, respectively) and in ten agricultural stands of the high várzea being abandoned between one and 15 years. The longer the areas were abandoned, the closer their canopy. In each agricultural stand, four 324 m<sup>2</sup> plots with different methods of weed control with a machete (“weeding”; “mowing”; “mowing of strips”; no weed control) were established. In the forest gaps, weed was mowed. Weed control was performed always when the weed was higher than 50 cm. Sapling growth, sapling health and working demand for weed control were intensively monitored.

From December 2008 to March 2009 mean height increase was high for *C. spruceanum* (133,6% of the initial height), *S. amazonicum* (129,4%) and *C. odorata* (81,9%), lower for *O. cymbarum* (23,7%) and negligible for *P. trifoliata* (10,2%). Canopy openness positively influenced growth of *C. spruceanum* ( $R^2=0,56$ ) and *S. amazonicum* ( $R^2=0,28$ ) but not growth of *C. odorata*.

Weed height reached 50 cm within one to four months in the agricultural stands. Forest gap weeds reached the same height only after a minimum of 2 months. Mean working demand for weed control in the agricultural stands was higher for the treatments “weeding” and “mowing” (58 and 46 min per plot, respectively) than for “strip mowing” (22 min). So far, the treatments had no clear influence on sapling development, but “strip mowing” seemed to hamper the attack of *C. odorata* with the shoot borer *Hypsipyla* sp. that occurred in three agricultural stands.

In conclusion, the fast growing species *C. odorata*, *S. amazonicum*, and *C. spruceanum* are appropriate for reforestation in the várzea, but high efforts for weed control are necessary for their establishment.

**Keywords:** *Calcophyllum spruceanum*, *Cedrela odorata*, *Ocotea cymbarum*, *Piranhea trifoliata*, *Schizolobium amazonicum*, weed control

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## Timber Regeneration in Treefall Gaps of Certified, Conventionally Managed, and National Park Forests in Northern Honduras

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In the Río Cangrejal water-shed, northern Honduras, 4419 ha of humid lowland forests have been certified since 1993 through the SmartWood Programme, accredited by the FSC. This forest certification programme promotes sustainable management of forests and certification is given if management fulfils certain social, economic, and ecological criteria. The ecological criteria for certified forestry include limiting harvest intensity and minimising mechanical damage of logging. Based on these requirements, we hypothesised that in comparison to conventionally managed forests, the logging gaps of certified forests host more established saplings of timber trees, due to a higher abundance of seed trees left in the forest, and provide more favourable environments for the establishment and growth of timber seedlings, due to the control of negative logging impacts. We tested these hypotheses, using regeneration data of ten shade-tolerant neotropical timber species (n=46 treefall gaps). We analysed twelve ecological gap characteristics as determinants of sapling abundance, using a statistical approach that emphasises their sensitivity to the forest management system as well as their ecological role. We found that gaps in certified forests were characterised by lower levels of logging-related disturbance than gaps in conventionally managed forests. However, differences were relatively small, since loggings are done at low intensity and without heavy machinery in the area, in conventionally managed forests as well. Despite the more favourable gap environment, regeneration success was poorer in certified forests than in conventionally logged forests. As expected, highest regeneration was found in natural forests. The good regeneration success in conventionally logged forests was largely due to the high abundance of *Mortoniendendron vestitum*. To explain the remaining differences in regeneration between management types, we suggest that loggings in certified forests have been more intensive in the past, leading to a scarcity of timber seed trees. We further propose two alternative explanations related to treefall gap frequency: low logging intensity after certification may have led to low frequency of treefall gaps, limiting the recruitment of timber species; or intensive loggings currently maintain an environment with too much disturbance for the success of timber regeneration.

**Keywords:** Forest certification, FSC, logging, natural regeneration, reduced-impact logging, shade-tolerant timber

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## New Consumer Markets, Culture and Polycentric Adjustment Processes in Kavango Forest Management

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Political, cultural, technological and economic transformations change forest users' incentives for natural resource utilisation, which can cause ecological degradation. Increasing pressure on the resources often leads to multiplying externalities if the institutional framework is not adapted to transformations. We assess how changes in socio-economic conditions and in particular new consumption opportunities and habits in combination with institutional weaknesses increase incentives for resource exploitation. We analyse attempts and capacities of different providers of institutional services such as the government, traditional authorities, development agencies and resource users to adapt institutions in order to avoid externalities.

This field of tension is studied in an interdisciplinary case study on forest management from the Kavango region of Northeast Namibia. In Kavango ecologically and economically important tree resources of the dry-forest savannah are under threat. Critical tree numbers are processed at an unsustainable rate mainly for commercial purposes. We observe that the process is strongly pushed by a rapidly growing cash based consumer market that incites a so far largely subsistent rural population to enter the cash economy by commodifying timber resources. This massive motion is flanked by: a) insufficient information about the ecological values of the resources, and b) a growing demand of a re-emerging timber industry operating with a post-colonial habitus. As a result price-structures do not reflect ecological costs. Attempts of institutional adaptation such as political and economic integration of traditional resource management regimes into emerging political structures largely failed. Reasons are uncertainty and scepticism in the relationships of different actors, a confusing definition of resource rights in this area of communal land-tenure, insufficient monitoring and enforcement, and the fact that existing cultural enforcement options are not fully leveraged.

Synthesizing our results we see the need for a polycentric resource governance approach which redefines the relationships among authorities and agents with overlapping jurisdictions to provide efficient incentives to consider multiscale present and future costs and benefits in resource users' decisions. In particular the integration of existing cultural management mechanisms is of crucial importance.

**Keywords:** Forest management, market integration, natural resource management, polycentrism, sustainable consumption

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## Predicting Tree Mortality Patterns Using NDVI of Aster Imagery in the Dry Afromontane Forests, Northern Ethiopia

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Spaceborne remote sensing has given a cost effective and useful data which have been widely used to examine the spatiotemporal dynamics and understand various ecological processes in forest ecosystems. The forest ecosystems of northern Ethiopia were highly affected by natural and human factors. High mortality of trees, which may be caused climatic factors, was observed along the western Escarpment of the Rift Valley in the northern Ethiopia. In this research we examined the applicability of Normalized Difference Vegetation Index (NDVI) of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data in predicting the spatial patterns of over-story tree mortality. We used *Olea europaea* L. subsp. *cuspidata* tree species, which is a widely grown tree species in the study area as indicator species in assessing tree mortality patterns along the landscape. Field data on live and dead trees were collected using 18 plots (50 × 50 m) and dead to live tree ratio of every plot was compared with their respective NDVI values derived from the optical bands of the ASTER imagery, which is taken in the dry season of 2006. Our result indicates that NDVI is a good estimator ( $R^2 = 0.58$ ) tree mortality patterns along the landscape. The result suggests that ASTER imagery has the potential to predict tree mortality patterns, which is useful information in managing the degraded dry Afromontane forests in the northern Ethiopia. Since our result is based on NDVI only, further studies that may improve the estimation of tree mortality in the study area are discussed.

**Keywords:** ASTER, Dessa'a forest, NDVI, northern Ethiopia, tree mortality

## Habitat and Regeneration Analysis of two Indigenous Tree Species to Combat Deforestation on Leyte Island, Philippines

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The Philippines are a contrasting hotspot of biodiversity and deforestation. On Leyte Island, rainforestation farming is propagated as an agroforestry system integrating local indigenous tree species. Seeds and saplings are collected from forests and are directly bed out at trial farms. In general, primary rainforests are not only essential for seedling collection, but also serve as important reserve for the faunal seed regeneration vectors. Inadequate ecological knowledge of habitat and regeneration patterns of many tree species constrains their application and thus conservation in rainforestation farming systems. For an integration of species in rainforestation farming, planting schemes need to consider ecological requirements of species.

Two endemic tree species, *Cinnnanomum mercadoi* (Cm) and *Dillenia megalantha* (Dm) were selected for field monitoring within natural and disturbed forests on Leyte Island. Fourteen mother tree locations were investigated per species to derive recommendations how to propagate and transplant the species. Regeneration patterns were analysed in four transects of 25m length and 5m width inakles of 90 for each mother tree.

Cm mother trees were found scattered as individuals in contrast to Dm which grew in clustered stands. Dm was found in altitudes above 500 m asl., with river creek locations in lower altitudes as exception. Cm was found in elevations of 100-800 m asl. A hypothesized topographic habitat indicator of Cm was only found in primary forests while Dm grew scattered at higher elevation ranges.

During the monitoring period from March to July 2003, flowering of Cm coincided with a local seasonal dry period whereas Dm continuously flowered on solitary branches. Cm seed dispersal is endozoochorous, mainly by larger birds, i.e. Hornbills (*Bucerotidae*). Cm seedlings were not found close to the mother tree, but in high densities around perching trees. In contrast, Dm seedlings occurred in high numbers in the investigated transects around the mother tree. The seed dispersal vector of Dm can be small mammals, fruit bats, water and gravitational move. Overall, Cm is a late successional and climax tree species, whereas Dm show pioneer characteristics, requiring forest canopy gaps to grow into maturity.

**Keywords:** Habitat requirements, native trees, reforestation

## Model for Estimation of *Acacia senegal* Volume from NDVI

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This study has been conducted to produce a model for the estimation of the stand volume of *Acacia senegal* using the Normalized Difference Vegetation Index (NDVI) and a field inventory. The study has been carried out during 2007-2008 in the southern Kordofan state in Sudan where this species has a great economic and environmental importance ranging from gum Arabic production to soil reclamation.

The study used NDVI values produced from the Terra ASTER satellite imagery data and normal forest inventory data. A stratified random sampling design has been used for the collection of the field data to estimate the *Acacia* stand volume (tree height and diameter), in order to calculate the volume for each sample plot. The satellite data were used to produce NDVI maps and to calculate the pixel value for each sample plot. Finally the calculated stand volume has been correlated with the NDVI values using SPSS. An algorithmic model has been produced to estimate the stand volume of *A. senegal* from the NDVI value:  $\text{Volume} = a_0 + a_1 \cdot \ln(\text{NDVI})$  with  $a_0 = .420$ ;  $a_1 = .750$ ;  $\ln$  = the natural logarithm; NDVI = Mean NDVI for sample plot of 0.36 ha.

The model will help to quickly estimate the standing volume for *A. senegal* which could assist the forecast for gum Arabic production and the estimation of tree damage by insects, fire or other factors. This study also showed the possibility to use remotely-sensed data of medium resolution together with field inventory for providing data for forest management. This study could be an initiative for replication and production of models for other (tree) species.

**Keywords:** *Acacia senegal*, modelling, NDVI

## **Assessment of Woody Species Diversity in Elain Reserved Forest, North Kordofan State- Sudan**

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The present paper was carried out in El Ain Reserved Forest and its surrounding buffer zones in North Kordofan State (Sudan) during 2008–2009. It was intended to investigate the woody species diversity in terms of richness, evenness and association in the area using relative abundance, similarity, dissimilarity and stocking density. Moreover, the study aspired to identify the prevailing species from taxonomic point of view, focusing on description and modern classification. The study merged ecological, taxonomical and socioeconomic dimensions to cover the stated objectives. Based on soil types and topography, five ecological zones were classified namely Gardud with no water catchments, Gardud with water catchments, Basement Complex, Mayaa, and Khor & Wadis. The study showed that Khor and Wadis zone is more diverse, rich in climbers and shrubs than the other zones. Association and similarity of woody species were common in all sites except in Mayaa that is dominated by one species (*Acacia nilotica*). The study identified 50 woody species belonging to 37 genera, 3 subfamilies and 20 families. The identified species are 35 trees, 13 shrubs and 2 woody climbers. Mimosoideae scored the highest frequency for genera and species. Five woody species were reported for the first time in the area. Other five species were found to be endangered. Four exotic species were recognised as well. The study reached to some recommendations which might help conserving diversity of woody species, improving forest potential and encouraging scientific research on ecosystem in the area. Accordingly, this may act as nucleus for an early warning system for detection of climate change depending on diversity of vegetation composition in the area.

**Keywords:** Climate change, diversity, evenness, richness, taxonomical dimensions, woody species

# Non-timber forest products and agroforestry

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## **Evaluation of Soil Fertility in Monoculture and Successional Agroforestry Land Use Systems for Citrus Sinensis, in Alto Beni, Bolivia**

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Agroforestry systems as a type of sustainable agriculture are important due to their productive potential and ecosystem services. To maintain soil fertility, preservation of soil organic matter, physical properties and nutrient levels are necessary. The study site is situated in a tropical submountainous rainforest at 600 m asl in the Alto Beni, Bolivia. For the past 50 years the region was converted into monoculture and agroforestry land use systems based on cocoa, citrus and banana which produce the main income for smallholder farmers.

The field experiment was done as a sampling study during the transition period from dry to rainy season 08/2008–01/2009. Seven citrus based systems cultivated for at least 20 years (three agroforestry, two monoculture, one abandoned monoculture, one monoculture in conversion to agroforestry) were selected as treatments and two representative plots of 20 m × 20 m were chosen within each treatment as replicates. For each treatment a soil characterisation was done by soil profile method. To evaluate the nutrient status (C, N, P, K) of the citrus plants four young leaves from three trees per plot were sampled at first flush and three months later. To evaluate the nutrient status of the soil each plot was overlaid by a grid of 5 m × 5 m to determine sampling points for augering from 0–10 cm, 10–30 cm, 30–60 cm depth (nine per plot, then bulked by depth for further analysis). The samples were analysed for bulk density (core), water content (gravimetric), pH, C, N, P-Bray1, K, CEC, electrical conductivity, soil texture. Four littertraps (1 m<sup>2</sup>) per plot were installed to monitor the nutrient recycling by litter. Litter was collected fortnightly from 09/2008–12/2008. Physical and chemical analysis of samples will be completed July 2009.

For both dates the nutrient status of the citrus plants showed no significant differences for C and N. The soils under agroforestry had deeper Ah-horizons and higher humus content but soil texture was not different. The additional contribution of litter from shade trees in the agroforestry systems provided more biomass than in the monoculture for soil organic matter maintenance.

**Keywords:** Leaf nutrient status, litter input, multi-storey cropping, shade trees, sweet orange

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## Forest payments schemes as real options to mitigate climate change

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Emissions reductions through forests can be provided through measures of afforestation and reforestation (A/R) or by Reducing emissions from Deforestation and Forest Degradation (REDD) that would otherwise occur. These measures could provide emissions reduction at lower cost than energy-related projects. However, comparing to energy-related emissions reductions strategies, carbon removals resulting from forest activities are particularly subject to risks of being reversed, *i.e.* face the risk of non permanence.

There are several types of risk that jeopardize permanence: natural/ecological, climate-change related, failure of project partners and political risks. We focus on demand side risks. Demand side risk is the risk that an increase in commodity prices in the world market raises landowners opportunity costs of keeping land under forest above to the payment level settled in the contract. In this case, it would be profitable for landowners to convert land to agriculture and permanence would not be warranted. Understanding how these risks affect landowners decisions can provide valuable insights for the design of payments schemes and how to ensure permanence.

The application of the real options approach to landowners land use decisions provides valuable insights for the design of payments for afforestation and for Reducing Emissions from Deforestation and Forest Degradation (REDD). According to the real options theory, in the presence of sunk costs and uncertain returns, landowners might value the option of delaying land conversion. This affects considerably policy recommendations for the design of payments schemes. Our results show that: (i) REDD is potentially more cost-effective and afforestation programs more expensive than estimated in the current literature and (ii) contrary to current proposals to address the risk of non-permanence, indexing conservation payments to agricultural prices would induce further deforestation

**Keywords:** Climate change, payments for environmental services, uncertainty; land use

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## The Benefit of Fair trade Coffee to Karen Coffee Farmers Living in National Parks in Northern Thailand

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Arabica coffee was introduced in northern Thailand as an alternative to opium production and has been planted as an alternative income source in natural forests and parks for the last two decades. Thai coffee is exported through different marketing channels, one of them is the fair trade channel. Research articles about the profitability of fair trade coffee and its contribution to the economic status of communities have concluded that fair trade certification has the potential to increase household incomes and benefit the communities. However, only very few studies evaluate shade-grown coffee as an alternative income source in national parks and none identified the impact of fair trade certified coffee in Thailand.

This study explores how fair trade certification contributes to the welfare of coffee farming households, focusing on the Karen hill-tribe people in two national parks in northern Thailand. Additionally, the perception of farmers towards fair trade certification and the determinants for participation are analyzed. Both, quantitative and qualitative methods were applied to triangulate information. The concept of sustainable livelihoods was used. In total, 90 farmers were interviewed with a standardised questionnaire and 9 qualitative interviews were conducted.

Results show that coffee usually is not the main income source for the Karen farmers in the national parks. The royal development projects offer alternative income possibilities. Although the price for fair trade certified coffee is not significantly different from the local conventional coffee prices, still farmers are satisfied with the fair trade certification because the market size of fair trade coffees gives farmers confidence that they can sell a large percentage of their coffee consistently at a fair price every year. It was also observed that fair trade is adopted by farmers with higher social capital. The farmer who's the head of a village is more likely to be contacted by the organisation than other farmers. That may relate to the fact that the fair trade certification was not obtained by a farmer founded cooperative but by a development project which created farmer groups. Concluding, the coffee production and the fair trade certification is part of an income diversification and risk management strategy of farmers in national parks.

**Keywords:** Arabica coffee, fair trade, Karen hill-tribe, national park, northern Thailand, sustainable livelihoods

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## Tea-Walnut Intercropping in Xishuangbanna, China: A Coevolutionary Analysis

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In recent years, the farmers in the higher altitudes of Xishuangbanna prefecture of Yunnan province, China, have seen their lowland neighbours enjoying rapid economic growth, and are trying to follow suit. Environmental features, socio-cultural characteristics and land use innovations are components of sustainable rural development, the evolution of which is strongly interlinked and mutually influenced. The aim of this research was to analyse this coevolutionary process and to examine whether there are alternative directions to which this process can lead. Richard NORGAARD's theory of coevolution provides amongst other ecological and economic theories the frame of approach. A chronological examination of (closely defined) society and (less easily described) surrounding ecosystems are being assessed, analysing the coevolutionary impacts on each other under changing circumstances. Those are namely the production system of tea (*Camellia sinensis*) and its changes over time, particularly the introduction of the innovation "intercropping".

A case study using a triangulation of narrative and semi-structured expert interviews, observations, content analysis of secondary literature etc. was made in the village of XiaoNouYouShangZhai, where Tea-Walnut intercropping was established five years ago.

The research disclosed three main findings:

- Altitude plays perhaps the most significant environmental parameter affecting farmers' decision of whether to switch to more marketing (labour extensive, cash) oriented cultures such as rubber;
- Development of agro-ecosystem is not related to the complexity of Han Chinese and ethnic Chinese minorities society, in which elaborated social structures existed prior to existence of market oriented agriculture production;
- Village, agro-ecosystems and community forests did not lose as much ecological complexity as in the case of lowland rubber plantations "Green Desert".

The people are open for alternative livelihoods and have the socio-cultural capacity to adapt to, and adopt new ideas, such as intercropping Camphor tree with Tea. New intercropping or forms of agro-tourism are some of the feasible options. This paper concludes with plausible ways of sustainable land use development. One such example is forest conservation through active farmer participation in nature reserve management, successful schemes in other national nature reserves in China.

**Keywords:** China, matrix of coevolution, nature conservation, stakeholders' analysis, tea-walnut intercropping, Yunnan

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## The Dynamics of Cacao Agroforestry 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 which are very important with regard to issues of biodiversity and conservation. Rural communities inhabit the forest margins certainly play a significant role in maintaining the stability of the rainforest. For more than two decades, land use in this region has continued to change substantially, driven by both the expansion and the intensity of cacao cultivation. Although cacao is an important factor in improving the economy of rural communities, such cultivation practices are not, over-time, beneficial for the environment. In this study reasons underlying unfavourable cacao cultivation practices were analysed to establish viable policy options which will better harmonise the goals of economic growth and environmental sustainability.

This paper presents the dynamics of cacao agroforestry over the past 26 years with respect to one particular forest using panel and recalled data from 2001 and 2007. This study is a part of a collaborative interdisciplinary research project, STORMA, (Stability of Rainforest Margins) funded by the DFG (Deutschen Forschungsgemeinschaft). The data were obtained from surveys of 80 villages on the periphery of national park by applying a random sampling method. Descriptive and econometric analyses were used to analyse the socioeconomic and spatial data. The GIS data are presented to explain physical changes in land use. Based on these empirical facts, cacao cultivation area in the last 26 years has expanded from 685 to 20,590 ha. The cultivation pattern has become more intensive; many shade trees have been cut down, contributing to the degradation of the rainforest. There is, nevertheless, still a future for cacao agroforestry in this region. To maintain the sustainability of the environment and thus to ensure rural welfare, it is imperative that the suggested policy options and institutional innovations be implemented.

**Keywords:** Cacao, land use change, Lore Lindu National park, spatial analysis

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## Quality Deterioration and the Role of Rehabilitation of Cacao Production Chain in Nigeria

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The goal of obtaining good income for cacao cultivation is intrinsically connected to the sustainability of this sector. This on the other hand cannot be realised without a well laid out plan to attain quality in all the various management aspects in the long cacao production chain. Over 90 % of Nigeria's cacao is produced in the cocoa-belt of the southwestern Region which is located in the Derived Savannah Agroecological zone of Nigeria.

Many of the existing cacao trees were planted under cleared or thinned primary forest that was then in abundant supply. Reserves of suitable soils no longer exist and so future cacao plantings are likely to be on soils that have already been exploited, hence, a downward trend is noticed in cocoa production. There is therefore need to search reasons and make recommendation for improved cacao quality management.

In this study, we investigate bio-physical, climatic and management factors of selected cacao farms in southwestern Nigeria and estimate their effect on the overall quality in the cacao production chain. We analysed 16 soil samples for basic cations, NPC and pH. Information on factors affecting cacao quality was elicited by interviewing farmers from 60 households on their farm using standardised questionnaires.

We discovered certain nine primary activities in the production chain that contribute to overall quality of production as seed choice, nursery, transplanting, young plantation, field production, harvesting, primary processing, storage - bagging, and marketing. Primary processing, harvesting and seed choice are the first three activities with the highest percentage of contribution to cacao quality. Restoration of cacao yield to its peak level is possible by systematic replacement of inferior trees.

We recommend a viable, well-informed and well-equipped extension services that will enhance the practice of good husbandry, especially among the smallholder cacao farmers.

**Keywords:** Cocoa production, extension service, production chain analysis, quality management, Nigeria

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## Effect of Tree Density and Tapping Techniques on the Productivity of Gum Talha from *Acacia seyal* in South Kordofan, Sudan

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This study was carried out in Umfakarin natural forest reserve, South Kordofan, Sudan. The objective of the study was to investigate the influence of tree density and tapping tools on productivity of gum talha from *Acacia seyal* Del. var. *seyal* and also to examine the probability of *Acacia seyal* to produce gum talha when tapped. Data for the study were collected during September 2007 to February 2008. A total of 167 individual trees of *Acacia seyal* grown in pure natural stands, in dense, medium and slight strata, were selected based on diameter at breast height (DBH ranged from 6.7 to 36.9 cm). In order to investigate the influence of tapping on gum yield, trees were exposed to tapping on 1<sup>st</sup> of November using local tools (saunkey and makmak) in addition to untapped trees used as control. Nine treatments *i.e.* a combination of 3 strata  $\times$  3 tools were executed. Comparison of means, correlations and a logistic regression model were applied.

The results of the study indicate that individual trees of *Acacia seyal* in different strata vary in gum yield. The overall mean gum yield was 13.68 g tree<sup>-1</sup> season<sup>-1</sup>. Average yield per tree and season was 7.1, 11.0 and 22.8 g in medium, dense and slight stratum, respectively. Non-producing trees comprise almost more than 50 % of the total sample. 73 % of the selected trees produced less than 10 g gum season<sup>-1</sup>. Although tapping trees using makmak in slight stratum produced highest gum yield (25.78 g tree<sup>-1</sup> season<sup>-1</sup>) the results of this study show no significant differences between the treatments in gum yield. The outcomes of the logistic regression model showed that 59.3 % of the predictions were correctly classified. However, when other variables were incorporated, 64.7 % of the predictions were correct. The results of this study may be of great importance for future studies in order to improve the predictions of gum talha yield and to manage *Acacia seyal* as multipurpose tree.

**Keywords:** *Acacia seyal*, gum talha, logistic model, Umfakarin natural forest reserve

## Does Plantation Teak Produce Comparable Quality as Naturally Grown Teak?

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Due to its durability and dimensional stability, teak has been one of the most sought-after hardwoods in the international market. As its demand outstrips natural supplies, it is planted in most parts of the world, even outside its natural range.

Myanmar, the home of teak, has established teak plantations extensively since 1980s, which were managed under a rotation of 60–80 years. Since 1998, special teak plantations have been established with a harvesting rotation of 40 years. At the end of 2006, teak plantation amounted to 373,407 ha (44.5 % of plantation areas). Mean annual increment of plantation teak decreases with ages while soil deterioration accelerates, but short rotation produces more juvenile wood than long rotation. In Myanmar, no research has been done on technological properties of plantation teak. To promote systematic utilisation, mechanical properties of plantation teak of ages 15, 20, 25 and 30 years were investigated at green and air-dry conditions. Ten trees were collected from each age class and intra-stem variations were also analyzed.

Tested properties increased significantly with distances from pith towards bark and increased with height in heartwood. Properties also vary significantly with ages, but the oldest plantation teak did not have the highest properties. Lewe teak of age 25 was found best, followed by Oktwin teak of age 20, Thandwe teak of age 30 and Yetashe teak of age 15. Lewe, Oktwin and Yetashe are where teak thrives best naturally in Myanmar. Thus, it can be said there exists the effect of locality on wood properties of plantation teak, and investigation of properties of plantation teak at different ages within each locality is recommended to fix harvesting rotations. All plantation teaks were lower than naturally grown teak by 11–24 % and 12–26 % in modulus of elasticity and maximum crushing strength, respectively, which brings them down to lower strength classes. Modulus of rupture of plantation teak can be compared to that of naturally grown teak. Fiber stresses in side and axial compression are significantly higher in plantation teak than naturally grown teak by 11–44 %. These variations should be taken into consideration in the utilisation of plantation teak.

**Keywords:** Mechanical properties, plantation, rotation, teak

## Genetic Diversity and Differentiation of Date Palms (*Phoenix dactylifera* L.) in Sudan

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Worldwide extensive research has been conducted on the characterisation of hundreds of date palm cultivars, mainly to provide a tool for cultivars identification based on apparent characters as well as molecular markers. Although studying the population genetics of date palms was not an objective of these studies, high genetic diversity was reported among date palm cultivars and the tested molecular markers were unable to discriminate between most of cultivars from different production areas in the world. In Sudan date palm culture is an old agricultural activity practised for more than 3000 years where existence of two types of dates (date palm fruits) cultivars - soft and dry - were recognised to follow some geographic distribution. Our objective was to study the population genetics of date palms in Sudan. We collected 200 individuals from 19 populations from different geographic locations in Sudan. The collection sites grouped according to the type of dates that dominates in the area. Ten microsatellite markers were used to investigate the genetic diversity within and among populations, and the correlation between the genetic and geographic distances. The tested microsatellite markers showed a high level of polymorphism. A total of 261 alleles were detected at the ten loci. The overall mean value of fixation indices equalled -0.163, which shows the presence of excess heterozygosity. However, the chi-square tests conducted for every locus in each population indicated no significant deviation from the Hardy-Weinberg equilibrium. The AMOVA analysis exhibited that about 95 % of the total genetic variation existed within populations, while significant differentiation within the type groups could be detected. Although significant isolation by distance ( $r^2 = 0.552$ ,  $p < 0.05$ ) was detected by a Mantel test, it seems that the spatial effect has become complicated as a result from the exchange and introduction of different kinds of plant material by date palm growers and traders as well as seed dispersal. This complexity was clearly apparent in the weak clustering relationships among most of the tested populations.

**Keywords:** *Phoenix dactylifera* L., heterozygosity, microsatellite markers, date palm populations

## Date Palm (*Phoenix dactylifera* L.) Plants under Water Stress: Maximisation of Photosynthetic CO<sub>2</sub> Supply Function and Ecotype-specific Response

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Drought and water stress to plants is a worldwide problem, however, it is more widespread and acute in arid and semi-arid regions where the cultivation of date palms constitute one of the most successful agricultural activity. Adaptation of date palm to water stress is more expected as it is one of the first fruit trees which were distributed and taken into cultivation in naturally dry regions. In this study the morphological and physiological responses as well as photosynthetic gas exchange characteristics were examined in date palm (*Phoenix dactylifera*) plants subjected to water stress under greenhouse conditions. Irrigation treatments include 10, 25, 50 and 100 % of field capacity (FC). Plants of soft and dry types of date palm cultivars, under different water levels were exposed to stepwise changes in CO<sub>2</sub> concentration. The Farquhar biochemical model was fitted to the response curves. Values for the photosynthetic parameters the rate of electrons supplied by the electron transport system for ribulose 1,5-bisphosphate (RuBP) regeneration (J<sub>max</sub>) and the carboxylation efficiency of the rubisco enzyme (V<sub>max</sub>) as well as their water dependences were derived from the measurements. The results showed that water stress induced multiple changes in plant growth and morphology. Overall reduction in photosynthetic capacity of date palm plants at 50 % FC (5.25±0.34) is moderate when compared to 100 % FC (5.61±0.38 μmol m<sup>-2</sup> s<sup>-1</sup>). However, the reduction was significant ( $p < 0.001$ ) at 25 % and 10 % FC, 4.0 and 2.55 μmol m<sup>-2</sup> s<sup>-1</sup> respectively. Higher levels of photosynthesis were observed at 1500 ppm CO<sub>2</sub> in every irrigation treatment. On the other hand, there was significant interaction effect ( $p < 0.001$ ; R Squared = 0.88) between water levels and the elevated CO<sub>2</sub>. Different types of date palm cultivars showed different capacities in growth traits as well as the overall net photosynthesis especially when subjected to water stress. The study also gives highlight to the effects of different treatments on J<sub>max</sub> and V<sub>max</sub>.

**Keywords:** Date palm morphology, *Phoenix dactylifera* L., photosynthesis, V<sub>max</sub>, water stress



## Collective Action for Promoting Sustainable Land Management Systems: An Agroforestry Case in Zambia

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This paper highlights how property rights regimes and other customary practices pose important institutional constraints to widespread up-scaling of sustainable land management and production systems. In this paper, we use agroforestry-based soil fertility management practice as a case study. First we will describe the technical details of the sustainable practices emphasising their relevance to the development of stable production systems to meet food security of smallholder farmers and environmental conservation in the region. Then we highlight institutional challenges that constrain rapid dissemination of the practice among farmers, and describe how collective action by stakeholders at the grass roots level has alleviated constraints to scaling through bi-laws. A sample of 200 households in eastern Zambia was used to assess the impacts of the policies on different social groups in the rural communities. The analysis of the data reveals that the bi-laws have helped to promote sustainable practices, but have different impacts on various members of the community. The results showed that collective actions can provide important framework for policy interventions on sustainable land management systems in rural communities, but distribution of the benefits (or costs) associated with natural resource commons and, the dynamics of power structure among stakeholders in the community are critical for enhancing or inhibiting successful implementation of such interventions. In general, the bi-laws impacted positively on farmers who have adopted the sustainable practices and women-headed households but, they had negatively effects on children and livestock owners. It is concluded that in addition to biophysical performance of sustainable land management practices, local institutional arrangements and the pattern of distribution of benefits (or costs) of the practices are important conditions and framework for their sustained and widespread uptake in rural communities

**Keywords:** Adoption, impact assessment, land tenure, policy dialogue, property rights, Zambia

## Silviculture Contributions Towards Sustainable Management of Plantation Forests in the Highlands of Ethiopia

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Besides heavily degraded natural forests dense plantations of exotic tree species form the forest landscape of the study area in Munessa, in the highlands of Ethiopia. Within management plans of plantation forests defined thinning concepts are neglected and scientific knowledge about the thinning effect on plantation stands is missing.

Therefore a silviculture experiment was implemented in plantation stands at the study area of Munessa in the highlands of Ethiopia. The overall goal of the experiment is to develop management concepts, how plantation forests of Ethiopia can be managed in a sustainable way on the basis of scientific knowledge. The silviculture experiment has a dual objective. Firstly, it aims for increasing the harvesting potential by mass and value. Secondly, it aims for identifying appropriate management practices to reconvert forest plantations into natural forest.

Three silviculture measures (control, intense promotion and conversion) were implemented at different age classes in plantation forests of *Pinus patula*, *Cupressus lusitanica* and *Eucalyptus saligna*. Promoting potential crop trees (PCTs) by removing competitor trees at different intensity levels form the basic idea of the silvicultural treatments. The impact of livestock on the forests is considered by including two different variants of protection (fenced and unfenced plots). In total 46 research plots were established in the study area and the silviculture measures were finalized in February 2008.

The effects of the silvicultural measures on mature stand, regeneration, ground vegetation and light climate are analysed in detail and repeated measurements are conducted annually. The first results, one year after implementation will be highlighted and possibilities will be demonstrated how this scientific information can be merged into the development of sustainable management concepts for plantation forests in Ethiopia.

**Keywords:** *Cupressus lusitanica*, Ethiopia, *Eucalyptus saligna*, forest fencing, *Pinus patula*, silviculture experiment, sustainable forest management, forest thinning experiment

## Effects of Tapping Tools and Tapping Dates on Gum Yield of *Acacia polyacantha* subsp. *campylacantha* in South Kordofan, Sudan

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*Acacia polyacantha* Willd. subsp. *campylacantha* (Hochst. ex A. Rich.) Brenan is a multipurpose forest species in South Kordofan and locally known as kakamut. The up to 15 m height tree is mainly distributed along rivers and valleys where the water table is fairly high. The wood is hard and durable. The edible gum of this species is locally used in different ways. Despite its uses, very little scientific information is available about the tapping possibilities of the kakamut tree.

A two factor randomised complete block experiment with three replications was set up in Umfakarin (12°05' N, 31°20' E), Tooma (12°00' N, 31°01' E) and Lagawa (11°50' N, 29°11' E) forest reserve. The first factor was the tapping tool, which was tested in four levels (control, makmak, axe and sonkey). In the control no tapping was applied, and only the natural gum exudation was recorded. The second factor was tapping dated at two different times (October 15 and November 15). The yield of each tree was determined by weighing the gum after each picking. Each experimental unit consists of 10 kakamut trees giving a total number of 240 trees for each experimental site.

The results clearly indicated that the gum yield can be improved by tapping *A. polyacantha* subsp. *campylacantha*. Overall average gum yield from natural exudation was only 28.37 g tree<sup>-1</sup> at the three different study sites. However, the tapping with makmak, axe and sonkey caused an overall average gum yield of 187.67, 169.74, and 160.33 g tree<sup>-1</sup>, respectively. At all three study sites the makmak proved to be the best tapping tool with a significantly higher gum yield. The date of the tapping did not show a clear effect on the gum yield production of kakamut trees.

In conclusion, the results indicate that the yield of kakamut gum can be increased by tapping, and the makmak is the best tapping tool.

**Keywords:** *Acacia*, gum arabic, Sudan, tapping technique

## Spider Web Density in Indonesian Cacao Agroforestry in Relation to Habitat Variables at three Different Spatial Scales: Tree, Plot and Landscape

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Web-building spiders are recognised as obligate insectivorous predators which reach high abundances in all terrestrial habitats. However studies on the functional role of spider communities and the impact of vegetation structure and landscape context on spider web-density especially in complex tropical agroecosystems such as agroforests are still rare. The relationship of five web-building spider guilds to habitat variables and to the presence of the numerically dominant *Philidris*-ant species at three different spatial scales: tree, plot and landscape was determined. In Sulawesi, Indonesia, we surveyed the distribution of several spider-web types within 420 cacao trees of 42 different managed cacao plantations. We fitted linear mixed model, selected the best model subset using information-theoretic criteria and calculated the model-averaged estimates. In addition we correlated the density of different web types to the incidence of the local main pests cacao pod borer (*Conopomorpha cramerella*) and cacao pod sucker (*Helopeltis sulawesi*). The analysis showed a significant impact of habitat heterogeneity on spider web abundance on different spatial scales whereas the requirements on plant structural complexity and environmental conditions diversified among web-building spider guilds. The orb- and line-weavers, that dominated the web guild structure on cacao trees showed a high dependence on tree structural complexity, while the abundance of tangle-, lattice- and sheet-weavers was additionally influenced by environmental conditions. Concerning to the pest controlling potential of each web-building spider guild and with respect for their interactions with *Philidris* sp., the multi-model inference generated no significant reduction in fruit damages trough *Helopeltis sulawesi* or *Conopomorpha cramerella*.

**Keywords:** *Araneae*, cacao agroforest, *Conopomorpha cramerella*, *Helopeltis sulawesi*, Indonesia, management strategies

## Microclimatic Effects on Premature Fruit Drop of Mango in Northern Viet Nam

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Mangoes (*Mangifera indica* L.) in northern Viet Nam are predominantly produced by different ethnic minorities for local markets; however, productivity is limited by the occurrence of premature fruit drop. The physiological mechanisms of the process of fruit drop are still ambiguous but are supposed to be related to lack of fertilisation, embryo abortion, competitive source-sink relations, pests and diseases pressure and the occurrence of adverse climatic conditions. It is hypothesised that physiological responses of mango to environmental cues such as excessive temperature, drought and/or high vapour pressure deficit will induce a high degree of fruitlet abscission. This in turn might be linked to relatively hot, dry prevailing winds and the lack of precipitation throughout the months of February and March as well as the common farming practices of non-irrigated orchards. These microclimatic factors might induce specific changes within the abscission zone (e.g. lack of carbohydrate supply, reduced export of indole-3-acetic acid [IAA] out of the fruit; increased fruit ethylene synthesis) which subsequently leads to fruit drop.

Consequently the aim of this study was to investigate the premature fruit drop pattern of irrigated and non-irrigated mango trees (cvs. 'Hoi' and 'Tron'). An automated weather station recorded air temperature, light intensity, wind speed and direction, rainfall and relative humidity within the orchard. In addition, measurements of soil temperature at 10 and 20 cm depths and soil moisture ranging from 10 to 40 cm depth were taken at regular intervals in close proximity of treatment trees. Air temperature and relative humidity within the tree canopy were recorded by micro-loggers. Phenological data such as full bloom, initial fruit set and fruit drop were recorded on selected mango inflorescences on each treatment tree. Throughout the fruit drop window between mid February and end of March 2009, corresponding with the period of hot, dry climatic conditions, fruit- and leaf-diffusates for IAA-export were sampled at weekly intervals. Initial results of hormone analysis indicate a correlation between a reduced IAA export and fruit drop.

**Keywords:** Abscission zone, auxin, irrigation, mango, Viet Nam

## Cause and Effect Relationships Between Product Quality and Environment as Prerequisite for Denomination of Origin Labels in Coffee

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Geographical indications (GIs) and the more demanding denominations of origin (DOs) are known more familiarly as labels of origin. The Protected Denomination of Origin PDO status is applied to products that originate in a specific region, place, or country, and have qualities or characteristics that are essentially or exclusively due to a particular geographical environment. The PDO's have often been used with wine and spirits, but are also applied to other foods (*e.g.* cheeses, meat products, oils, or nuts). PDO's pursue a double purpose; they protect a product and are tools of marketing a unique product. Several coffee producing countries and regions launched their denomination of origin in the last decade based on different criteria. The objective of this paper is first to review and compare existing coffee denominations schemes, secondly to describe a scientifically sound method to underpin denomination of origin labels, and finally to demonstrate the method in Cauca and Nariño, two selected Colombian coffee growing areas. The results show that the denomination schemes being implemented across the coffee producing countries are based on a variety of methodologies and focuses. The success of the methodology we propose rests on answering four core questions: (i) Is the geographical environment different to other environments, (ii) is the quality different to other qualities, (iii) what is the relation between the environment and the quality, and (iv) how can the areas geographically be delimited. In the Cauca and Nariño growing area case study the results show that coffee domains can statistically be distinguished by their predominant environment and the produced beverage quality, and subsequently be delimited by means of spatial modelling.

**Keywords:** Coffee, Colombia, denomination of origin, geographical indication

## Drivers and Impacts of Intensification in Smallholder Cacao Agroforestry in Central Sulawesi, Indonesia

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Agroforestry systems have repeatedly been praised as potential win-win situations in terms of economic returns and biodiversity, although the intensification of this land use system may also raise trade-offs. Sulawesi as a major cacao producing region had a ‘cocoa boom’ in the 1990s, resulting not only in an expansion in cropping area around the Lore Lindu National Park (LLNP) in C. Sulawesi, but also in an ongoing intensification of cacao agroforests, most notably by the removal of shade tree cover, primarily in order to increase yields and income. However, intensification is not only subject to economic incentives but is also expected to be driven by various characteristics of farming households and their land.

The relationship between cacao producing household attributes, the intensity of the cacao system (shaded vs. unshaded), cacao yields/ farmer income and biodiversity is poorly investigated so far. With the aim to contribute answers to these key issues in tropical agroecosystems, we conducted a systematic characterisation of cacao agroforestry with 144 cacao producing households in 12 villages around the LLNP, covering the entire intensification gradient. Yields and several yield determining factors (input of labour, agrochemicals, management) as well as plot structure parameters were surveyed (intercrops, shade tree species, canopy closure) for one year. Ecological impact data is provided by a large scale agroecological experiment in the same study region.

Cacao management currently shifts towards unshaded, intensive systems. Shade is negatively correlated with yield in both the survey and the experimental plots. Intensification by removal of shade trees partly goes along with an increased use of material and labour input. A range of farm properties including farm size, farm diversification and soil fertility and household characteristics such as poverty affect the propensity to intensify the management of agroforests. Biodiversity is not related to yield, which suggests that high yield, high biodiversity targets can be achieved if incentives are provided for appropriate management.

**Keywords:** Biodiversity, cacao agroforestry, intensification, smallholder, Sulawesi

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## Evaluation of Soil Fertility on Cacao Plantations in Central Sulawesi

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Soil fertility is a key factor for crop production, especially where the availability of or capital for agrochemicals is lacking. Sulawesi produces 80 % of the Asian cacao production (FAOSTAT). For Central Sulawesi sufficient data on soils and cacao is missing. Within multidisciplinary research project STORMA (SFB 552) a soil survey was conducted on 48 smallholder cacao plantations. On each plantation soil mapping was conducted (6 to 15 Pürckhauer augering) to select a representative soil profile and three 5 m × 5 m subplots. Depth wise mixed samples were taken (0–10 cm, 10–30 cm, 30–50 cm) for chemical analysis (C/N, pH, P [Bray], CECeff, total Ca, K, Mg, P). Yield was surveyed within a one year household survey by weekly reports (JUHRBANDT). Soil parameters were classified for the qualitative appraisal of the soil inventory and for fertility status of the soils. Principle component analysis (PCA) was used on soil parameters for an empirical definition of latent dimensions that comprehensively characterise the investigated soils (including data for yield and water logging classes). Linear regression analysis was conducted to assess the degree of explanation of the yield variance through soil parameters.

The soils found are dominated by Cambisols and Gleysols, which fit the claims of cacao for most parameters. Available phosphorus is limited and so is nitrogen. Organic matter is at medium rates regarding the topsoil. Ca and Mg can be taken up in luxury rates. Al and Fe concentrations are low and do not inhibit growth. Physical properties are good, groundwater near sites and skeleton rich soils compromise the situation. PCA reveals three main components. The first PC represents pedochemical parameters and can be interpreted as the main fertility component (CECeff, ex. Ca, ex. Mg, pH [H<sub>2</sub>O]). The second PC summarises the humus content and biological activity (Ct, Nt, av. P). The third PC pools the most influential soil parameters for yield (av. P, Pt, Water logging). Linear regression analysis affirms influence of phosphorus and water logging on yield. The explained variance of these two parameters is, however, low ( $r^2 = 0,232-0,313$ ).

**Keywords:** Agroforestry, cacao, Indonesia



# Forests and livelihoods

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## Community Forest Management in Nepal for Achieving Millennium Development Goals

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Since 1990 and onwards, the Government of Nepal has placed the community forestry programme (CFP) as major thrust in forestry sector. Started with the handing over the patches of National Forests particularly degraded areas to community forest user groups (CFUGs), CFP has significantly contributed addressing millennium development goals (MDGs) of the United Nations, particularly MDG 1– eradicate extreme poverty and hunger; MDG 7– ensure environmental sustainability; and MDG 3– promote gender equality and empower women. The objective of CFP was broadened with the increased success of CFUGs to conserve, manage and protect their community forest resources. The CFUGs also succeeded to generate cash income by managing the excess timber and other forest products. Such fund is invested to undertake different types of conservation and development initiative at community level.

Both qualitative and quantitative aspects of CFP's real contribution, types of activities, decision making process and the beneficiaries were frequently raised. Hence, this study tries to explore the answers of these aspects and analyses how they contribute to achieving MDGs. Different participatory tools such as focused group discussion, informal discussion with executive committee, and general members, and key informants interview were employed. Field work was conducted in 2004 in two selected CFUGs in the western Terai of Nepal.

The study depicts that CFUGs invested about 88.2 % of their group fund on road construction and micro-credit (MDG 1) in the study area. Such activities helped the forest users to execute different income generation activities and increased access to the markets. The women and poor users' participation in decision making processes of CFUGs affairs is significantly increased by 65 % (MDG 3). Illegal logging in community forest is drastically decreased and the species of flora and fauna increased by 19 species from 1997 to 2003 (MDG 7). Thus, it can be concluded that though CFUGs activities are not strategically planned to address MDGs, community forest management largely contributed in achieving MDGs in Nepal and the role of community forestry in achieving the MDGs has to be strategically set up defined under the framework of community forestry program.

**Keywords:** Community development, community forestry, empowerment, micro-credit, millennium development goals

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## Forest User Perceptions of Today's Forests in Western Kenya

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In the traditional communities of Kenya the land use has been regulated within the clan and family system. The control was based on religious and cultural value systems. These systems have been influenced by the colonial and the subsequent independent government. Nevertheless, the traditional way to perceive and use forests has partly persisted.

The aim of this paper is to highlight these remains of traditional management with special emphasis to the intangible values. Furthermore, the question is how this knowledge can be used to foster a sustainable participatory forest management. Can traditional management strategies be revived and applied together with today's forest management of the government?

An interdisciplinary method mix has been applied to investigate this topic. Social empirical data of the forest user perceptions, attitudes and values have been collected in three case studies (among Isukha, Tiriki and Ogiek) in Western Kenya in 2006 and 2007. Their views are mirrored against the paradigm of science based governmental forest management.

The adaptive hierarchical structure of the culture ecologist Bargatzky (1986) that orders values in a structure from profane to very abstract serves as theoretical framework and demonstrates that values are anchored in religious and cultural value systems that on the other side need to be practised to persist.

The results reveal that high value is given by the respondents to those resources that are helpful in daily life. Local forest users are knowledgeable on possibilities and limits of their natural environment as well as on misuse of these resources in the course of governmental management. The rules stipulated by contemporary forest management regimes are less effective than traditional rules in terms of forest protection. These results are integrated in the adaptive hierarchical structure of Bargatzky. This structure thus provides the basis to understand the importance of different values to different stakeholders.

The discrepancy between traditional and actual forest management could be reduced if the traditional forest user perceptions are no longer neglected but implemented in a participatory forest management.

**Keywords:** Intangible values, Kenya, local forest users

## Practical Work in Forest Development Cooperation - Bridging Practice with Theory

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Forests play an indispensable role in efforts to combat poverty, conserve biological diversity, and the significant contribution of forests to mitigation of and adaptation to Climate change is broadly recognised. However, forests are in the centre of societal conflict of interests. The need for arable land for large and small scale production as well as infrastructure projects, urbanisation and demand for timber and timber products puts pressure on the resource and leads to an alarming rate of annual deforestation.

The major causes of continuing forest loss can be attributed to the realm of governance, including unfavourable macro-economic framework conditions, institutional deficiencies, a lack of political will, inadequate legislation and law enforcement, insecure land tenure and centralised decision-making with insufficient participation from civil society. Development cooperation commissioned by the Federal German government (BMZ) and implemented by GTZ concentrates on concepts to moderate a societal dialogue to find solutions for conflicting interests and build capacity of all actors. Our work takes a multi-level approach:

- At the local level we assist our partners in implementing land use planning and land titling, protected area management, certification and natural resources management.
- We enhance national sector reforms through supporting national forest programmes and strengthening Forest Law Enforcement and Forest Governance (FLEG).
- We are actively engaged in regional initiatives in the Congo Basin, South East Asia, the Amazon region and Central America.
- We contribute to the development of the international forest regime in the relevant international and UN fora and help our partners formulate and represent their interests in these fora, most currently in the UNFCCC-negotiations for REDD.

Together with our partners we combine institutional assistance with the development of practical solutions based on sound scientific knowledge to enhance sustainable forest management, provide for stable framework conditions and increase benefits from sustainable resource management. The orientation and priorities of our future work will be strongly influenced by major challenges: climate change, rising global demand for energy and other raw materials and rising global demand for timber and timber products as well as for forest ecosystem services and biological diversity.

**Keywords:** Development cooperation, combatting deforestation, forest governance, participation, multi-level approach, capacity building

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## **Power Play — Not a Quest for Mutual Benefit! Creating the Conditions for Communal Forest Governance in the Brazilian Amazon, Pará**

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The paper analyses the trajectories of five tenure reform projects that aim at securing smallholders' rights to land and forest to allow for sustainable resource use by them. These rights are infringed upon by logging companies and "land thieves". It draws on five contrasting case studies conducted in the years 2006–2008 in the federal state of Pará. In three of which smallholders successfully fought for the demarcation of their lands.

Results show that smallholders need to overcome heavy resistance by those who benefit from the status quo. Misinformation, violence, and cooptation of fellow smallholders are among the strategies employed by reform opponents. Smallholders find it difficult to call upon the state to enforce their rights, as municipal administrations are often co-operating with those actors who disrespect smallholders' rights. The presence of federal Government agencies is sporadic. To overcome this situation of "might is right", smallholders need to form a strong local resistance and to enter alliances which allow them to take their struggle to other arenas. Globally operating environmental NGOs are crucial to achieve this. The paper emphasises that changes in power account for the success of tenure reform. The importance of "power plays" stands in stark contrast to the "quest for mutual benefit" motive highlighted by much of the literature on collective action for sustainable communal resource management. Efforts to create the conditions necessary for sustainable communal forest governance need to address the political nature of tenure reform processes and employ measures to support local civil society movements during tenure reform processes.

The paper reports on the struggles of smallholders for secure rights to land and forest. It suggests a framework that highlights the many ways power was exercised during the reform processes and highlights the challenges smallholder communities need to confront when they are striving for secure rights to land and forest.

**Keywords:** Amazon, communal forest governance, smallholders, traditional people

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## Conserving the Forests of the Indian Himalayan: A Comparison of Four Conservation Regimes

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The Indian Himalayas are one of the 34 biodiversity hotspots in the world. These are the world's richest and most threatened reservoirs of plant and animal life. Although population density is relatively low compared to other parts of India human pressure on the Himalayan forests is intense. They are exploited as sources of energy and animal fodder. Many studies reported that the current rate of forest degradation is posing a severe threat to the landscape and existing biodiversity in the region. Soil erosion and slope instability cause further problems.

In the present study we compared four different approaches of forest conservation that are widely recognised in the study region of the Uttarakhand state in central Himalayas: (1) Traditionally conserved forests, (2) Governmentally conserved forests, (3) Protected areas, and (4) Community conserved forests. We used remote sensing data of the last three decades (such as Multi-Spectral Scanner, Linear Imaging and Self Scanning, and Enhanced Thematic Mapper) to study the change in vegetation dynamics of the mountain forests. We also collected botanical ground data from the forests to verify the spatial dimension and the validity of the remote sensing approach. Furthermore the acceptance of the different conservation regimes by the Himalayan dwellers was studied.

All conservation regimes showed different results regarding the state of the forests. We concluded that the "Community conserved forests" showed the best results regarding biodiversity conservation and forest management in the region. This is due to a variety of reasons including the level of social acceptance of conservation regimes. We recommend encouraging this conservation approach in the Himalayas, alongside with the sustainable livelihood concept of the mountain societies. But all four conservation regimes may fit to certain conditions and the concept of "Community conserved forests" may not be accepted by all communities. Therefore, we suggest advancement and a revision of the concepts of "Protected Areas" and the "Governmentally conserved forests". Furthermore some elements of the "Community conserved forests" may be included in the concept of "Traditionally conserved forests" to meet the rapid socio-economic and cultural changes taking place in the communities.

**Keywords:** Conservation regimes, diversity, empirical study, forests, Himalaya, land cover, remote sensing, sustainable development

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## Can Community Forestry Survive in Restructuring New Nepal?

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Nepal is the pioneer of people centred forestry in the world. It has started community forestry in 1978. Since then, the country has achieved wider name and fame for mobilising people participation to restore degraded forestry resources and sustainable supply of forestry products to local community.

Nepal is predominantly an agrarian country with very diverse geographical and cultural conditions. The elevation range is unpredictably varied within the narrow stretch. The elevation varies from 70 m asl at South to the 8848 m asl at North. The country is divided into three regions on this basis; Terai (17%), Hill (68%) and Mountain region (15%). Terai is the most populated region with nearly half of the population whereas the northern part of the country is very sparsely populated. Altitudinal variation has tremendous influences in social, economical and environmental equilibrium.

Despite all these differences, the government promulgated the same sets of community forestry management throughout the country. The community forestry has achieved some successes in maintaining the greenery, restoring degraded lands and supplying forest products to communities in hilly regions. But, the community forestry has different consequences and externalities in the Terai and Himalayan regions.

As in the Terai, the local ethnic groups have been displaced further South by the hill migrants in the course of time, and also have been indirectly barred from their traditional rights over natural resources. The forest is being handed over to local people who are in proximity to the forest. The distant user cannot be involved in community forestry.

During the recent period of political upraise and transformation of Nepal to the Federal system, community forestry is certainly going to be questioned at least in terrain regions where the most commercial and productive forestry resources are available. During these periods of political turmoil, also the rights of hill migrants and local people is going to be discussed, and the communal conflicts will multiple. Preliminary symptoms in this direction have already been noticed. The pros and cons of community forestry in the context of terai region in Nepal, and a perspective solution to the perceived challenges will be presented in this presentation.

**Keywords:** Community forestry, Nepal, political change

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## To Plant or Not to Plant? - Cultural Reasons and Barriers for Adoptive Transplantation of Wild Fruit Trees in West Africa

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Climate change, population growth, deforestation, monocultures and overharvesting threaten local ecosystems in West Africa. The availability of wild plants that have traditionally been collected from these ecosystems is decreasing. Local farmers need to decide which wild plant species they may want to start cultivating in their fields and agroforestry systems. This process is called ‘adoptive transplantation’. A regional ethnobotanical study on the traditional use and management of baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.) trees was undertaken to highlight the cultural context of adoptive transplantation. This research aims to identify the farmers’ perspectives and motives that lead to or prevent the adoptive transplantation of these two species. 220 individual interviews were conducted with 11 ethnic groups in Benin, Mali and Senegal covering 4 agroecological zones. Methods include structured questionnaires, group discussions and participatory mappings. Local cultural belief systems are key elements in the farmers’ decision-making processes. Reasons that motivate or prevent the farmer from planting trees can be the presence of spirits that are believed to live in trees, the view that trees are ‘planted by god’, and gender-related tree uses. These emic and traditional perspectives mostly concern indigenous trees and only partly relate to non-indigenous trees. This regional study highlights that it is not a lack of knowledge on planting techniques, but underlying cultural reasons that prevent the farmers from planting indigenous fruit trees. Local belief systems need to be considered by development agencies and forestry institutions intending to establish sustainable reforestation and in-situ conservation programs. Innovative concepts need to be elaborated together with the local population. Conservation strategies need to work with or even ‘work around’ local belief systems that are hindering the adoption of unsustainably used wild trees.

**Keywords:** *Adansonia digitata*, agroforestry, belief systems, Benin, conservation, domestication, Mali, Senegal, *Tamarindus indica*

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## **Native Woody Plant Community Organisations around Farms and their Role to Improve Diversity of Trees on Farms: The Case of North West Ethiopia**

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RRA and PRA tools are used to understand drivers of land use practices and land allocation to different land use types with a special reference to remaining native woody plant communities in NW Ethiopia. A collaborative planning and implementation process shall lead to improved sustainability and productivity of land use. In a first step, a survey with questionnaire and semi-structured interviews were used to collect information on tree species preferences and tree niches and uses as well as selected socio-economic characteristics of farms of 100 households. Group discussion was carried out to prioritise woody plants against selected attributes. Floristic diversity differences between households were analysed by using species richness, Shannon and Simpson diversity and evenness indices. As a result, 60 plant species were identified. Diversity values differed markedly between farms. Multiple linear regression of diversity statistics on household characteristics showed significant relationship: much of the variation was explained by wealth, age, gender, educational level of the households, and size of land holding, explaining from 2–53 % of the variation. From group discussions, eight attributes with which farmers value a tree species have been identified. Prioritisation of tree attributes showed major constraints and motivations for growing trees. Prioritisation of trees was based on their importance for fodder, compost and fuel wood. Poor survival due to moisture stress, propagule supply and free grazing has been mentioned as major constraints. Urgent needs for finding solutions leading to improved survival of seedlings were detected. Diversity and abundance of trees on farms might be increased by using household socio-economic characteristics as extension entry points. Recommendations on research priorities of native plant species and on how to maximise the species pools for future conservation and restoration efforts are provided.

**Keywords:** Farm forests, household characteristics, native woody plants

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## The Role of the Olive Co-operative in Enhancing Farmers' Income and Olive Production in Salamieh, Syria

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Olive has become a major crop during the last few decades in Syria and is the main source of income for a large number of small and medium farmers. Most olive orchards are grown under dry farming in marginal lands, unsuitable for other crops. Statistics show that 60 % of the area under trees is olive (90 % of olive production is milled), and more than 377 000 families work in this field. This rapid expansion of olive plantations and approximately 50 % increase olive tree plantation in Salamieh area in the middle of Syria in the last decade led the olive farmers to establish an the first ever Olive Co-operative by a group of olive farmers in Salamieh district, Syria in 2006. This paper aims to study the case of this olive co-operative, a non governmental co-operative and a non-profit organisation, established with the assistance of the Aga Khan Foundation. This co-operative aims to train the farmers on pruning, grafting, IPM, modern irrigation methods, harvesting, etc. through workshops organising and to help them in improving harvesting, delivery time and processing procedures, co-operative-milling of olive, marketing their production in addition to encouraging the secondary industries of the olive such soap and bottling of oil. The establishment of this cooperative and its technical assistance did lead to premium quality extra virgin olive oil, acquiring premium of 6 % over prevailing market prices as a consequent for the high quality and it is a good example of cooperation between farmers. In addition the harvesting cost was reduced by 20 % in 2006. This can be used a model for agriculture extension and the establishment of such cooperatives should be encouraged to help value addition and increase farmers income through better harvesting, milling and marketing through cooperative behaviour.

**Keywords:** Income, marketing, olive co-operative, olive oil, Syria

## **Factors Influencing Institutional Arrangements for Effective Management of Non-timber Forest Products in Community Forest User Groups of Nepal**

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The management of non-timber forest products (NTFPs) is considered as one of the approaches for poverty reduction in rural communities. In Nepal, several policy documents have emphasised the importance of effective management of NTFPs by community forests user groups (CFUGs) with specific emphasis on the involvement of marginalised people. The management of NTFPs, however, is governed by the institutional arrangements of the CFUGs, which are comprised of formal and informal provisions addressing NTFPs management in the forest, marketing, and benefit sharing among the CFUG members. The formation and development of the provisions can be influenced by several internal and external factors of CFUGs. This paper investigates the factors contributing to the formation and development of such provisions in two CFUGs in Dolakha district of Nepal. By using a case study approach, data was collected through key informant interviews, focus group discussions, formal and informal discussions, participant observations and the study of CFUG documents. The study results suggest that, on the one hand, representative inclusion in the executive committee, involvement of governmental and non-governmental organisations, and market linkage are positively influencing the formation and development of provisions for effective management of NTFPs. On the other hand, remoteness of the CFUG and the dominance of the executive committee by higher economic CFUG members have had negative effect on formation and development of the provisions and also on effective management of NTFPs. It is anticipated that these results will help to strengthen institutional mechanisms that support the effective management of NTFPs in CFUGs.

**Keywords:** Community forest user groups, inclusion, institutional arrangements, Nepal, non-timber forest product

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## Does Community Forestry Contribute to Poverty Reduction? an Evidence from Nepal

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The Community Forestry programme in Nepal has dual mandates: the conservation of forest resources and poverty reduction. It is widely accepted that community forestry (CF) is successful in conserving forest resources; however, its poverty reduction approach is still a subject of discourse. In general, the community forestry programme is to be considered successful when it provides equitable benefit to all users and decreases income inequality in the community. To evaluate the community forestry programme for its economic contribution to the poor user, a study was carried out in two community forest users groups (CFUG) of Dolakha District of Nepal. Total households of each CFUG were stratified into four economic strata viz. very poor, poor, medium and rich by means of participatory well-being ranking. From each stratum 25 % of the households were selected constituting a sample of 115 households. The following participatory methods were used to generate empirical data: free listing, household surveys, group interviews as well as key informant interviews. Lorenz curves and Gini-coefficients were calculated in order to characterise the distribution of the household income. Calculations with and without the contribution of community forestry to the households' income underpin the significance of income based on forest resources especially for the poor. The results show that in both CFUGs community forest is contributing to reducing the income inequalities among different economic classes. Hence, it is concluded from the study that community forestry is not only successful in forest conservation but can also help in abating poverty. Further studies investigating indirect benefits and multiplier effects of CF as well as respective impacts on rural livelihoods and poverty alleviation are suggested.

**Keywords:** Community forestry, economic contribution, income inequality, Nepal, poverty reduction

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## **Interrelation Between Customary Forest Use by Hmong People and Governmental Forest Project in Viet Nam**

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Numerous ethnic minority groups have been living on the uplands of Viet Nam for a long time. Understanding of forest use by these ethnic groups and appropriate decision-making are crucial for improvement of forest management intervention. This study looks into forest use by the Hmong people and a governmental forest project in Vietnam. The Human Ecosystem Model is employed to frame the study. In three sedentary Hmong villages a mix of qualitative and quantitative methods, such as Rapid Rural Appraisal (RRA), Forest Inventory and Household Survey, is used to capture required data. The findings show forest uses by Hmong villagers serving preferably for their subsistence. Uses of the forests customarily claimed by households, clans and village as a whole are strictly regulated by customary tenure, customary rules, and traditional/village institutions rather than by formal tenure, rules, and institutions. The government's forest project which still has been planned and implemented following technocratic approach has not shown results as what were expected, but entailed conflicts between the state and the villagers over the forest resources. It is concluded that elements of the local human social system, particularly customary social order and traditional/village institutions, have to be taken into account in the government's forest project. Tripartite project planning that involves Forest Department, local people and a mediator has been elaborated as a potential means to harmonise the governmental intention with customary use of forest resources. By making use of the Human Ecosystem Model or human ecosystem approach, local-specific strategies of sustainable use and management of the forest resources fulfilling both state's and local people's agenda are able to be worked out.

**Keywords:** Customary rules, customary tenure, forest conflicts, forest project, forest resources, harmonisation, human ecosystem, traditional institutions

## Promoting Quality in the Value Chain: The Case of Tea from Nepal

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In recent years, Nepali tea is growing to become a competitive agricultural export product. Out of the total tea produced in Nepal, 43 % is exported but with only 1 % being exported to the EU, especially Germany. To find out how to promote the exports of Nepali tea to the German market, the following three research questions have been raised: 1) how do the value chains (technical & actor) for exported Nepali tea look like?; 2) is the quality infrastructure (QI) in Nepal sufficiently developed?; and 3) how can the consumers' tea consumption habits be characterised?

Based on expert interviews with tea traders in Germany, major actors in the tea value chain are identified: agro traders (tea plantation raw materials suppliers); tea estates and small-scale farmers (producers/processors of tea leaves); packers/exporters; and wholesalers/retailers. The tea importers in Germany are responsible to test every consignment of their imported tea in German laboratories for Maximum Residue Levels (MRL). This requirement has been found to often act as a barrier for Nepali tea exporters, and the underdeveloped QI system of Nepal can be mainly accounted for this. A Code of Conduct (CoC) for producing and processing tea has been developed in Nepal, referring to product, social and environmental standards, but the CoC is not internationally recognised.

To study the Nepali tea value chain on the consumption side, a survey of 300 consumers was conducted in Germany. Preliminary results show that 24 % of the respondents drink Nepali tea. These are mostly males (69 %) and younger people (59 %) with an income of less than € 2000. Factor and cluster analyses will further be applied to identify the characteristics of consumers who buy Nepali tea. The results will help to identify German consumers' tea consumption habits which again will feed back as important information to the producers and exporters in Nepal.

**Keywords:** Consumer behaviour, Nepali tea, quality infrastructure, value chain

## **Assessing the Contribution of Community Forestry to Rural Development: A Comparative Study of Africa, Asia and Europe**

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Community forestry has been widely promoted as a potential approach to sustainable forestry. It is centred on the meaningful involvement of forest dwellers on forestry activities, with core aims to lifting them from poverty and to supporting rural community development. This is because a large number of poorest households dwell within and or near forests and are heavily dependent on the resources. It further emphasises on improving the communities' socio-economic well-being, promoting social justice, and giving better access to the forests to the people. Therefore, this practice is believed to trigger rural community development by empowering the rural people.

With such philosophies, community forestry has clearly a large potential to contribute to poverty alleviation efforts and rural development. Our case study results from different countries nonetheless suggest that community forestry has not yet signalled significant progress from the earlier forms of forest management. Our cases further reveals that while community forestry has provided some tangible benefits to forest dwellers, there is no clear signal that the programme has lifted them from poverty. The incentives gained commonly only include rights of access for collection of non-wood forest products, and less so for more valuable products, *e.g.* timber. In addition, our analysis vividly suggests that community forestry is structured with more complex binding contract systems causing hardships experienced by forest dwellers in accessing the forest resource and craft mere impact on rural development. Therefore, to achieve the initial objectives of community forestry, policy makers and forest managers should explore innovations beyond the current practices and genuinely provide more access for local communities on the forest resources.

**Keywords:** Access, community development, community forestry, empowerment, poverty alleviation



## Auctions of Forest User Rights and Conservation Performance Payment Schemes of Non-timber Forest Products of Kakamega Forest, Kenya

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Participatory forest management (PFM) is often advocated as an instrument that can overcome excessive extraction of non-timber forest products by local communities and resultant forest degradation. We test an innovative PFM design attempting to combine market forces with PFM in field pilots around Kakamega forest, Western Kenya, by auctioning area-specific user permits to individuals and by establishing a communal monitoring system. 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. The Kenya Forest Service currently employs a forest management system of issuing permits for the extraction of forest products. The permit system attempts to charge forest users directly for the external costs they impose on society. Yet, the appropriate price per permit is not known and the system is subject to exploitation due to monitoring difficulties. Recent legislation by the Kenyan government encourages local communities to participate more actively in the forest's management. The objective of the field pilots is to examine whether auctions are an effective instrument for the allocation of user rights within PFM schemes in developing countries and how flexibility in scheme design, extracted product and community characteristics affect PFM outcome. The auctions are expected to help determine competitive market prices and sanctioning can lead to the individual's loss of user rights and the community's loss of auction income thus providing incentives to comply with rules of sustainable resource use. The pilots are implemented in three communities which differ in degrees of flexibility in scheme design, auctioned forest products (firewood, grazing, grass cutting) and community characteristics. Preliminary results show that the community is willing to pay for exclusive rights in extraction of non-timber forest products and offer monitoring services so long as Kenya Forest Service ploughs back some of the paid revenue for improvement of their livelihood. Part of the revenue generated from the above auction of forest user rights was used for reforestation through conservation performance payment contracts and improvement of livelihood.

**Keywords:** Allocation efficiency, cost minimisation, forest conservation, participatory forest management

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## **Sustainable Cocoa Production in Southern Cameroon: Potentials and Constraints of Integrated Pest Management (IPM)**

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This research work was aimed at complementing the theoretical and practical courses offered to the final year students of the International Master of Science in Rural Development (IMRD) in the ERAMUS MUNDUS programme co-hosted by Ghent University Belgium (coordinating), Humboldt University Germany, PISA University Italy, Cordoba University Spain and Agrocampus Rennes France.

This study aimed to analyse the potentials and constraints of sustainable cocoa production in Southern Cameroon through the use of Integrated Pest Management (IPM) techniques. Specifically, the study will probe into the following: identify current Integrated Pest and Management practices by smallholders and assess factors that favour adoption of the technique (IPM). To attend the objectives of this study, semi structure interview was conducted to 20 smallholders using a guided questionnaire, focus group discussion with some members (president-manager and secretary general) of common initiative groups and cooperative, direct field observation and lastly key informant interviews conducted with some stakeholders (actors) in the cocoa sector using the Participatory Rural Appraisal (PRA) method and tools. The 20 smallholders that the questionnaire was administered to are graduated of the farmer field school (FFS) conducted by International Institute of Tropical Agriculture (IITA) under its Sustainable Tree Crop Program (STCP).

Concerning identification of current Integrated Pest Management practice by smallholders, they identified in order of importance in terms of time concerning labour and capital investment, the following practices were listed: pruning, clearing, harvesting, spraying, shade management etc. ranked according to importance.

Factors such as price incentives, available markets for cocoa, traditional (indigenous) knowledge, good climate and vegetation, scarcity and high prices of chemicals are amongst the reasons that facilitated the adoption of Integrated Pest Management techniques by smallholders in the study area.

**Keywords:** IPM, PRA, smallholders, sustainable cocoa production

## Study on Attitude Difference among the Indigenous Groups and Settlers on Forest and Forest Conservation in Bangladeshi Hill Tracts

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The indigenous people of Chittagong Hill Tracts are distinct and different from the majority Bengali population of Bangladesh in respect to race, language, culture, religion, and ethnicity. Their socio-economic condition, life style, culture and religion are influenced by the forest. This study identifies the attitudes of the indigenous people and settlers towards forest. This result compares attitudes difference of these two groups in terms of the forest resources utilisation and conservation. This study analyses indigenous peoples' daily forestry activities, socio-economic and cultural activities of CHT along with the dependence on forest for livelihood with a comparison to the settlers

Indigenous people are not only utilising forest product more than the Bengali Settlers but also possessing more knowledge on forest. The indigenous people are much more dependent on forestry activity for their livelihood where as the settlers are much more interested in timber business and agriculture. As a result the scope of livelihood opportunity for both indigenous people and Settlers are decreasing due to competition. In consequence, the conflict for recourse is increasing in the region resulting a gradual depletion of the rain forests of Chittagong Hill Tracts in terms of productivity and biodiversity through indiscriminate illegal logging, excessive minor forest product extraction. This study reveal that the settlers are more exploitive in comparison to the indigenous community and there is a difference among the Chakma, Marma, Tripura, Tanchangya and Khyang people in having dependency on forest. It is clear that they live in or around the forest they posses' different level of dependency on forest. It is shown that among the ethnic groups Khyang are more dependent than others and Chakma are less dependent on forest. It is a common belief that the indigenous people are more close to nature, How ever this study tries to analyse the attitude of the indigenous people of Bangladesh hill tracts when their society has been exposed to the comfort of modern civilisation. Where as, among the 5 major tribes Chakmas are more exploitative than other 4 (Marma, Tripura, Tanchangya and Khyang) tribes while Chakmas are more habituated with comfort and scopes modern civilisation.

**Keywords:** Atetude, indigenous people, nature conservation

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# Institutions and macro-economics

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# Poverty, innovations and knowledge

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## Development of Absolute Expenditure Poverty Indicators in Northern Viet Nam

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In Viet Nam, the poverty assessment method (MOLISA tool) screens poor households annually in order to allocate subsidised services in the area of credit, health, housing, and education. However, this method suffers from a number of shortcomings since it uses complex indicators (such as income) as well as strongly depends on how knowledgeable neighbours are about each others' poverty situation. The paper investigates two major hypotheses.

First, the MOLISA tool leads to high undercoverage of the poor, and high leakage of scarce public resources to the non-poor. Second, a new tool based on regression analysis will lead to lower undercoverage and leakage errors while using less complex indicators. Both hypotheses are accepted in the analysis.

The study measures per-capita daily expenditures, as a proxy of income, of a 300-household-random sample which is representative for Yen Chau district, Son La province. To capture a considerable amount of seasonality in agricultural productions and incomes in the area, two expenditure survey rounds were implemented, following the methodology of the Living Standard Measurement Survey of the World Bank. Four regressions have been used: Ordinary Least Square, Quantile, Linear Probability Model and Probit with more than 200 poverty indicators to identify the best10 and best15 indicators within the survey that most accurately reflect the "true" poverty status of each household.

It is found that the quantile regression has highest accurate performance among other regressions. It almost perfectly predicts the observed poverty rate with an optimal point of estimation set at the 31<sup>st</sup> percentile. The leakage amounts to 26 % when using the new tool as compared to 66 % for the MOLISA tool. Moreover, the best derived poverty indicators are reliable and also cost-effective to measure poverty but allow to give high accuracy criteria compared to the currently used method and promise to improve targeting efficiency of policies in Viet Nam. These results will be shared in a feedback workshop to stakeholders in Son La province in September 2009, and the paper presentation at the Tropentag will also include feedback by government institutions and communities on their perceptions about the usefulness of the new poverty assessment tool.

**Keywords:** Poverty, poverty indicators, quantile, targeting efficiency, Viet Nam

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## **Influence of Policy Measures and Economic Growth on Intercropping Systems in China**

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Highly intensive agricultural practices in North China lead to decreasing land and water resources and endanger sustainability severely. Intercropping is a traditional production system in the North China Plain. According to several studies it is a means of producing high yields with limited environmental resources, reduced leaching and erosion. A qualitative inquiry was conducted in the NCP, interviewing practitioners, researchers and decision makers on distribution and future of intercropping systems. Additionally statistical data was consulted to understand current trends and get an idea of future developments of systems and distribution of intercropping. Four main drivers were recognised to influence intercropping distribution. Economic growth leads to steadily increasing off-farm income possibilities for rural farm households. Therefore, the time invested on farmers' fields is decreasing and labour intensive systems like intercropping are practised less. Most plots of farm households are very small. Due to the effects between two neighbouring plots, which are cultivated with different crops so called "unconscious strip intercropping" is wide spread. As the government wants to increase agricultural efficiency land consolidation is promoted heavily. In the course of that "unconscious strip intercropping" is decreasing. A policy that encourages intercropping, at least in a short term is the establishment of green belts of trees along big roads in most provinces. In between the ten to fifty metre wide strips farmers continue to crop their fields until the competition by the growing trees becomes too strong to reach a satisfying crop yield. Until then agroforestry-systems are practised all over the country. Use of agricultural machinery is rapidly finding its way into Chinese agriculture. Researchers and extensionists are required to develop and disseminate new intercropping systems that can be mechanised. If intercropping should have a future in China, government incentives should be given to farmers to adapt new and improved systems developed by researchers.

**Keywords:** China, intercropping, sustainable production

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## Does Contract Farming Benefit Farming Community?: A Comparative Study of Contract and non-Contract Farmers in India

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The impact of contract farming on farmers, especially in a developing country context, is highly debated and it is suggested that the private actors are dominating food agribusiness whereas farmer's influence is declining. The present investigation attempted to analyse the impact of contract farming on farmers and to study the factors influencing farmer's participation in contracting. The survey was conducted in Pune region of Maharashtra state of India using an ex-post facto survey research design. Personal interviews using a structured questionnaire were conducted with contract farmers (n=53) involved in chip quality potato production with a multinational company (Frito Lays Ltd.), and non-contract farmers (n=41) who followed traditional farming and sold their produce through unorganised marketing channels. Samples were selected using random sampling. The logit model was used to analyse the factors determining farmer's participation in contract farming. The results of comparison of costs and returns between the two groups indicated higher net returns for contract farmers which attributed to the higher yield, predetermined prices, lack of middlemen and organised marketing channel. On the contrary, the lack of access to storage facilities and quality inputs, exploitation by middlemen and traders, lack of bargaining power and highly fluctuating market prices affected the net returns of non-contract farmers. The factors including age, education, distance to credit source had a positive influence on farmer's participation in contract farming while, off-farm income and membership of cooperative organisation had a negative impact on participation. Farmers with good education, low off farm income, distant access to credit source, lack of membership of any agriculture co-operative society and comparatively large land holding showed greater interest in contract farming. The results of Mann-Whitney test suggested that the contract and non-contract farmers differed significantly in terms of their satisfaction level for access to extension services, credit and quality inputs, with contract farmers having higher satisfaction for all the three. The contract farming model used in the study region worked well mainly due to transparency in price determination mechanisms, efficient seed supply and organised market channel and the contract farmers were better-off compared to non-contract farmers.

**Keywords:** Contract farming, Logit model, non-contract farmers, potato

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## Economic Impact of Livestock Research on Farmers' Knowledge and Productivity — The Case of Trypanosomosis in West Africa

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African animal trypanosomosis (AAT) imposes a serious constraint on the livelihood of cattle-dependent farm households in sub-Saharan Africa. Trypanocidal drugs are predominantly used as a preventive and curative control strategy, but the inadequate application of trypanocides fosters the development of pathogens' resistance. The research activities of the International Livestock Research Institute (ILRI) in the cotton zone of West Africa have tackled this problem by the provision of information material in local language as well as the demonstration and practice of correct treatment. In particular, the principles of rational drug use had been brought into focus.

In this study a methodology is presented to measure the impact of ILRI's activities on farmers' knowledge and its resulting productivity effects at farm level. The impact pathway from improvements in knowledge to a behavioural change of applying more effective practices, which in turn will reduce treatment failures and hence output loss, is investigated. Therefore, data were collected from 508 cattle farmer in the region of Kéné Dougou - common to south-eastern Mali and south-western Burkina Faso. Propensity Score Matching techniques are applied to establish an adequate counterfactual group in order to assess the effect of ILRI's activities on farmers' know-how. Knowledge on specific disease management techniques are measured by knowledge test scores.

Results show that participating farmers reach higher scores in all knowledge categories. Moreover, the acquisition of additional knowledge and the application of improved control strategies significantly increase farm performance. It is also shown that farmers benefit from reduced trypanocide expenditures and are able to substitute these drugs by less expensive inputs.

**Keywords:** Burkina Faso, Mali, propensity score matching, trypanosomosis



# Biofuel and (international) trade

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## Food Miles and Agrofood Trade Between Africa and European Union

DJOKO NOUMODJE PATRICE

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In response to growing anxiety over climate change, policy-makers, firms and consumers are considering ways in which to reduce greenhouse gas emissions. A possible mitigation mechanism undergoing rapid development is food miles labeling. The “food miles” is well known and widely used by consumers interested in having more information available to them on how far food has travelled to make buying decisions. Of particular concern is to assess the capacity of low income countries to participate in food miles labeled trade and help assure that new opportunities exports are exploited. Research shows that the allocation of carbon dioxide emissions varies from one country/region/actor to another. So is there possible to recognise in any food miles labeling the concept of “fair miles”?

A multivariate regression model will be run to assess association between socio-economic and biophysical conditions by taking farm income as dependent variable, and quantity of fertiliser use (carbon dioxide emission) and cost distance to the market as independent variable. This will show that the cost distance to the market and the carbon dioxide emission explain the income potential of a farm in a given location. Statistical techniques (average, frequency,..) will be used to determine categories with ecological credit. If a category is able to produce goods that have lower carbon emissions per unit than the average category, then that category may expect to be rewarded for supplying the good demanded by consumers (and society). Rewarding the carbon efficiency producer serves to simultaneously encourage innovation in the food chain, and to bring about reduced atmospheric pollution.

The future strategies of maintaining/increasing access of sub-Saharan enterprises to industrialised country’s markets through carbon credit investment of elected categories will be found suitable for promoting sustainable development and equitable environmental protection.

**Keywords:** Carbon credit, climate change, equitable environmental production, food miles, sustainable development

## **Analysing the EU Canola Oil Trade with Developing Countries: A Gravity Model Approach**

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In recent years, many developed countries emphasised support for the production of biofuels in their political agenda. This new interest in biofuels arose mainly from the quest for increasing national energy sovereignty due to rising dependence on oil, but is also based on environmental concerns, and strong fluctuations of crude oil prices. Among others, the European Union (EU) has set a mandatory quota for the use of biofuel. By 2010, fuels used for transportation are required to have a fraction of 5.75 percent biofuel (biodiesel or ethanol). Whereas Brazil and the US are the major producers of fuel ethanol, Europe quickly became the world's most important producer for biodiesel. For European biodiesel production, canola oil is the main raw product. With this production of biodiesel, trade of raw products increased. Since the EU cannot satisfy its own demand, an import pull is created. Two main drivers are assumed to affect the amount of bilateral trade of European countries: (a) trade agreements with developing countries and (b) political measures like mandatory quotas in the EU.

This paper aims at evaluating the magnitude of the effect of European trade and sectoral measures concerning trade with external partners, especially developing countries. In doing so we control for steps of the value chain in examined countries, yielding an inference about the import pull created by downstream biodiesel industries.

In order to analyse the key factors related to the bilateral trade flows of canola oil for the use of biodiesel, a sector-specific gravity model is used. The empirical model uses cross-sectional data from 2006 for a sample of 41 countries, 24 of which are members of the EU, 18 of which are developing and emerging countries and the remaining being developed trade partners. We allow for zero inflated trade flows in the gravity equation in order to capture effects of potential bilateral trade relationships. A two stage Heckman estimator is applied to counter the resulting selection bias.

**Keywords:** Biodiesel, canola oil, gravity model, international trade, selection bias, zero-inflated data

## **Spatial Price Transmission and Market Integration Between Fresh Tomato Markets in Ghana: Any Benefits from Trade Liberalisation?**

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Spatial price transmission or market integration measures the degree to which geographically separated markets share long-run market information on homogeneous commodities. One very contentious issue in Ghana is the concern about the implications of trade liberalisation for spatial price transmission and integration of local tomato markets. Despite insufficient empirical evidence on how Ghana's tomato markets performed following trade liberalisation, prevailing public opinion blames perennially volatile and uncompetitive prices of tomato on the importation of tomato products into Ghana. To verify this opinion and contribute to the policy debate, we analyse monthly prices from four tomato markets to determine price transmission between them under a high tariffs and a low tariffs period following trade liberalisation in Ghana. We employ two variants of the threshold autoregressive (TAR) model for the analysis. Results from the standard TAR model reveal that the speeds of price transmission in each of the two periods under study are high, averaging about 49 % and 45 % in the high tariffs and reduced tariffs periods respectively. Using an extended TAR model which estimates speeds of price adjustment as time-varying parameters, we discover that price adjustment speeds are more rapid; averaging about 65 % under the high- and about 70 % under the reduced tariffs periods respectively. Our empirical evidence is therefore mixed, with results from the first model implying deterioration in the rate of price transmission, while those from the second model suggest an improvement in price transmission between tomato markets following trade liberalisation in Ghana. It appears the underlying factors responsible for price transmission and market integration in Ghana did not deteriorate over the period of trade liberalisation and there is no compelling evidence to suggest that trade liberalisation is responsible for the price volatility and marketing problem of fresh tomato in Ghana. Extensions to this study should consider the role of factors like seasonality, market power, road barriers, storage and processing on price transmission. Further research along these lines will improve our understanding of the problem and develop more nuanced policy recommendations for the sustainable management of the resources used for tomato production.

**Keywords:** Market integration, price adjustment, trade liberalisation

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## Do German Consumers Differentiate Between Fair Trade Certification and Charitable Giving?

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The reduction of poverty is one of the United Nations millennium goals. Whether aid, free trade or Fair Trade (FT) is the best way of decreasing poverty and increasing welfare in developing countries is still an open and widely discussed question in the scientific community. Not least because there are differences between values behind concepts, between topics taken into account (sustainability, environmental issues, societal aspects etc.) and between implementations – e.g. FT as originally North-South movement stresses market failures and seeks to implement longterm business relationships, special pricing mechanisms etc. whereas the central objective of today's aid programmes is poverty reduction.

Similar for FT (according to FLO certification system) and donations to developmental purposes is that they are the most common options allowing Western consumers to contribute to the realisation of the millennium goals. Because consumers interested in poverty reduction in developing countries can spend their money only once we analyse if German consumers prefer FT or donations or if they use them as substitutes. Moreover, if they make a difference, we investigate why they are making it. In times where the German donation volume stagnates and FT sales increase this is an important issue. Therefore, we raise the question how well informed German consumers feel about FT, charity organisations, their respective goals and the efficiency of both systems. Also, we want to know how much consumers think of 1 € given to each system should reach the needy person / the farmer. For this purpose we conducted a survey with n=112 in 2009 in Germany. We found evidence that even if knowledge about FT, donations, the goals and efficiency of the systems is sparse, German consumers differentiate between FT and donations. Besides this, the demanded efficiency for both systems is significantly different: if FT products are 1 € more expensive than conventional products consumers expect that at least 74 % of the additional charge goes to the producing farmer. Regarding charitable organisations they are thinking that these should work more efficient.

**Keywords:** Charitable giving, fair trade

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## Rubber Contra Biodiversity? An Analysis of the Adoption Processes of Selected Innovations in Xishuangbanna, Southwest-China

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Xishuangbanna prefecture in Southwest China is one of the world's "biodiversity hotspots" and an array of various ethnical groups with different languages, cultural traditions and land-use systems. Currently, the region experiences tremendous changes, mainly through the introduction of new crop varieties, in particular hybrid paddy rice, tea bush plantations and most important: rubber. The aim of the study was to analyse the diffusion processes of those crop varieties in order to identify relevant driving and inhibiting forces for the adoption of certain types of innovations. This allows predictions on the adoption likelihood of future innovations respectively essential requirements for future improvement of the existing systems.

Farmers decisions upon land use are quite complex. It is necessary to consider their perspective in order to be able to understand and to identify the relevant factors in their decision-making processes regarding land use changes. For this kind of survey, qualitative data collection approaches such as observation methods, narrative farmers' and open expert interviews were combined with semi-standardised household surveys.

The presentation will show the preliminary results of an in-depth analysis of exemplary adoption processes in selected villages and it will give a first overview on the identified relevant driving and inhibiting forces for the adoption and dissemination of more recent innovations within the formal and local knowledge system. In Xishuangbanna, a rubber-driven rural development leads to rapid socio-economic changes, but also to a fundamental cutback in biodiversity. Since rubber has become the driving engine for economic development in the area, nearly all suitable areas are already cleared and planted by rubber trees. Many households have given up their traditional farming systems and now rely completely on rubber. On the short run, it is hardly imaginable that any other cash crop may be able to compete with the pure economic performance of rubber production.

The question might not be on how to completely substitute rubber but rather on how to improve the existing rubber plantations towards a more sustainable production system in order to maintain the current status of biodiversity.

**Keywords:** Adoption, biodiversity, China, diffusion, force field analysis, innovations, knowledge systems, rubber, situational analysis, Xishuangbanna, Yunnan

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## Consumers' Attitude, Willingness to Pay and Preference Towards Organic Vegetables in Kathmandu Valley: A Conjoint Approach

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Demand of organic vegetables has been increasing in the Kathmandu and niche markets are established. Several factors leading to rise in demand are increasing purchasing power of the consumers, health and environment awareness, tourist inflow and education. However, organic vegetables are not certified and market is running in truth basis. Realizing the need to study how consumers perceive organic vegetables, at what extent consumers would be willing to pay, what factors make consumption appealing to consumers and what consumer values take priority over others in terms of socio-demographics, present investigation was carried out at Kathmandu valley using conjoint full profile approach with 3 attributes (vegetable types-organic/non-organic, quality- good/poor and price-high/low) and ordinary least square regression was applied for finding part-worth utilities. Questionnaire based on conjoint analysis technique was developed after pilot study and 90 consumers from organic and inorganic markets were interviewed. Original ranks were first aggregated and utility function model was developed and later market segmentation was done to form homogeneous groups and simulation was made accordingly.

Study demarcates that most of the consumers are aware about quality of organic vegetables; however, knowledge about their availability in the market is poor. On an average, the willingness to pay for unlabelled and labeled organic vegetables is NRs 5.07 and 8.47 per kg over non-organic vegetables respectively. Multiple regression result shows that socio-economic aspects of the consumers such as education, personal affiliation in job and family income play crucial role in willingness to pay for organic vegetables. The estimation of the relative importance suggests that vegetable purchase decision is basically governed by the attribute price; lower is the price of the vegetables, better will be the chance that most of the consumers would prefer and buy. Utility function model envisages preferential differences in terms of market types, family size, education and income. The study shows that niche organic vegetable markets should be developed targeting certain segments of the consumers who would be willing to pay more for organics and certification should be initiated to give credence to the consumers and provide benefit to the producers.

**Keywords:** Conjoint analysis, Nepal, organic vegetables, part worth utility, willingness to pay

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## Linking Natural Resource Management with Market Oriented Commodity Development: Case Studies from the Ethiopian Highlands

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Ethiopia has been in continuous struggle to achieve the three objectives of increasing agricultural production, reducing poverty and ensuring sustainable use of the natural resources, especially since the early 1990s. Increasing population pressure on an already degrading land resource has rendered the struggle even tougher. A significant increase in agricultural productivity can not be attained if the land resource base continues to be degraded. Hence, ensuring sustainable land management is a matter of critical importance for agricultural growth in Ethiopia. A number of programs and projects for sustainable land management have been implemented in Ethiopia since the early 1970s, aimed at promoting private and collective efforts to conserve natural resources. In designing policies, programs and projects for sustainable land management, it is of critical importance to make a distinction between the proximate (direct) and underlying (indirect) causes of land degradation. Efforts for sustainable land management need to address the underlying causes primarily, as focusing on the proximate causes would mean to address the symptoms of the problem rather than the actual causes. In this paper we focus mainly on the effect of short-term benefits to farmers from sustainable land management practices and the explicit considerations of the linkages between natural resource management and market oriented commodity development. We hypothesise that linking natural resource management with market oriented commodity development enhances sustainable land management by providing farmers with short-term benefits. We test this hypothesis with analysis of case studies of four districts in the highlands of Ethiopia. Two of the case studies deal with the linkage between forage resource development and market oriented livestock development, and the other two case studies deal with the linkage between conservation agriculture and market oriented wheat production. Results indicate that, indeed, direct linkages of natural resource management with market oriented commodity development that have profitable market opportunities can enhance sustainable land management.

**Keywords:** Causes of land degradation, land degradation, market oriented commodity development, short-term benefits, Sustainable land management

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## Maize Boom in the Uplands of Northern Viet Nam: Economic Importance and Environmental Implications

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In Viet Nam, the demand for meat products has grown dramatically due to rapid economic growth and urbanisation and is expected to further increase in the future. Being the primary source of feed for the country's livestock and poultry industry, maize has become the second most important crop after rice. While this maize boom has the potential to reduce rural poverty, it promotes the expansion of agricultural cultivation into fragile agro-ecological zones, often leading to deforestation and soil degradation, especially in the uplands. Using empirical evidence from the mountainous district of Yen Chau in north-western Viet Nam, the objective of this paper is to investigate the current economic importance and the environmental implications of maize cultivation. Furthermore, applying a Tobit regression model, particular emphasis is placed on the identification of factors that influence farmers' decision how much area to allocate to maize in order to derive research and policy recommendations.

Maize is the dominant crop in Yen Chau, covering most of the uplands and generating 65 % of households' total cash income, on the average. Although farmers are well aware of soil erosion on their maize plots, effective soil conservation measures are rarely practised. Maize is attractive to farmers from all social strata, notably the poor. It is comparatively easy to obtain in-kind credit for maize production from maize traders or via village-level institutions. Although the interest rates charged are typically high, this is attractive especially for the poorest farmers living in remote areas. We conclude that access to low-interest formal credit should be enhanced to facilitate crop diversification and mitigate farmers' risk of being caught in a poverty trap when maize revenues plummet due to pests, diseases, price fluctuations, or adverse weather conditions. To address the problem of soil degradation in the maize-dominated uplands, research is needed on soil conservation options that are economically more attractive than those promoted thus far. Since the livestock sector in Viet Nam is rapidly growing, technologies that produce feed and are easily combined with the current production of maize may be particularly promising.

**Keywords:** Environmental sustainability, maize area expansion, Tobit regression, Viet Nam

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## **Trade-offs Between Agricultural Practices and Environmental Quality: An Econometric Assessment of Chemicals Use and Wildlife Loss**

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The motivation of this work is based on the empirical evidence showing that pesticides use has direct consequences on wildlife. Such relationships are however not straightforward; they are characterised by complexity, interdependence and uncertainty. The appropriate model specification of the agricultural production function for productivity estimation of damage control inputs has dominated the debate since the first research efforts. However, less attention has been paid to farmer adaptations in response to a change in pesticide prices.

The analysis of farmer's adaptations to economic policies is essential for designing effective instruments. Taxes on pesticide use have prevailed as an effective economic instrument. However, relatively research effort has been devoted to farmer's adaptations to taxes. A single tax on all pesticides is possibly the most cost-effective instrument, but is likely to be ineffective since it would not take into account the basic differences on toxicity levels and the amount of damage to environment when different pesticide are used. A tax on a single pesticide could remedy such situation. However, a farmer dealing with a change in pesticide price will allocate the whole own resources accordingly. There is evidence that a pesticide tax on a pesticide modifies the use of another pesticide (possibly more damaging) which is simultaneously used by a farmer before the tax was imposed. Hence, besides the reduction of the targeted pesticide, these 'side' effects have to be assessed when designing policy instruments. If the aforementioned side effects are more damaging to the environment, a single pesticide targeted instrument may incur larger benefits to society.

The analysis centred on production technology modelling using a parametric approach. Using a multi-crop production framework, the substitutability between pesticides and farmer's adaptations to changes in pesticides price is analysed, where each farmer produces several crops and uses several pesticides. The underlying relationships will be assessed through an econometric approach that takes into account the interactions among agricultural practices (pesticide use) and nonpoint pollution with impacts on environment. It is essentially intended to explore issues around an optimal pesticide regulation though more effective economic instruments.

**Keywords:** Damage function, econometrics, Mexico, pesticides, wildlife

## **Agricultural Biotechnology and Sustainability: Evidence from Shandong Province, China**

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In this paper, the question of sustainability of biotechnology solution in Chinese agriculture is addressed by means of a case study in five cotton growing villages in Linqing county, Shandong Province, China, where Bt cotton varieties were first approved in 1997. Panel data of village and farm characteristics as well and in particular on cotton production were collected from 150 farmers through season-long monitoring in 2002 and 2005, leave samples from all the monitored fields were also collected in both years to assess the actual concentration of Bt toxin.

The study consists of both descriptive statistical analysis and modelling approach. The descriptive comparison of cotton production in the two observation periods shows even higher pesticide dosage, still large proportion of high toxic pesticides and dramatic drop of Bt toxin concentration in the later period, which indicates that the cotton farmers in China have to fight against the considerable uncertainty about the quality of seeds, fertiliser and pesticides as well as various pests and casts cloud over the sustainability of biotechnology in the study area. A stochastic bio economic simulation model is used to probe into different combinations of three different seed choices - high or low quality Bt, conventional varieties - and three intensity levels of insecticide use - no spray, moderate spray, farmers' practice, according to which it can be shown that under the institutional conditions with considerable input uncertainty the cotton farmers in China behave economically rational when opting for cheap local genetically modified Bt cotton seeds combined with moderate use of pesticides rather than high priced Bt cotton seeds and reduced insecticide use against the cotton bollworm. The paper shows that agricultural biotechnology requires supportive institutional conditions in order to provide a sustainable solution to biotic stress factors such as insect pests. The paper also identifies some gaps in knowledge and deficiencies in the institutional frame conditions that need to be addressed if agricultural biotechnology through genetically modified crop varieties will live up to its promise.

**Keywords:** Biotechnology, China, sustainability



# Ecosystem service payments

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## Hydrological and Economic Modelling for Setting up Payment Schemes for Environmental Services in Latin America: A Comparison of Models and Approaches

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Latin America is currently going through a revolution in payment schemes for environmental services (PES), thanks to strong institutions, clear market opportunities, and a number of high profile success stories. However, many schemes also fail after a number of years due to a range of different reasons. We believe that one of the keys to success of payment schemes is that they are established based on a sound set of goals, for which all actors involved in the PES are aware of. In order to set these goals, sound science is required for the more optimum valuation of expected biophysical and economic benefits. In this paper we test different modelling and analysis tools for setting the social, economic and environmental service goals for a PES through the development of a case study around the compensation payment for watershed services (discharge in dry season and sediment load) from downstream commercial agriculture services users to upstream smallholder service providers in the Central Cordillera of Colombia. For 9 case study catchments, three hydrological models (SWAT, FIESTA and INVEST) are applied using differing levels of ground-based information availability for the zone, against discharge data collected from the field in order to provide a valuation of watershed service flows. The pros and cons of each model are evaluated, and recommendations are made on the criteria for selecting the most appropriate modelling approach depending on the broader context of the PES and physical conditions of the study area (e.g forested vs. agricultural landscapes). Economic models are then discussed for evaluating the potential costs and benefits of the PES, and a set of good practices are recommended. The paper concludes by evaluating the difference in model outputs based on the different modelling approaches, and discussing how these might affect the likelihood of success for the establishment of a PES.

**Keywords:** Economic models, hydrological models, payment schemes for environmental services (PES), watershed

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## Challenges in Integrating Biodiversity Conservation and Local Development: A Case Study of Ang Trapeang Thmor (ATT) Protected Area in North West Cambodia

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A common approach to protected area management efforts in developing countries is to address the problem of maintaining local economic development whilst conserving biodiversity by applying the Integrated Conservation and Development Projects (ICDP) approach. The ICDP approach seeks to offer sustainable alternatives to traditional methods of conservation management. The central assumption behind ICDP is that local people and their livelihood practices are the most important threats to the biodiversity, and thus, diversified local livelihood options and local community participation will reduce human pressure on biodiversity.

Ang Trapeang Thmor (ATT) is a protected area in North-West Cambodia, which was designated in 2000, and covers an area of 12650 ha consisting mainly of a large reservoir, and serves as habitat to the highly endangered *Sarus crane*. Eight villages border the area. This study focuses on the conservation and management of ATT crane sanctuary and its surrounding areas in light of an ICDP. The study investigated how the designation of the ATT as a protected area has affected the livelihoods of the people in two villages bordering ATT.

The findings revealed that the designation of the protected area has had a very negative impact on the livelihoods of the villagers. Restrictions to access and user-rights to land and management of resources around the area resulted in the loss of a large proportion of agricultural land, thus severely jeopardising most villagers' primary livelihood. The loss of agricultural land combined with a boom in cassava prices led to encroachment and cultivation of cassava by villagers into a state forest East of ATT. Conflicts arose between the studied villages and several other downstream villages over irrigation and the control of water resources. The general perception of the local populations regarding ATT is unsurprisingly negative (88 %). This is probably because the local populations passively participate in the management of the protected area and due to the lack of understanding of the aims of the conservation project.

This case demonstrates the difficulties in finding the balance between conservation and development and the importance of sufficient level of participation of local populations for the success of ICDP projects.

**Keywords:** Biodiversity conservation, community participation, conflicts, livelihoods, natural resources, *Sarus crane*

## Contribution Behaviour Towards Collective Management of Common Pool Forest Resources in Western Kenya

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Kenya has a forest cover of 1.7 % while deforestation and degradation still continues. Unless this trend is slowed, livelihood sources of many of the poor communities surrounding the forests will be lost and greenhouse gas emissions from forest loss will contribute to global warming. One of the commonly cited reasons for the continued deforestation is the lack of involvement of the local communities by the central government in managing forest resources adjacent to them. To address this, the government of Kenya revised and enacted a new forestry policy in 2007 which provides for the involvement of adjacent communities through collaborative forest management (CFM). Yet, for CFM to be successful, community members need to behave cooperatively. Literature indicates that this is not always the case as communities are not composed of homogeneous groups who act in the interest of the larger community. To examine the level of cooperative behaviour and institutions to control uncooperative behaviour, we conducted economic experiments using randomly selected household heads from villages surrounding Kakamega forest in western Kenya. In the experiments, each person was endowed with 10 money units (MUs) from which they were expected to contribute any amount ranging from 10 (everything) to 0 (nothing) towards a group conservation kitty for financing conservation activities of their hypothetical communally owned forest resource. The experiment was designed so that pay-offs (each MU had a value of 0.01 Euros) were highest for individuals if all participants contributed everything to the kitty. Twelve rounds of the game were played with two scenarios: with and without sanctioning rules. There was a significant difference ( $p = 0.05$ ) between mean overall contributions without sanctioning rules (5.13 MUs) and with sanctioning rules (7.32 MUs). This underscores the importance of sanctioning rules and their enforcement if high cooperative levels are to be expected under social dilemma situations like voluntary conservation of a common pool resource. The results have important policy implications for the design of CFM projects in Kenya.

**Keywords:** Common pool resource, deforestation, degradation, economic experiments

## Comparison of Methods to Economically Value Irrigation Water in the Qazvin Irrigation Network (Iran)

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Physical availability as well as an adequate allocation of irrigation water are two of the most pressing resource management issues globally. From an economic efficiency perspective, the economic value of irrigation water supplied by public irrigation infrastructure should be a central aspect in water pricing and allocation. Likewise, it is widespread engineering practice to justify plans for new irrigation infrastructure with cost-benefit analyses which, in turn, require data on the economic value of irrigation water. In absence of water markets, market prices are not available in many tropical and sub tropical areas in need of irrigation water, and low efficiency is a widespread problem. We report on the results of a comparative study using three different methods to determine the irrigation water value in the Qazvin irrigation network in northern Iran. Current water fees do, by far, not cover water production costs/not even cover operation costs. This fee was 42.8 Iranian Rials per cubic metre of irrigation water for 2005. A field survey was conducted in 2005–2006 in part of Qazvin irrigation network area. Via the contingent valuation method (bidding game), farmers' willingness to pay for additional units of irrigation water was assessed as 197 Iranian Rials  $m^{-3}$  of irrigation water from canals. The hypothetical nature of the method and some strategic responses may have resulted in understatements of true water values. Thus, a stochastic frontier analysis was used to correct for undervaluation bias. The value marginal product method resulted in a value of 430 Iranian Rials  $m^{-3}$  of irrigation water. Cobb Douglas and Translog functional form were used to estimate household production function. The change in net rent method is the most commonly used in the *ex ante* assessment of irrigation projects. Theoretically, the method is known to compromise accuracy for ease of application. It indicated a value of 1076 Rials  $m^{-3}$ . We conclude that results differ substantially, and that the net rent probably yielded the most unreliable estimate. Our results suggest that higher water prices in Qazvin irrigation network would be justified.

**Keywords:** Change in net rent method, contingent valuation, economic value, irrigation water, stochastic frontier, value marginal product

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## Designing Conservation Auctions in Developing Countries: Insights from Field Experiments in Kakamega, Kenya

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Payments for ecosystem services (PES) are an increasingly used instrument both for financing and implementing ecosystem conservation. PES could help to implement conservation measures such as corridors and buffer zones for Kakamega Forest Protected Area in Kenya. However, because landholders' specific costs are not known to the conservation agency, procurement auctions have been conducted (in developed countries e.g. US and Australia) and shown to be effective instruments to reveal these costs. The main goal of this study is to experimentally investigate the effectiveness of different auction designs: the price rule defining how auctions' winners are paid (whether uniform or discriminative prices) and if communication and learning effect over time affect the effectiveness of the auction.

Because more complex auction design may become analytically intractable, more complicated settings have been tested using experiments with human subjects (economic experiments) or artificial intelligence (agent based models). In this study, economic experiments are used to investigate the bidding behaviour of landholders around Kakamega Forest. In these experiments, PES auctions are simulated where landholders participating in the experiments are the buyers and the experimenters, the sellers. Four treatments were designed to allow the test of price rule and communication separately in repetitive auctions with 10 periods. In total, sixteen experiments were conducted in four villages.

Results show that the discriminative price rule is more cost effective than the uniform price, however the effect of communication has not been shown to be significant. Further tests are being conducted to investigate learning effects over time. The results of this study give insights to cost-effectively implementation of PES via conservation auctions, contributing to conservation policy in developing countries.

**Keywords:** Conservation auctions, Kenya, payments for environmental services

# Financing and marketing

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## The Efficiency of Cooperatives and their Influence on Poverty Alleviation: An Institutional Analysis in the Ethiopian Dairy Sector

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The presentation will focus on the organisation of cooperatives in the dairy sector in Ethiopia and discuss their contribution to poverty alleviation.

Starting October 2008, literature surveys, mainly from the International Livestock Research Institute in Addis Ababa, supported by expert interviews were implemented. During a field trip in February 2009 an in-depth situational analysis has been conducted combining extensive observations and semi-structured interviews with different stakeholders.

In the scope of the interdisciplinary Ethiopian-German research cooperation “Food Value Chain Analysis - Institutions, Challenges, Education. The Case of Dairy in Ethiopia” the authors examined the efficiency of organisational structures in the dairy value chain. The dairy sector in Ethiopia consists to a large extent of smallholders practising backyard farming with only a few animals. Due to a vast amount of fasting days there is no constant demand for fresh milk throughout the year. Furthermore, farmers face problems of fodder and water shortages, lack of extension services and a lack of power due to institutional inconsistencies. Cooperatives are an important key element to enable smallholder market access, a constant supply of fodder and extension services, and to strengthen their position based on collective action. Cooperatives constitute the opportunity to use natural resources sustainably and to contribute to poverty alleviation.

Based on the findings of the New Institutional Economics, we used the transaction cost approach by Menard to show the inefficiencies and institutional problems within the organisation structures. We identified informal relationships, imbalances of power, opportunistic behaviour and conflicting interests in the management as the main factors hampering efficiency. For future improvements there is a tremendous need to increase transparency of internal decision processes combined with a continuous capacity building of the cooperatives’ members.

**Keywords:** Dairy value chain, Ethiopia, institutional analysis, natural resource management, organisational structures, poverty alleviation, transaction costs

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## Emerging Challenges for Farm Labour in the Indian Coffee Sector

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Agricultural production systems in India are often labour intensive and exposed to a high level of farm risk. Though agricultural labour is considered to be abundant in most parts of rural India, the coffee sector of Karnataka state is subject to conditions pointing at a different dynamic. Coffee production in Southern India offers little scope for mechanisation and is consequently dependent on labour, and as such representing the most sensitive production factor. Given that labour shortages frequently occur, labour is furthermore an issue associated with risk, especially for plantations growing Arabica coffee. The analysis of the coffee sector in Karnataka indicates a consistent scarcity of labour in recent years, which is likely to jeopardise both the production system and the local economy. The irreversible movement of labour out of the agriculture sector has doubled agricultural wages for the past five years. Results further indicate a yield reduction for medium and large plantations of up to 30 percent thus affecting the returns and profitability of the respective coffee farms. It is observed that the backward bending labour supply curve is demonstrated among the labours as the number of working days has been relatively reduced to previous years with lower wage rates. While small coffee plantations are able to cope with the scarcity of agricultural labour by a substitution of family labour, medium and large coffee plantations are facing distinct problems to fetch manpower resources, putting the viability of the sector at stake. Strategies to overcome the scarcity of agricultural labour are needed particularly for medium and large plantations to secure the sustainability of the corresponding livelihoods in the long run. Apart from challenges related to the skills and quality of the labour force, it is concluded that incentives for labours such as a contribution of cash and kind, a fixation of standard wage rates as well as the acquisition from labour surplus areas may ease the emerging problem to some extent.

**Keywords:** Agricultural labour, coffee sector, farm risk, India, labour scarcity

## The Impact of Coffee Production on Nepali Smallholders in the Value Chains

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The ecological settings in the Himalayan hills provide a unique opportunity for resource poor farmers to sell their organically produced Nepali coffee as specialty coffee to the global market. The central question of this study is whether organically certified as opposed to conventional marketing chains provide better livelihood opportunities to the smallholder coffee farmers.

To answer this question, semi-structured interviews have been conducted with 120 coffee households in Gulmi and Kavre districts in August-October 2008. Three villages were selected in each district according to criteria of high (>1000 m), medium (850–1000 m) and low (<850 m) altitudes. In addition, six focus group discussions with coffee producers in each village and six expert interviews have been conducted. Coffee from Gulmi district is sold through the cooperative that has organically certified, while in Kavre district it is sold to the non-certified conventional market chain. Findings of the study reveal that most Nepali coffee producers have little power and trust in trade; in addition to asymmetric market information, there is a lack of adequate support in farm level upgrading activities. Econometric results show that especially the variables distance to input markets, trust in trade and whether there is a personal relationship between the producer and the cooperative or company determine upgrading possibilities at the farm level. The price premium to the certified smallholders seems to play a less important role, although organic certification is seen as a passport to enter international markets. Inconsistencies in coffee quality and low quantity supply are major entry barriers to the international market. Estimated results from the regression analysis indicate that annual household income from coffee was significantly determined by experience in coffee cultivation, productivity of coffee, upgrading practices at farm, information about coffee price, number of trainings and distance to the inputs markets. Therefore, investments should be made in product and process upgrading by improved production management through extension and investment in wet processing at farm according to altitudes.

**Keywords:** Nepali smallholders, organic certification, specialty coffee, upgrading, value chains

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## **Global Rise in Food Prices and Countervailing Measures: Analyzing Determinants for Heterogeneity in World-Wide Policy Response**

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This research seeks to contribute to the ongoing world-wide discussion about appropriateness and motivation of policy reactions to rising world food prices, as well as to provide information on why various governments and policy makers in attempting to react to soaring food prices chose certain policy types. It highlights the true motivations of governments in addressing a global food crisis based on political-economic theories of food policy. The interaction between policies taken by various countries world wide in response to the 2008 global food crisis, and their respective drivers were examined. Countries affected by soaring food prices have responded in various ways and the institutional policy heterogeneity that emerged was found worthy of being analyzed. With the use of descriptive statistics and multivariate regression analysis, panel data from the World Bank's aggregate governance indicators and FAO's database on basic food market situation of countries were analyzed between 2006 and 2008. Results showed that the adequacy and heterogeneity of global responses as countervailing measures depends to a large degree on the governance infrastructure in existence, macro-economic indicators, policy and program-related reactions of national-level policymakers. Tax reduction on food and other trade measures such as lowering/abolition of import tariffs were the most common policy response imposed by net food importing countries. Close to 30% of countries outside sub-Saharan Africa used food grain stocks, export taxes and quantitative export controls to increase supply, stabilize domestic market and curb price shocks. Aggregate global policy responses were more producer and trade oriented than consumer oriented. There was a significant relationship between single policy response to high food prices taken by countries and their food trade/market situation, population size, urbanization, landlockedness, food price protest, governance indicators and some macro-economic factors. Recommendations on ways by which countries could enact collective actions according to common country food market characteristics that could lead to a more effective food crisis policy response in the future will be presented.

**Keywords:** Food crisis, food market, political economy, food policy, world-wide policy response

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## Upgrading of the African Cashew Subsector: Synopsis of the Strategy of Value Chain Promotion in Benin

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Value chain promotion is a central element of Benin's policy to create pro-poor growth on the basis of a competitive agriculture. "Cashew" is one among 12 chosen subsectors.

The ValueLinks approach - developed by the German Technical Cooperation (GTZ) - has been applied to selected value chains of the cashew subsector by private-public working groups. Participatory analysis focusing on selected value chains identified upgrading projects (drafts) comprising a joint upgrading vision, fields and activities of improvement, and next steps towards their validation by a larger value chain community at national level. During the final workshop, attended by more than 100 representatives from private and public sectors as well as donors, the necessity for harmonisation of the diverse support assets provided by the government and development programs has been largely recognised. Temporary coordination structures under private leadership, *i.e.* lead enterprises and professional organisations with support from governmental organisations and development partners, have been established to implement the next steps prior to the validation events that will include a larger and more representative value chain community.

For scaling up, a new project implemented by GTZ in cooperation with African Cashew is established in five sub-Saharan African countries. This new project is expected to create, 5,500 new jobs in cashew processing within four years and an additional 15 million US-Dollars in revenues per year generated by 150,000 small-scale cashew producers.

To achieve these objectives and to strengthen the competitiveness of the African cashew subsector, the stakeholders must join their forces, talents, and experiences to promote value chains by enforcing the public and private partnership in terms of sustainable capacity building.

**Keywords:** African cashew, public and private partnership, value chains promotion

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## Small Agricultural Producers Linked to High Value Agri-Food Markets: The Experience of Asian Vegetable Production in Honduras

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Proponents of broad-based economic growth strategies (growth with equity) to reduce poverty in developing countries emphasise the significance of small producers participation in high value markets. In this context, niche markets such as Asian vegetables consumed in the United States represent an excellent opportunity for Honduran producers because of the relatively small production volumes demanded and the resulting income-enhancing opportunities. However, evidence suggests that these potential opportunities are not utilised automatically; in fact it depends on particular economic, social, political and environmental conditions. This study presents how small producers have connected to high value markets through their insertion in an evolving network of contrasting relations such as interdependence, cooperation and confrontation. Expert interviews with different actors of the chain were carried out. The results show that this linkage was initially established by the private sector initiative influenced by the confluence of several distinctive elements but without direct intervention of the government and other third parties. Small producers' connection to the market has been reached through linkages with agro-exporters to whom they sell the product based on contractual arrangements which define resources access. However, outcomes are mixed and turn out complex. Pest problems have emerged in some regions due to inappropriate crop management. Moreover, the cost of inputs has increased considerably and technical support is irregularly available. For the majority of these small producers of Asian vegetables, income is stable and higher compared to small producers of staple crops. Nevertheless, most of them are still poor. Their perception is that economic gains are not fairly distributed among the various actors in the chain. Likewise, lack of trust between the parties is ever present. Remarkably, a group of producers by means of this experience has gained a better understanding of marketing activities and hence feels prepared to adopt a much more commercial approach. Consequently, this group of producers has resorted into working collectively, trying to export on their own.

**Keywords:** Economic growth, high value markets, network relations, poverty reduction, small producers

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## **Governance Relations on the Global Value Chain of Northeast Brazil's Grapes and Mangoes: The Influence of Private Standards on Local Bargaining Competencies**

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Authors engaged with the study object of Global Value Chains (GVC) and globalisation of agriculture stress that the institution of grades and standards as groundwork of market regulation and coordination is a central feature of the globalisation process, being the former a fundamental entryway for the international market. The extent to which compliance to international market standards enable the capture of more value-added activities in global market is a major trait of developmental processes on global value chains nowadays. But the degree to which it promotes actual competitiveness of local players is, however, not so clear. A study project on a producing region of fresh grapes and mangoes in northeast Brazil illustrate the case of local actors involved in a strong agribusiness sector on irrigated fruit production which for some years has lived the process of overarching productive restructuring to comply with demands of main international consumer markets for mangoes and table grapes. Although in preliminary phase, the study project is already supported by data collected in exploratory interviews with fresh fruit and vegetables (FFV) GVC's key actors and the outlines of a longer research conducted by the Globalisation of Agriculture Research Group in the Federal University of Pernambuco on the aimed research region, the San Francisco Valley in Pernambuco, Brazil. The work seeks to illuminate on the dilemma of the vulnerability of local actors in the attempt to cope with quality perceptions and arrangements structured by international players. According to collected data quality standards are an increasingly important framework which influences productive parameters, local rhythms and strategic possibilities for economic development and social change, promoting particular advancements in food safety, social and environmental responsibility at the same time that enforce the reproduction of power asymmetries and the shrinking of actors' bargain competencies upstream. The latter point to the necessity of investigating the build up of competencies related to the structuring of market coordination instruments and quality assessment.

**Keywords:** Bargaining competencies, global value chains, globalisation, private standards

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## The Role of Micro-Financing in Poverty Reduction in Azerbaijan

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In this contribution the poverty level in Azerbaijan and the influence of the micro-financing on the poverty reduction is analysed. For this analysis reports from micro-finance associations were used.

It was found that a higher GDP growth as influenced by increasing income from oil reduced the poverty rate in the country from 49 % in 2001 to 15.8 % in 2007.

The weak development of the the non-oil sector, missing infrastructure in the regions, and weak structures for small enterprises play a considerable role on the low income level of the rural population. The small and medium sized companies in the non-oil sector do not dispose of enough funds to finance their production cycle, or to develop their business.

World wide is it shown tha, especialy in poor countries, micro financing can be an important instrument in poverty reduction. The micro finance sector is well developed in Azerbaijan over the last 10 years. The number of people borrowing money via these financial institutions has become more than 300 000 and the loan portfolio amounts approx. 600 thousand \$ (1.5 % of the GDP).

Through micro financing small and medium sized enterprises they get access to funds to continue their production and to extend. Also, the short treatment time to obtain a loan and the little security demand are also decisive. The trust of the population in the financial systems has grown although the higher inflation rates since the fall of the Soviets have reduced their savings.

The investigation of 2 000 borrowers showed that through the micro financing their poverty level decreased. Further, the analysis showed that old borrowers have higher income levels and lower poverty levels as compared to people that are just starting to get loans through micro finance institutions. In conclusion the micro financing has a strong positive influence on the reduction of poverty and raise income in the rural area of Azerbaijan.

**Keywords:** Azerbaijan, microfinance, poverty reduction



## Comparison of two *Jatropha* Production Approaches Targeting Bioenergy Supply in Tanzania and Madagascar

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With the worldwide agro fuel boom, international companies started to invest in local agro fuel production in Africa. Several companies have come to regard *Jatropha* seeds as the preferred feedstock for liquid agro fuel production. To produce *Jatropha* different business models like contract farming or plantation estates are applied. These different approaches vary with respect to their effects on the involved farmers and, therefore, rural development. This article is based on a literature review and the authors' socio-economic analysis derived from local household surveys. It addresses the pros and cons of the following two production models. First we take into account the case of a contract farming model in Tanzania which targets smallholders as contracted outgrowers. These outgrowers can sell their *Jatropha* seed production to the investor at a guaranteed price. Further we look closely on a plantation model in Madagascar where an investor offers income for labourers working on the plantation. By using socio-economic analysis we compare the two systems and describe which parts of the rural population are participating on *Jatropha* production with respect to the production model. We conclude that, despite the lack of knowledge on *Jatropha* production, both systems have the potential to push rural development by creating additional income possibilities for the rural population. However, the *Jatropha* value chain and market structures are still in an initial stage. Therefore, scientific monitoring and support, especially on the production side, is required. Further research on possible effects on rural development is recommended.

**Keywords:** Agro fuels, *Jatropha*, Madagascar, rural development, Tanzania

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## Foreign Direct Investment in Agricultural Production: Win-Win Deals or Neocolonialism

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Agriculture and rural development plays a significant role in alleviating poverty, improving food security, and increasing economic growth. Foreign direct investment (FDI) in agricultural projects by state-owned or private companies of developed countries in low-income countries and elsewhere has increased recently, perhaps fuelled by the food and energy crisis. The scale of the land acquisitions and leases have caused some concerned voices to term the phenomenon as land grabbing and possibly neo-colonialism. Throughout the world, land is a critical resource with direct links to food security and poverty alleviation. However, developing countries often lack the investment capacity to increase their agricultural productivity, hence; foreign direct investment in agriculture may provide a win-win situation for the investors and the host countries especially the rural population. The paper builds on an extensive review of scientific as well as popular literature and also on interviews with experts in the North and South. The aim of the research is to explore the potential benefits, risks and costs of foreign direct investment in agriculture for various stakeholders, in particular smallholders and the rural poor in developing countries. We give an overview of the state of FDI in agriculture, the actors and the host countries, the prime motivation of actors, how the contracts are set up between the investors and the host country government, the factors influencing the terms of contract and the conditions for maximising benefits and minimising risks of FDI in agriculture. The research is rooted in the concept of critical triangle of development consisting of equity, economic growth and environmental sustainability. Infrastructural development, social development, employment creation, and stronger multiplier linkages to the domestic economy are some of the potential benefits of the investments. In order to have a win-win situation, equitable bargaining power and equitable share of benefits among the investors, the host government and the local people are necessary as well as strict enforcement of agreements. Contracts should give conditions for sustainable resource use and emphasise environmental impact assessment beforehand to prevent loss of biodiversity. Political and institutional changes such as land tenure system and technological changes for specific countries should be fully understood by the investors.

**Keywords:** Economic growth, environmental sustainability, food security, foreign direct investment, land tenure, neocolonialism, poverty alleviation

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## Financing, Handling, Hardening and Marketing of Tissue Culture-Derived Planting Material through Nurseries: The Case of Banana in Kenya, Uganda and Burundi

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The distribution of contaminated planting material (suckers) remains a major cause of spread of pests and diseases in banana. A traditional subsistence staple in East Africa, banana is becoming increasingly a commercialized commodity in the region. Essential for effective commercialization of this crop, however, is the supply and use of uniform and healthy planting material. Tissue culture (TC) technology can help provide this. However, TC plantlets are delicate and require substantially greater care and handling than conventional sucker planting material. To distribute TC seedlings to farmers and improve their robustness for successful use on farms, numerous hardening nurseries have been established by TC producers in Kenya, Uganda and Burundi. These nurseries are pivotal in the dissemination of plantlets. In 2008, financing, handling, hardening and marketing of TC-derived planting material through nurseries was assessed using semi-quantitative interviews of nursery operators. The nurseries in Kenya and Uganda are mostly farmer-led and obtain their material from the producer. In Burundi, the nurseries are owned and centrally managed by the producer, while daily activities are handled by technicians. In each country, water supply was identified as a key limiting factor, as the young plantlets desiccate easily. In farmer-led nurseries, plantlet transport and phytosanitary measures, such as soil sterilization and plant protection, are often limited, which can lead to significant plant losses. Governmental and non-governmental institutions purchase large fractions of the TC planting material. Public extension services for TC nurseries were evaluated as poor, leaving the TC producers as the single source of information for nursery operators. Additionally, plantlets tend to be viewed as relatively expensive, while supply is currently sub-optimal, compared to traditional planting material, resulting in a relatively limited and exclusive market. TC planting material in the region is therefore yet to become sufficiently available for most banana farmers.

**Keywords:** Agricultural management, East Africa, horticulture, seed systems

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## Economic Instruments to Promote Carbon Sequestration in Silvopastoral Systems in Central America: When and How Much Should Be Paid?

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In search of possibilities to reduce carbon dioxide (CO<sub>2</sub>) emissions from deforestation and soil degradation caused by cattle production, technology alternatives to extensive grazing are rediscovered which have a less detrimental impact on the integrity of natural resources and human health - those alternatives include silvopastoral practices like dispersed trees in pasture. Extensive research carried out in Central America demonstrates that well designed silvopastoral systems present a win-win situation for farmers and the society since they have the potential to increase cattle productivity and to generate environmental services like carbon (C) sequestration and biodiversity protection. Despite private and public benefits, adoption rates of silvopastoral systems have been low what lead to the use of different economic instruments in the region to compensate farmers for the provision of environmental services on cattle paddocks.

In the first part of our study we develop a model to simulate the incorporation of different tree densities into pastureland through natural regeneration on cattle farms in Costa Rica and Nicaragua, and we determine their C sequestration potential as well as changes in meat and milk yields. Improved pastures with a tree canopy coverage of 20 % have the highest net present values in both countries and sequester 104 t CO<sub>2</sub> ha<sup>-1</sup> over a 30-year period without the need for compensation payments. In Costa Rica, canopy coverages lower and higher than 20 % require C payments in the range from US\$ 0.8 to US\$ 4.5 per t CO<sub>2</sub> whereas Nicaraguan farmers are able to carry out the respective land-use changes without payments. In the second part of the paper we analyse the cost-efficiency of different economic instruments which could be or already have been used to remunerate cattle farmers for C sequestration services. Those instruments include: payments for environmental services (PES) offered by Costa Rica's National Forestry Financing Fund for the establishment of agroforestry systems; Global Environmental Facility (GEF) funded PES for C sequestration and biodiversity protection through silvopastoral systems, and Certified Emission Reductions (CER) as they are issued for afforestation and reforestation project activities in the Clean Development Mechanism (CDM) of the Kyoto Protocol.

**Keywords:** Costa Rica, land-use change, market and non-market based instruments, Nicaragua, payments for environmental services

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## The Effect of Land Reform Policy on Land Use Pattern Change and Environment in Post-Apartheid South Africa

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Land reform in rural South Africa aims at readdressing the inequity inherited from the former Apartheid era by assisting the black population to attain land from white farm owners. However, the reform has been slow in progress up to now. Post-settlement support is also said to be poor and inadequate, resulting in a suppressed productivity of the new farmland or even in a collapse of the farm itself. In order to maintain the productivity and economic value of the transferred farmland, corporation between agricultural agencies or the previous owners of the farm is sought by the government in the recent years.

Nevertheless, the detailed economical and environmental effects of the land reform are yet to be assessed even though evident shortcomings can already be noticed.

In order to assess the biophysical impact of the land reform we collected soil samples from farmland where land transfer has occurred and compared these with soil characteristics recorded during the years before land transfer. Interviews with farmers were conducted to assess the farming system and management skills applied to relate farming management change and its environmental consequences. Areas with different types of farming systems and mode of land transfers were selected to illustrate the different consequences among them.

Expected results are that in areas where land transfer has happened farming management will have changed and there will be some biophysical consequences such as degradation of soil, resulting in a reduction in production. This development should be seen, irrespective of whether farming systems have changed or not. This study will help to understand the relationship of farming management and the environmental effect on the newly transferred farmland. Furthermore, an understanding of the constraints that the farmers face will be beneficial to plan a more appropriate agricultural extension project for the area.

**Keywords:** Environmental effect, farming skills, land reform, soil fertility, South Africa

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## Assessing the Standards of Organic Farming in Bangladesh: A Comparison with European Standards

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Bangladesh has some of the most fertile agricultural land in the world but for getting the dynamic production Bangladesh agriculture is on the way to move from subsistence to commercial farming. For this reason, farmers are using chemical fertilisers and pesticides with the increasing rate. Department of Agricultural Extension (DAE) of Bangladesh and 14 non-governmental organisations (NGOs) have been supporting and training smallholder farmers to introduce ecological as well as organic farming methods for limiting the use of chemical inputs. Many trained farmers realise the importance of ecological agriculture and have adopted this approach on their homestead land. However, they are not always able to do it on major farming land because of the lack of consumers' trust. It is also very important at this moment to search export items from Bangladesh. So, In this regard, international standard should be followed which can give trust for the local consumer as well as earning foreign currency from export organic food items. The main goal of the study is to assess GO and NGO efforts to launch organic agriculture, what type of standards are their contact farmers maintaining, compare them with European standards, where and how can be exported their products with improving the existing standard. Information has been collected from 30 different types of key informants and qualitative analysis has been done. It is found that farmers are maintaining good standard but little below than European standard. If they can be sure that they will get high price, it is possible for them to uphold international standard. Moreover, certification is necessary for exporting products and it is costly which is not affordable for individual. The study recommends to develop cooperative marketing for organic products which will be able to support poor farmers in gaining certification and connecting them to the effective domestic and international markets.

**Keywords:** Non-governmental organizations, organic agriculture, Bangladesh

## Application of Internal Control Systems in Organic Export Companies: Two Case Studies from Uganda

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The organic agricultural sector of Uganda is considered the most developed in Africa with a total of 296 203 ha organic certified land and the most certified organic producers worldwide (206 800), 90 % of whom are small scale farmers. They are certified organic under contract production by export and processing companies, using an Internal Control System (ICS) as a group certification scheme defined by IFOAM (2004). The ICS is a viable and well accepted tool to certify small scale producers in developing countries all over the world. In Uganda however, certification difficulties are stated among the main constraints for the organic sector development.

Therefore, a qualitative study was conducted from June to August 2008 that aimed at better understanding the organisational context in which the ICS is implemented and at outlining factors for improving ICS performance. Overall, 34 expert interviews after were conducted with two small- to medium-sized organic export and processing companies and their contracted farmers in two districts of central Uganda. Data analysis was carried out according to RITCHIE & LEWIS (2003). Relevant areas influencing ICS implementation were identified as company management, farmers' production, farmers' group structures, external consultation and ICS requirements.

Contracted organic producers produce quality organic products with a positive environmental effect and comply with the organic regulations. Nevertheless, the results indicate varied constraints in the situation of the contract farming, e.g. the focus on only the export crops, unsatisfactory amounts of purchases, and an increased need for controlling farmers challenging the companies' working capacities. Developing a good ICS staff structure is hampered by inapplicable consultation and management resulting in fluctuation and conflict of interest. Although the ICS is meant to involve producers, the companies studied bear all the ICS-responsibilities. Sharing responsibilities with producers is a promising new strategy. It is complicated by a lack of trust between the companies and farmers. Farmers' knowledge on organic farming practices needs to be developed, additional marketing options provided and farmers' group structures strengthened. Possibilities for improving the ICS concept are in the areas of regulating control by inspectors and farmers, controlling crop purchases, adapting yield estimation and clarifying multiple registration rules.

The results obtained from the two companies hint towards opportunities and constraints for improving certification of small scale farmers in developing countries.

**Keywords:** Contract farming, group certification, internal control systems, organic agriculture, organic certification, qualitative research, social research, Uganda

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## Fish Marketing in Cameroon: Case Study of Yaoundé Markets

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Fish like most seafood is a very rich source of protein. Generally fish is consumed in all corners and parts of Cameroon. However, the present local fish production is not sufficient; resulting to Cameroon highly dependent on import from other countries. What this entails is that excess production from other parts of the world is traded in Cameroon. To help balance the terms of trade, most developing countries like Cameroon are restructuring their internal markets. Therefore, market studies for aquaculture and fish products in Cameroon are one of most importance because marketing is a vital function of any business as it is disastrous to produce any commodity which could not be sold.

This study was carried out in the domain of IITA/Worldfish programme and the data collected centred around Yaoundé markets and communities. The study highlight fish marketing situation in Cameroon, sources and prices of fish sold, the marketing channels and stakeholders working to promote fishing activities in the country.

Interviews, discussions, observation and questionnaire were administered to both fresh and smoked/dried fish dealers in the markets that constitute Yaoundé city. But more emphasis was laid on fresh fish, which concentrated around Mvog-mbi and Mvog-ada markets. The results obtained from the study were as followed:

Fresh fish are of two categories: fresh life and fresh death fish. The fresh life fish constitute mostly of life Catfish (*Silureiform*) and fresh death fish, which are “Kanga” (*Heterotis niloticus*), Tilapia (*Oreochromis niloticus*) and Capitain (*Lates niloticus*). These fish comes from the River Nyong in Akonolinga, Ayos and Mbalmayo. While the smoked/dried fish comes from river Lagdo and Noun (Mappé) in the North and Western region of Cameroon.

The fish were classified into three sizes: large, average and small. An average cost of a kilogram of fresh life Catfish was 1510 fcfa (2,40 euro) and the selling price of the retailers was 1855 fcfa (3 euro).

**Keywords:** Fish, market, Cameroon



## Jatropha Seed Production in Tanzania – A Chance for Smallholder Farmers?

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The substitution of fossil fuels with biofuels continues to be discussed worldwide. Many international companies investing in biofuel projects have focused their interest on African countries. In Tanzania, *Jatropha curcas* L. – a preferred plant to supply feedstock – has been subject to much attention. While there is no clear legal framework for bioenergy in the country, a number of Jatropha-oil projects are in operation. They aim to increase the use of renewable energy sources and contribute to rural development. Therefore, most projects follow an outgrower-approach where smallholder farmers are contracted to grow and produce the seed supply for the investing company. The few studies which have been carried out mostly rely on assumptions and expectations of production figures that leave the actual economic viability and competitiveness of Jatropha unclear. This article addresses the knowledge gap and presents results of recent case studies including first quantitative research findings on smallholder Jatropha production in Tanzania. The current cultivation practices, the Jatropha value chain and the socio-economic implications for smallholder farmers are discussed. With Jatropha being a new production crop, a lack of knowledge on best practice is found to be common to all stakeholders. Further, the value chain is still in an initial stage where linkages are basic and markets vulnerable. To smallholder farmers though, investing in Jatropha seems profitable if seed yields of 2–3 t ha<sup>-1</sup> can be reached. We conclude that there is potential for economic viability of Jatropha. However, due to the uncertainty of attainable yields and the knowledge gaps in Jatropha cultivation, alternative crops may prove preferable. Therefore, substantial further research is needed and recommendable.

**Keywords:** Biofuel, competitiveness, economic viability, Jatropha, Tanzania

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## **Emprasefor: A Case of Resilient Farmer-led Forage Seed Entrepreneurship in Central-America**

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Adoption of novel forage technologies depends often on the availability of seed. In Central America for instance, the demand for seed of drought-adapted grasses of good quality (e.g., *Brachiaria brizantha* CIAT 26110 “Toledo”) is not met and imported seed is expensive and often not accessible. Hence, based on their experiences with CIAT-led participatory research on forages, a group of around 10 small crop-livestock farmers in the region of Victoria, Yoro, Honduras, founded the seed enterprise “Emprasefor”. CIAT and local partners provided initial support through advice and an initial investment of USD 2000. Four years of increasing area and seed production (up to 2000 kg from 20 ha), reaching a yearly turnover of approx. USD 12,000, resulted into an agreement with a private seed company guaranteeing seed purchase at a fixed price and supply of inputs. However, adverse climatic occurrences during 2005 caused a major drop in production, putting the farmers into debts that were partly covered by selling seed at the local market for a better price. In the following years the area for seed production decreased and the remaining area was used for improved fodder for own livestock. While seed production continued, an additional initiative was developed to diversify into producing hay and concentrates for the local market. Mixing equipment was acquired and initial production during 2008 amounted to 5 tonnes of concentrate consisting of mainly locally produced ingredients. This case shows the vitality and resilience of a farmer-led forage seed production enterprise, as well as its possible role for diversification into related activities. The modest, strategic support from third parties makes the concept replicable. Farmers value highly the opportunity to be an entrepreneur and increase their income. Other perceived benefits include increased knowledge on forage seed production, as well as higher animal production from own improved plots.

**Keywords:** Central-America, farmer seed systems, forages

# Research development and tenure

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## Comparing the Effectiveness of Informal and Formal Institutions in Sustainable Common Pool Resources Management in sub-Saharan Africa

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In Africa, common pool resources (CPRs) management plays a crucial role for livelihood security and conservation of natural resources. This makes sustainable CPR management an essential component to be considered in rural poverty reduction interventions. In such efforts, the need of institutions to mobilise community at grassroots level has been highlighted by various donors and development agencies. At this point, the need of empirical evidence which examines the contributions and constraints of different institutional arrangements in rural sub-Saharan Africa (SSA) becomes an important research task. This paper compares the effectiveness of informal and formal institutions for sustainable CPRs management in SSA and investigates the social, political, and demographic conditions which influence the institutions' effectiveness. By focusing on publications addressing micro-level CPR management, a comprehensive literature review was conducted. Articles were grouped, based on main themes of the study, including types of institutions and conditions that influence their effectiveness. Textual data was analysed qualitatively using a deductive coding approach. Results revealed that informal institutions have contributed to sustainable CPRs management by mediating access to and control over CPRs, influencing interactions of CPR users, developing and mobilising social capital, and solving collective action problems. Although published evidence suggested less support to formal institutions under decentralised governmental reforms, they play an important role to implement technologies for sustainable CPR management. Conditions that influence effectiveness of both types of institutions include high population growth on limited CPRs, unequal power sharing among CPR users, and lack of clearly defined responsibilities to institutions. Emphasis should be given to create collaborative conditions in which both types of institutions have specific and supportive roles with proper power relations among CPR users. Furthermore, policies and development interventions that encourage negotiation and active participation of CPR users in decision making are essential.

**Keywords:** Common pool resources, formal, informal, institutions, sub-Saharan Africa, collaborative conditions

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## **Rural-Urban Migration in China: Lessons from an Empirically Based Framework of Positive Impacts on Rural Development**

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In contemporary China, rural-urban migration takes place at considerable scale. While unfolding a number of positive development impacts on migrants' communities of origin, migration happens in a context of official restrictions and is characterised by a high importance of social networks on which migrants rely to coordinate their movement. Due to these attributes – its scale as well as the particular institutional, administrative and social context – studying the case of migration in China can reveal important lessons on how policies can be designed in order to enhance positive impacts of migration on source communities.

Relying on a review of literature from sociology, geography and economics on rural-urban migration in China, this paper collects empirical evidence on development impacts of migration on source communities, the migration process itself and the institutional, administrative and social context in which migration takes place. Interactions between the latter and the two former are highlighted and points of interactions are identified, providing a guideline for potential policy interventions. The detailed analysis of the interactions between the migration process and its positive effects on the one hand and determining factors on the other hand reveals that a reduction in the barriers of migration may not necessarily lead to a full exploitation of the potential of migration for rural development, but rather unfolds ambiguous development impacts. While barriers to migration, such as the Chinese household registration system, restrict out-migration and keep marginal returns to labour as well as potential flows of remittances and return migration at a lower level, they also drive migrants to maintain stronger ties to their home communities and thus ensure a high level of return flows. This policy dilemma may require the identification of an optimal level of barriers to migration. Finally it is argued that observing the Chinese central government's activities regarding migration offers a perspective which is missing in ongoing international migration negotiations, as it has to reconcile the conflicting interests of both migrant sending and receiving regions.

**Keywords:** China, international migration, migration, rural development, rural-urban migration

## Facilitating Adoption of Best Practices — More Work for Research than Extension!

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The presentation points at the implementation challenges we are facing in tropical agriculture when recommended ‘best’ practices *e.g.* to stop erosion or change irrigation or food handling practices do not have obvious short-term benefits like increased yields or reduced labour but maybe even increase production costs, and this without market incentives for farmers to accept the extra burden.

The resulting low technology adoption rates are a major bottleneck we are facing in the Research for Development continuum since decades despite increasing efforts to move more research from stations to farms.

While many still argue about missing research extension linkages, unsupportive socio-economic frame conditions etc., we might miss the point that understanding and facilitating adoption requires at least as much social and economic research than the more biophysical development of a ‘recommended’ technology.

The presentation draws mostly - but not only - from research work in West Africa on safer irrigation and food handling practices where wastewater is used in market gardening putting thousands of consumers at risk of diarrhoeal diseases. It outlines the importance of understanding farmers’ and food caterers’ knowledge and perceptions of health risks and risk reduction measure to understand possible adoption drivers and barriers. The studies also show that probably only a mix of approaches might lead to a lasting adoption, which builds on social marketing research, incentive systems, awareness creation/education and applied regulations, even if these can not be enforced. There are also many examples of innovations at farmers’ end which might have a different cause and purpose but support the same larger ‘social’ objectives to build on.

An important conclusion is that all this analysis requires serious research of the target group, strongly involving social sciences, which we should not underestimate in the planning of related projects. It also shows that relying on imported strategies and dissemination materials to support technology adoption might not fit local conditions.

**Keywords:** Behaviour change, on-farm research, safer irrigation practices, social marketing, technology adoption

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## Land Property Rights and their Influence on Innovations in Rural Societies in South West China

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This presentation looks at the transformation process of land property regimes in rural China. Using the New Institutional Economics as a theoretical framework, it analyses different institutional settings and their influence on the adaptation of innovations in land-use decisions.

In the scope of the Sino-German research cooperation “LILAC: Living landscapes China” the authors studied several villages in Xishuangbanna prefecture, South West China. The region is well known for the cultural diversity of its many ethnic minorities such as Dai, Akha, Bulang or Lahu. Starting in January 2007, an in-depth situational analysis was conducted combining (amongst other PRA tools) extensive observations and narrative life histories with a stratified, semi-standardised household survey.

After 1982, serious changes in land use rights have been implemented: collectively managed land was transferred to the communities to be rented out to individual farmers on a contractual basis. Usufruct rights were guaranteed for a period of 15, later 30 years. According to the Government of the People’s Republic of China (29<sup>th</sup> Meeting of the 9<sup>th</sup> National People’s Committee, 2002), land adjustments during these periods are prohibited by law. Farmers are entitled to prolong contracts if necessary. This transformation process has not yet been fully completed. The research area has undergone dramatic economical development from subsistence farming to high revenue agriculture. This process was based on the introduction of cash crops such as rubber, tea and hybrid rice. The authors identify, analyse and discuss appropriate institutional arrangements to meet the demands of economical development, ethnic diversity and biodiversity. In this context, they analyse advantages and disadvantages of traditional collective institutions, private property and hybrid arrangements.

Research results suggest that rural societies show a great diversity in institutional arrangements when managing their natural land resources. Often, these arrangements are non-transparent, and formal and informal institutions show considerable differences. Thus, they can be susceptible to misuse and do have a great impact on biodiversity and sustainable land-use.

**Keywords:** Biodiversity, China, institutional analysis, natural resource management, poverty alleviation, property rights, sustainable land-use

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## Extension Messages on Pesticide Use: A Precondition for Safe Vegetable Production in Jharkhand, India

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In many developing countries, pesticides are overused and applied without appropriate precautions. Pesticide residues contaminate food, animal feed, water, and soil, placing the health of farmers, their families, consumers, and the environment at risk. A Sir Ratan Tata Trust-funded project implemented by AVRDC - The World Vegetable Center, Regional Center for South Asia promotes the production of safe vegetables through integrated pest management. A study by Bond et al. (forthcoming) in selected villages of two districts in Jharkhand, India, revealed that farmers' attitudes toward pesticides account for most of the three determinants (attitudes, subjective norms, and perceived behavioural control) of farmers' intention to apply pesticides to vegetables. In Jharkhand, farmers receive advice on pesticide use from pesticide dealers and extension agents working for nongovernmental organisations, the government's agricultural extension service, and the local agricultural university. It is assumed that farmers' positive attitudes towards pesticides are influenced largely by extension messages that encourage the use of pesticides but do not explain the side effects on human health, nontarget organisms, and the environment. The objective of this study was to examine the extension practices of persons involved in advising farmers on the use of pesticides. Their perceptions on pesticide toxicity and related health risks were elicited and evaluated in relation to farmers' practices. Farmers, pesticide dealers, and extension agents from NGOs and the governmental agricultural extension service in selected districts of Jharkhand were interviewed using semi-structured and structured methods to collect qualitative and quantitative data. Where possible, level of knowledge tests were conducted with extension agents and farmers and direct observation was used for triangulation. The information gathered was used to describe farmers' pesticide use patterns and extension agents' common pesticide extension practices. The level of knowledge results and perceptions on pesticide-related risks were used to formulate recommendations for future strategies to promote integrated pest management among extension agents and farmers.

**Keywords:** Extension, India, perception, pesticide use, safe vegetable production

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## Long Term Benefit of Research for Development Projects through Sustainable Information Management

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A lot of data is gathered from stakeholders of research for development projects. After termination and publication of the analyses the data is archived and the stakeholder do not directly benefit from the data other than through the more general new methodologies and approaches developed.

Research projects can increase impact and sustainability through a more targeted and intelligent use of information technology. Easy to use and internet based information management systems (IMS) can bring positive long-term effects to project's beneficiaries and boost the project's success beyond general applicable results.

We propose an IMS that permits to capture and maintain data as near as possible to where it is generated and used. An intelligently designed web based IMS can provide direct and targeted data access and feedback to the corresponding stakeholders, that can include rapid data analyses and automatically generate reports whenever needed. It has long-term benefits for all participants of a project. Stakeholders such as farmers and associations have always and direct access to their data and learn to manage it, projects benefit from efficient data provision, researchers and project managers dispose of the required data and information in real time to perform analyses and take accurate decision.

We describe a case study of a research project funded by an industry donor where data compiled by farmers associations is used to predict and quantify the impact of climate change on farmers livelihoods. The same data within a multiple stakeholder data base framework is used to increase product sourcing efficiency and to keep farm and production data up-to-date.

**Keywords:** Development research, information management

## Contract Farming as a Concept for Rural Agricultural Development. Evidence from Potato Seed Culture in Punjab, Northern-India

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A large portion of India's rural population is dependent on agriculture and allied activities. Despite intensive farming regimes accounting for an increase in overall productivity figures, traditional, extensive ways of land use are widespread in rural India. These traditional farming systems, however, are often associated with limitations in terms of access to new agricultural technologies. Likewise, market imperfection is regarded amongst the most impeding factors for rural farmers to increase productivity. Contract farming has been widely discussed as an institutional arrangement providing a viable alternative for farmers to alter shortcomings related to traditional farming systems. Recent experiences with contract farming schemes are predominantly referring to poultry systems, yet contract farming is increasingly popular in the crop sector. The present study is investigating the economic feasibility of contract farming schemes for potato seed culture in Punjab region in Northern India. Costs and returns are analysed for both contract as well as non-contract schemes using gross margin analysis. Beyond this, focus is set on resource use efficiency aspects between these two farming models applying marginal value productivity (MVP) measurements. In contrast to non-contractors, results show that farmers involved in contract farming have regular access to both seeds as well as technical support by the contract providing company. Economic analysis confirmed the linkage between contract farming and productivity increase. In contrast to traditional farming patterns, findings proved an enhanced access to input- and consumer markets for medium- and large scale farms, resulting in an increase in farm output in terms of yields and returns. However, results show that contract farming schemes tend to exclude small-scale farmers in the region. The role of the state government to support the formation of groups, associations and cooperatives to improve the situation of smallholders is outlined. It is concluded that considerable potential exists for contract farming as a concept for rural agricultural development, yet the elaboration of approaches to ease smallholders' access to contract schemes remains a prerequisite.

**Keywords:** Contract farming, economic feasibility, gross margin analysis, marginal value productivity, smallholders

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## Development of a Conceptual Model for the Dinario Project, Rio de Janeiro, Brazil

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The complexity of interactions between numerous environmental and socioeconomic systems in the globalised world requires a deeper understanding of the related systems. Global problems, such as climate change, land degradation, energy crisis or poverty cannot be solved without an understanding of system behaviour and structure. For various broad-scale systems, models have been developed. Well known are climate models which are used to generate projections of future climate. For use on regional scales, climate models are downscaled. In addition to climate models, numerous other models have been developed, related to specific topics, such as regional economic models, hydrology models, erosion models, or traffic models. Common aim to all models is the optimisation of systems or the solution of certain problems, respectively. In the hinterland of Rio de Janeiro, many problems, such as biodiversity loss, water pollution, and soil degradation are related to land use intensification processes which are in turn linked to population and economic growth. Against the background of biodiversity conservation in the Atlantic forest, the BMBF project BLUMEN (2002–2005) focused on system stability in the agricultural landscape in the mountain region of the Serra dos Órgãos, which still contains a high proportion of small forest fragments. Based on BLUMEN, the current BMBF project DINARIO - Climate Change, Landscape Dynamics, Land Use and Natural Resources in the Atlantic Forest of Rio de Janeiro - integrates lowland landscapes into the research. Furthermore, the development of sustainable land use strategies will be supported by a deeper analysis of water and soil systems.

Here we show the conceptual model for the DINARIO project developed by ITT M.Sc. students and their supervisors. It is based on a problem analysis via literature research in the fields of biodiversity, water availability, water quality, soils and geomorphology, climate change, agricultural structure analysis, agronomy and socioeconomics. Methods of information exchange, definition of system boundaries, identification of key parameters, analysis of relations between the parameters, as well as means of evaluation are briefly described. The conceptual model can be used as a basis for numeric models and decision support systems.

**Keywords:** Atlantic forest, DINARIO, Rio de Janeiro, sustainability, system analysis

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## **Social and Economical Improvement through the Implementation of Land Tenure in Rural Java, Indonesia**

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Rural and agricultural development on Java, Indonesia, is undervalued. Land tenure and tenure security are under pressure due to a fast growing population in relation to an already high population density. Over 40 % of Indonesian workers are engaged in agriculture. With regard to agricultural production, Java alone contributes for more than 50 % of the national rice production. However, Java's population accounts only 0.07 % of the total Indonesia population. On Java the population density varies from 764 people km<sup>2</sup> in East Java to 13,499 km<sup>2</sup> in Indonesia's capital Jakarta. By considering Java as the most densely populated island, the need for land for living compete with the need for land for agricultural purposes. On Java, particularly in peri-urban areas, the presence of agricultural land is becoming scarce due to the urban expansion. Secure access to land is therefore becoming more and more crucial for further agricultural and rural development on Java.

This paper explores the implementation of land tenure in rural Java. It analyses the factors that have and had an influence on the implementation of land tenure systems in rural Java. Finally, it offers feasible suggestions to prevent situations and to overcome conditions in which the implementation of land tenure is not viable. This paper is primarily a literature study. Meanwhile secondary data are collected from FAOSTAT and Badan Pusat Statistik (BPS) - Statistic Indonesia.

This study shows that there are various ways to implement land tenure systems in rural Java. However, these varieties can be categorised in either land ownership or land renting. The main threats to the implementation of land tenure are the lack of agricultural laborers, inequality of agricultural land ownership, poverty and insecure land tenure. Agricultural revitalisation in the way of accelerating rural infrastructure and providing adequate agricultural production inputs such as fertilisers and seeds, a land reform programme (for example distribution of land to rural landless), and a land registration programme can increase the social, economical and ecological security of land tenure.

**Keywords:** Agriculture, Indonesia, land tenure, rural Java, tenure security

## The Changing Roles of International Agricultural Research Centers

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International agricultural research increasingly has to demonstrate its effectiveness in reducing rural poverty in a sustainable way. In order to achieve this, and so to respond to the increase in societal accountability and to the change processes imposed by certain donors, research centres within the CGIAR need to reposition themselves. As a commodity-based centre the Africa Rice Center (WARDA) has a long history of developing and promoting rice-based knowledge and innovations. Fund allocations no longer depend merely upon outputs (such as new varieties) but upon the uptake and impacts of such outputs, and so the Centres are likely to promote and disseminate knowledge and innovations generated by their own scientists more readily than those developed by other actors in the rice sector. A range of institutional innovations, such as rice TIME, described in this paper, will be required in the future to allow WARDA and other commodity-based centres to play a role as source-neutral knowledge-broker in regional innovation systems. International agricultural research centres (IARCs) will increasingly need to ensure local knowledge and innovations are valued, built upon and shared through south-south and south-north exchange mechanisms. If they do not have the in-house capacities that are needed to achieve this, partnerships with appropriate actors should be aimed at to make this happen. Brief details of some example of effective partnerships of this kind will be included in my presentation. Commodity-based IARCs should also extend their role to build national capacities to develop effective learning tools and strategies that enhance production, quality and marketing. This will require them to open up to different types of professionals, partnerships and learning alliances. Stimulating IARCs to expand their roles in national and regional innovation systems will at the same require donors to create more flexible (project) learning environments and move away from logical frameworks with pre-set quantifiable targets. The examples that shall present provide some clues for donors and others as to the way in which these goals may be pursued.

**Keywords:** Actors, Africa, innovations, institutions, knowledge, partnerships, rice

## Failure and Success of Tropical Research and Development Practices Using the Example of Pacora, Nicaragua

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The intent of this investigation was to evaluate the success of former development projects and research work to improve farmers' livelihood and promote environmental friendly farming. Investigations were carried out in Pacora, a typical rural Nicaraguan village of about 250 habitants with a high grade of poorness. In that village, different types of projects were realized, such as top-down approaches, participating action research, farmer-to-farmer programs, farmer trainings and classical field trials with low influence of farmers to the management and design. Failure or success of these projects are detected and explained. The findings are based on project reports and empirical studies. Over a period of five months, participant observation, as well as formal and informal talks have been done in Pacora. Various obstacles could be detected in the ecological field as well as in social and financial areas. Amongst others, these had been that farmers focus on their own advantages in the decision process and hardly transmit new technical knowledge to other families or groups of villagers. Neither they contribute to communal benefits or participate in common actions. The consequence was intensified, when new coming agencies were working with the same few families like other agencies before, despite of different approaches of participant finding. Further, the difficulty to change traditions, overcome apathy and convince to long lasting adaptation of new technologies was obvious. Participatory action research showed a high adaptation rate among farmers, when technologies were explained well. Several new technologies have failed due to ecological difficulties and unsuitability to the local situation, or because further adaptation for the local situation or technical support was missing. Several donations have failed to improve the farmers situation by far. Improvements, such as sudden connection to electricity, have caused new, fatal difficulties for the villagers. The on-side trials have contributed little to increase farmers knowledge or to change their agricultural practices. Diverse recommendations were concluded from the results to help development agents to realize greater and long-lasting success in comparable situations in rural areas. Furthermore, ideas for large scaled projects for basic progresses in rural low developed areas were derived, which need to be carried out in cooperation with the government.

**Keywords:** Evaluation, farmer training, livelihood, participation, poverty reduction, sustainable development

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## Information Technology for Agriculture and Rural Development in Africa: Experiences from Kenya

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Access, efficiency and affordability of agricultural information continue to be a major impediment for raising agricultural productivity among smallholders in Africa. Recently information and communication technology (ICT) has provided a possible pathway to ameliorate this scenario. A variety of innovations that integrate ICTs into the dissemination of agricultural information to farmers (Farmers Information Services - FIS) have been developed at local, national and regional levels. They have currently demonstrated a promising field of new research and application in e-agriculture whilst bringing new sources of information and new tools for local knowledge dissemination. This paper reviews and discusses the role of ICT and its practical contributions to agriculture and rural development in Kenya. Data from various sources-Kenya's agricultural departments, ICT providers, NGOs and grey literature reviews were used. Results indicate use of ICTs especially mobile telephones is currently widespread in the rural areas of Kenya. Approximately one member of smallholder farming households own mobile phones. Extension service providers have harnessed this technology by putting it into profitable use in rural Kenya. For example, Kenya Agricultural Commodity Exchange (KACE) has developed a short messaging service- SMS SOKONI in partnership with Safaricom mobile phone provider. Any farmer anywhere in the country can access updated and reliable market information on prices and commodity offers at an affordable rate using their mobile phones. So far, the service is easy to use, reliable, convenient and affordable. The average monthly usage of this service increased from 1,273 in 2006 to 24,716 in 2008, demonstrating its subsequent usefulness and eagerness of farmers to explore the market information and linkage systems. Farmers are also able to access information on the right Hybrid Maize seeds to plant in their respective agro-ecological zones by way of texting to Kenya Seed Company Ltd a major seed distributor in East African region. This paper recommends adoption of such technologies by institutions such as Metrological Department to enhance provision of updated data on climate for appropriate decision making by agricultural farmers. This paper is critical to enhancing awareness on appropriate transferable technologies of 21<sup>st</sup> century that are still compatible to diverse cultural perceptions.

**Keywords:** Affordability, agricultural productivity, information technology, rural development

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## **Coca Temptation: Why Do Some Farmers Grow it and Other Do Not? The Case Study of an Indigenous Community in Peru**

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Coca is a native bush from the Amazon rainforest. The leaves of this bush have been traditionally used by indigenous populations for thousands of years. Traditional uses include chewing coca leaves as stimulant to overcome fatigue and offering them to the gods during religious ceremonies. Moreover indigenous populations invite and exchange coca leaves to show caring and respect to others. Coca is therefore a social cohesion facilitator and an important part of indigenous populations' cultural baggage.

Unfortunately, since the 1970s coca cultivation have largely grown in Colombia, Peru and Bolivia as raw material for cocaine production. Those countries supply 99 % of the cocaine worldwide (Colombia around 60 %, Peru 30 %, and Bolivia 10 %). Growing coca for narco-trafficking business is a highly profitable activity. It is believed that farmers grow coca as cash crop because they lack alternative profitable crops. In fact, most of the coca growing regions are located in remote areas without appropriate transportation systems. Transaction costs are high, and thus it is difficult for farmers to make a living by cultivating legal crops.

Actually, high profits could not be the only reasons why farmers are willing to grow coca. Coca cultivation could have other advantages. Coca bushes can be harvested three-four times per year. In contrast, coffee and cacao, the main alternative crops, can only be harvested once per year. So, coca could serve as saving account that provides constant monetary resources all-year round. In addition, coca could provide farmers with the financial support to face large expenses like weddings, and even the expansion of coffee or other legal cash crops areas. The presence of the Government in coca growing areas is almost null; and in general, farmers do not have access to formal credit.

There is a lack of research about the role that coca plays in the socio-economy of individual farmers mainly because of the absence of data. This research tries to explain the determinants of coca growing decisions by analysing a unique individual household-level database collected last year from an indigenous community in Peru. The methodology used include bivariate probit and multinomial logit models.

**Keywords:** Bivariate probit, coca, illicit drugs, multinomial logit, Peru

## Indonesian Biology Teacher and Agronomy Students' Perception of Commons Dilemmas

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Central Sulawesi harbors core ecosystems of the global Wallacea biodiversity 'hotspot'. Largely consisting of common pool or open access forest resources, it is heavily threatened by intensive resource appropriation such as rattan extraction and forest conversion into agricultural plots. To improve prospects for conservation and sustainable long-term development, a set of socio-ecological 'commons dilemmas' need to be solved. This requires local actors who command knowledge on the social, economic, institutional, and ecological aspects of forest resource utilisation. In the spirit of the Agenda 21 or the Convention on Biological Diversity (CBD), fostering such knowledge should be a prime task of international environmental education. While Indonesia strives to include environmental education in its school curricula, we report on results of a study that systematically investigates the pre-concepts that future teachers bring to local resource conservation issues in Central Sulawesi.

Based on the 'Protection Motivation Theory', we abstracted our results from 19 qualitative in-depth interviews with agronomy and biology teacher students from UNTAD University, Palu, i.e. from potential key communicators on resource use dilemmas. They are only able to teach or provide advice what and how they themselves understand the resource management problems as well as potential solution strategies to be. Most interviewees readily recognised ecological aspects of the exploitation of forest resources, and frequently called for state regulations. While emphasising e.g. the time tap of over-exploitation of natural resources, the core of the commons dilemmas, i.e., the need to institutionally balance short-term individual exploitation profits with long-term and community interests was not recognised in any detail, however.

**Keywords:** Commons dilemmas, education, Indonesia, natural resources

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## Weed Control in Maize Crop Using *Leucaena leucocephala*

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*Leucaena* (*Leucaena leucocephala* (Lam.) de Wit) has been observed to control weeds when used as soil mulch. It contains mimosine, which, among other allelochemicals, is responsible for the allelopathic effect. In this work, the effects of leucaena shoots were assessed in field experiments against weeds of maize crop. A field experiment was carried out at the National Maize and Sorghum Center Research located in Sete Lagoas, Minas Gerais State, Brazil, with four treatments: 1) 40 t ha<sup>-1</sup> of fresh leucaena shoots material used as mulch in soil; 2) 20 t ha<sup>-1</sup> distributed at the stadium of 3 leaves and the other 20 t ha<sup>-1</sup> distributed at the time of flowering maize; 3) manual weeding control and; 4) no weed control. The maize was sown with spacing of 0.80 × 0.20 m<sup>2</sup>, corresponding to a population of 60 000 plants ha<sup>-1</sup>. Each month, phytotoxicity evaluations were made of leucaena on maize using a scale of notes of the European Council of Research on weeds (EWRC); as well as the identification and counting of weeds in a square metre in each plot. The values obtained for weed counts were converted to  $\sqrt{x}$ . In the plot with 40 t ha<sup>-1</sup> of leucaena mulch the weed population was controlled without any damage to the maize grain yield. Was also observed that all treatments with leucaena showed reductions in amounts of weeds (grasses and broad leaves) compared to the control without weeding. The treatment which received 40 t ha<sup>-1</sup> of leucaena showed fewer weeds than the treatment with repeated application of leucaena (20 +20 t ha<sup>-1</sup>). It was observed that the use of leucaena as mulch did not cause phytotoxic effect on the maize development favouring an increase of nitrogen and phosphorus content in the leaves. This probably influenced the higher grain yield of maize in treatments with the addition of leucaena.

**Keywords:** Allelopathy, leucaena, mulch, *Zea mays*

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## **Strengthening the MDG Progress through Collaborative Research Efforts: Some Lessons from Oat Project in East Mau Catchment, Kenya**

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Food insecurity, poverty, lack of water (quantity and quality) and diseases continues to be perverse in many sub-Saharan countries. Destabilisation of the natural resources especially forests and soil is the main culprit. Worst affected are smallholders who rely entirely on natural resources. Coincidentally, these resultants are the core of the MDGs. This was the driving force for the initiation of the collaborative research effort- OAT (Organic Agriculture with Trees) between one European University, BOKU, Vienna, World Agroforestry Centre, Nairobi and Egerton University, Kenya from which the East Mau catchment provides the research test bed. It was aimed at identifying strategies to re-establish trees in smallholder farms and to contribute in developing of low input organic systems and perspectives for the marketing of organic products. Results are presented from this cooperative research endeavour. The project was conceptualised into three research themes; farming systems, social systems and marketing systems. A quantitative analysis of 300 sampled smallholder farms indicates that there is a decline in agricultural productivity. The use of externally purchased inputs is on a downward trend due to their rising costs coupled with wearing incomes. However, there exists a high potential for the development of low external input organic systems due to high crop diversity and the mixed systems. There is a high farmer co-operation through the common interest groups which facilitates ease of knowledge transfer. This is a good entry point dissemination of low input technologies for the farmers. Results from consumers' analysis indicate that there is a large market potential for of organic products in the urban cities in Kenya. Other tangible outputs were the development of a tree manual in cooperation with local farmers as well as agricultural advisors and researchers. The establishment of an organic demonstration farm with a tree component at Egerton University. Various farmer outreach trainings on composting and tree planting in the region. Finally with the integration of several faculty members, research scientists and students from the three institutions there was an intensive knowledge exchange and transfer. Recommendations: further collaboration with extension advisors on the dissemination of organic technologies and formation of farmer groups.

**Keywords:** Kenya, millennium development goals

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## Land Ownership in Nepal: Are Lower Castes Excluded?

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In Nepal, the land ownership still determines the economic prosperity, social status and the political power of an individual. Therefore, unequal distribution of land has caused a differentiation, hierarchy and divisions in the society leading to perennial conflicts. Still a large number of land dependent households are deprived from their primary source of livelihood, *i.e.* land. Statistics show that one-fourth of the total population of the country is either landless or have less than 0.1 ha of land. An overwhelming majority of low caste people belong to this landless category. But, the caste aspects of land ownership have not been looked into seriously. This paper, based on a study carried out in Morang, an eastern Terai district of Nepal, explores the socioeconomic status of the lower castes groups and relationship between the land ownership and livelihoods among them. The study was carried out in 3,054 households selected through stratified random sampling. Among which 125 were dalits, the lowest in the caste hierarchy. Semi-structured questionnaires, focused group discussion and key informants interviews were conducted to collect the primary data. The study revealed that there is a strong correlation between caste hierarchy and landownership pattern: the higher the caste, larger the land size he holds. This is further resulted into the differentiated access to education, health service and loans and eventually to the job markets. The study found that 44 % of all households fall under the landless category, where, total landlessness among the low caste is as high as 62 % whereas only 26 % of the upper castes fall under this category. No household of lower castes owns more than 2 ha of land. Legally regulated pro-poor land agenda are to be brought into practice to prevent absentee landlordism, which is 44 % in the study area, and ensuring landownership rights of the tillers, who are usually unregistered and low castes. Such an action would not only increase the productivity and food security, but also provides low caste with livelihood security and social justice leading to reduced tensions and conflicts.

**Keywords:** Caste, ethnicity, food security, land ownership, livelihood

## **Certification as a Means for Sustainable Biofuel Production? – Potentials and Constraints**

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Within the past few years there has been significant increase in biofuel production in several countries across the globe with governments making policies to encourage its production. While biofuel has been applauded as a potential means to reduce dependence on fossil fuels which also account for a high share of worldwide green house gas emissions, concerns have been raised about its possible social and environmental hazards such as reducing access of smallholder farmers to land, food insecurity, as well as green house gas emissions caused by indirect land use changes.

Due to their potential for growing biofuel feedstocks many developed countries are now looking towards tropical countries for meeting their blending targets and mandates. As a means to avoid the perceived negative impacts of biofuel production, several governments and independent organisations have come up with certification initiatives in order to ensure that certain minimum sustainability standards are met when producing biofuels. At present, efforts are made towards an internationally recognised certification scheme.

Based on the review of current literature, the purpose of this paper is first, to assess all possible impacts of biofuel production especially in rural areas of Africa, second to assess progress made so far in creating certification schemes for biofuel production and third, to analyse under which conditions certification can be a successful instrument of promoting sustainable resource use.

In the focus of this analysis will be the trade-offs between biofuel production and food security as well as between land use for biofuel purposes and forest conservation. On the one hand biofuels could be a source of increased farmers' income in rural areas of Africa. On the other hand, due to subsidies and tax incentives in developed countries the marginal product of the land used for biofuel production rises when compared to food production. Using a comparative-static approach the related trade-off and its possible effects on food prices and land use will be analysed by means of a graphical model. Finally, based on the model results main implications regarding farmers' income, food security, land conversion, climate change mitigation and effects on biodiversity will be discussed.

**Keywords:** Biofuel, certification, food security, sustainability

# Food security, nutrition and health

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# Food security, nutrition and health

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## Household Livelihood Strategies and Non-marketed Benefits Dependence in Gaza Province of Mozambique

STANLEY KARANJA NG'ANG'A<sup>1,2</sup>, JEANNETTE VAN DE STEEG<sup>2</sup>, AN NOTENBAERT<sup>2</sup>, MARIO HERRERO<sup>2</sup>

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Non-marketed benefits of livestock provide substantial contribution to the wellbeing of many rural dwellers. However, the level of livestock use and the degree of reliance on non-marketed benefits of livestock differs across households. The factors that condition a household's economic reliance on a particular economic activity in general and on non-marketed benefits of livestock in particular way may vary depending in the resource endowment of the household, the household's demographic and economic characteristics, and exogenous factor such as markets, prices and technologies. This paper identifies the factors that condition a household's livelihood strategy choice with a particular focus on agro-pastoralist production system in areas of high level risks associated with climatic change. For this, livelihood approach as a framework of analysis will be used. Livestock augmented household income data were collected from 180 sample households in Gaza province of Mozambique. On the basis of the share of livestock non-marketed income in total household income, sample households were clustered into distinct livelihood strategies. Student's t-test and ANOVA were used to test income differences among the clusters. Multinomial logit (MNL) regression on asset-based explanatory variables will be run to identify the main factors that determine households' livelihood strategy choice and non-marketed benefits dependence. The analyses is expected to indicate how differential access to, or endowment of, livelihood assets determines the choice of a household's strategy in the climatic change context and the risks profiles associated with agro-pastoralist households. Finally, the paper will seek to prescribe policy in relation to asset-poor households and their engage in activities with higher economic return.

**Keywords:** Livelihood asset, livelihood strategy, livestock dependence, livestock non-marketed benefits, Mozambique, rural households

## Health Development Nexus: Macroeconomic Estimation Using Developing Country Data

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Health is a fundamental human right and a basic capability that augments human capital, and thus positively affects output. Good health is a critical input into poverty reduction, economic growth, and sustainable development. In spite of economic improvement, social and demographic indicators in Pakistan present a dismal picture. Nevertheless, Pakistan still has one of the highest infant, child, and maternal mortality rates compared with the developing countries of the same income level. It is empirically estimated that Pakistan has losing its economic growth potential considerably due to lack of improvement in health status. According to World Bank, poor governance, frail health sector management and low levels of public spending are the key factors behind poor health outcomes and hence low economic growth. Keeping in view the likely role that health sector can play in economic development; this study uses time series macroeconomic data spanning from 1972 to 2008 and aims at answering the following questions: what role health can play in economic development of Pakistan? What are the affects of nutrition availability per capita on development status in the long run? Does health causes development and/or vice versa? And how shocks to health variables are affecting economic development over time? Augmented dickey fuller (ADF) unit root test are used to check for stationarity. Johansen multivariate cointegration approach is employed to estimate the cointegration relationship. Engle-Granger causality framework is applied to see the direction of causality and its extent. Finally, Impulse response analysis (IRA) is carried out, as post estimation tool, to account for shocks in health variables and their likely impact on development of Pakistan. Augmented Dickey Fuller (ADF) and Philip Perron (PP) tests showed that all data series are non-stationary I (1) in their level form and become stationary I (0) after first differencing. Study further estimated that there exists a single cointegrating vector which means that a unique long run equilibrium relationship exists between health variables and economic development (income per capita at national level). This analysis will help in understanding the dynamics of health development relation in the long run and helps in better decision making.

**Keywords:** Cointegration, health, nutrition per capita, Pakistan, time series

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## Feeding Habits of Children under Age of Five in Rural Area of Sudan: An Overview about the Nutritional Situation

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Early introduction of complementary foods in the developing countries is associated with an increased risk of diarrhoea due to poor sanitary conditions and lower quality of supplements. In Sudan the most supplementary food offered to children are cereal-based stuffs which are naturally deficient in protein constituents. A survey was done in a central rural area of Sudan to study the feeding habits of children under age of five and related information about breast feeding, drinking water and complementary foods during breast feeding for the infants. Moreover, the weaning parameters as well as the most common food consumed by the children under age of five have been detected. The type of diet consumed by children under question was determined by using the Recall method. The results discovered the importance of early and continuous breast feeding for infants of the studied area. 60.7 % of the infants were breast-fed for two years and only 10 % of them were using bottle-feeding. Moreover, it was recorded that a higher share of the children (97.3 %) were taking complementary food during the period of breast feeding while 12 % of the infants started such complementary feeding programme earlier (< 4 month of age) and 57.3 % involved in the range between four to six month old. The assessment of the weaning regime was found to be sudden in about 23.3 % of the infant community. Imposing of such sudden weaning without gradual introduction of complementary food was reported as one of the terrible traditional practices affecting the child health in various parts of Sudan. Most of the children were found consuming cereal-based diet and due to the low socio-economic status large number of families consumes on average 0.25 kg of meat for preparing meals for the whole family. All the children examined were found consuming dried okra (*Abelmoschus esculentus* (L.) Moench) in their meals during three consecutive days.

**Keywords:** Breast feeding, cereal-based foods, children under 5, complementary foods, okra, Sudan

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## **HIV/AIDS Impacts on Commercial-orientation in Home Garden Cultivation: A Case Study of Rural Ghana**

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Recent studies on home gardens have focused on their potential in enhancing food security in rural households in HIV/AIDS affliction. Their role in contributing to cash income has received relatively limited research attention. This study assessed the extent of variations and similarities in crop species composition and diversity, availability of products and external inputs used in commercial and non-commercial home gardens managed by rural households in HIV/AIDS and non-HIV/AIDS affliction in the Eastern region of Ghana and discussed their significance in rural livelihoods. A purposive sample of 32 HIV/AIDS afflicted and a random sample of 48 non-HIV/AIDS afflicted rural households were surveyed. Seventy-five crop species consisting of 49 food crops and 26 other species were identified. Seventeen of these species were found in all four home garden types, twelve solely in commercial home gardens in non-HIV/AIDS and six in HIV/AIDS affliction. In non-commercial home gardens only two species were solely found in non-HIV/AIDS and one single species solely in HIV/AIDS affliction. In HIV/AIDS affliction, commercial home gardens were significantly larger, had more species and individual plants, and also had more perennials and species that were harvested throughout the year and evenness was lower compared with non-commercial home gardens. Chemical fertiliser was used in a higher proportion of these commercial home gardens. HIV/AIDS affliction had no effects within the non-commercial home garden category. Within the commercial home gardens HIV/AIDS affliction was associated with a larger home garden, more plants and lower evenness but there were no differences in species richness. Rural households adapt the structure, species composition and management of home gardens to suit their needs and preferences; rural households in HIV/AIDS affliction in cultivating commercial home gardens aim to cultivate crop species to meet subsistence food needs rather than for cash income.

**Keywords:** External inputs, home garden products, non-commercial home gardens, HIV/AIDS, species composition, species diversity

## Towards Boosting Aquaculture Production: An Identification of Key Determinants of Catfish (*Clarias gariepinus*) Consumption in Ibadan Metropolis of Oyo State, Nigeria

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Recent climatic events and poor fish catch technology have significantly contributed to the decline in the quantity of domestic fish production in Nigeria, while the need to augment local fish supply through importation with hard earned foreign reserve have been inevitable. Presently, aquaculture is fast gaining increasing relevance as a way of reducing the present gap, between fish demand of 2.66 million metric tons and local production of 0.62 million metric tons. Specifically, catfish production has shown great promises in terms of geographic spread, climatic suitability and acceptability in Nigeria. In order to boost aquaculture production through this fish species, it becomes pertinent to investigate the key factor that affects its consumption among different socio-economic and income strata in Ibadan metropolis of Oyo State, Nigeria. The study utilised stratified random sampling to obtain information from 120 households using well structured questionnaire. The respondents were classified into low, medium and high income group based on infrastructural developments in their respective residential locations. The logit regression analysis was used to identify the important determinants of catfish consumption. Results showed that 56 % of catfish consumers were female, 88 % had tertiary education, 72 % had a household size of 1–5 people, 39 % earned below N 50,000 monthly, 70 % spent below N 20,000 monthly on food, 92 % consumed between 1–5 kg of catfish monthly. Also, 91 % of the total respondents consume fish generally while 68 % consume catfish. The logit analysis showed that the amount spent on other fish types and amount spent on other non-fish proteins showed positive significant relationships with the probability of consuming catfish. It is recommended that producer should take advantage of the wide acceptability of catfish and explore all avenues so as to increase their present level of production.

**Keywords:** Catfish, *Clarias gariepinus*, protein consumption, household survey, water resources

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## Nutritive Quality of Blends of Sprouted Corn with Germinated, Fermented and Dried Jackbean (*Canavalia ensiformis*), *Mucuna vulgaris*, Pigeon Pea (*Cajanus cajan*) and Vegetable Cowpea (*Sesquipedalis*)

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Legumes have been found to be an important source of protein in human and animal nutrition. The usefulness of most legumes is limited by the antinutritional factors that curtail their nutritional utilisation. However, various workers have reported the possibility of total or partial elimination of the deleterious effects by various processing methods. This study was carried out to evaluate the protein quality of four legumes namely, jackbean (*Canavalia ensiformis*), *Mucuna vulgaris*, pigeon pea (*Cajanus cajan*) and vegetable cowpea or 'Akidi' (*Sesquipedalis*) processed under previously determined optimum conditions of germination, fermentation and drying. Forty (40) (130–250 g) albino rats were divided into eight groups of five rats each. The rats were weighed and housed in individual well labeled metabolic cages. Five rats of each group were assigned to a diet formulated from the blends of processed legumes and sprouted corn. The diets were formulated to provide 1.6 g N 100 g<sup>-1</sup> diet daily for the entire study period. The recorded feed intakes were used to estimate nitrogen intake and nitrogen balance of the rats. There were no significant differences in the maintenance weight of the rats at  $p > 0.05$ . The rats fed diets from *Cajanus cajan* ate more than others (63.29 g) while the lowest intake (37.50 g) was observed for the rats fed *Mucuna* diets. The highest biological value (88 %) and net protein utilisation (NPU) (83 %) were observed in rats fed diets from *Cajanus cajan* and these were significantly different ( $p < 0.05$ ) from that of *Mucuna* blends (40 %, 37 %) for BV and NPU, respectively. It could be concluded that the blends from the tested legumes with the exception of *Mucuna* gave diets of high nutritive quality that can be used in the formulation of complimentary food for children.

**Keywords:** Animal studies, legumes, nutritive value



## Effects of the Addition of Partially Defatted Peanut Paste on Some Properties of 'kokoro', a Popular Nigerian Maize Snack

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'Kokoro' a popular Nigerian snack obtained from maize has nutritional deficiencies, especially in terms of protein and amino acid contents. Therefore, it was enriched with partially defatted peanut paste by partially substituting the maize with the groundnut paste in varying proportions ranging from ten to forty percent paste. The various mixtures obtained were separately processed into snacks following the traditional method of production, involving thorough mixing, dough formation and deep frying in vegetable oil. The products obtained were analysed for proximate composition, some physico-chemical properties and pasting characteristics. The sensory attributes were also evaluated.

Results obtained indicated substantial increases in the level of protein with increases in the level of substitution with peanut paste, ranging from 12.33 to 23.77 % in the zero and 40 % levels of substitution with peanut paste. This may be an indication of the potentials of the peanut paste in improving the nutritional status of the snack. While similar trends were observed with respect to the fat contents, the levels of ash, crude fibre and carbohydrate showed a reverse trend.

The swelling capacity of the resulting flour mixtures before frying decreased in value with increases in the level of substitution, but increases, although only slightly in the values of water absorption capacity respectively. Slight increases were also recorded with respect to the generally low values of bulk density, an indication of a possible positive impact on the ease of packaging and transportation of products. There were no significant changes in the pasting properties of the resulting flour mixes regardless of the level of substitution. Sensory evaluation of the products obtained indicated that the greater the level of substitution with the defatted peanut paste in the mixture, the more acceptable the product is to consumers.

**Keywords:** Maize, peanut, snacks, Nigeria

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## Weaver Ants Convert Pest Insects into Food — Prospects for the Rural Poor

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Weaver ants of the genus *Oecophylla* prey on pest insects. The ants live in the canopies of tropical trees and bushes including most perennial crops. They are able to protect crops against more than 50 pest species and are increasingly applied in tropical biocontrol. The ants have been used in biocontrol in South-East Asia for at least 1700 years. Ants have been shown to be more efficient than chemical pesticides and may thus facilitate organic production. It is less known that the ants are utilised as a human food resource in some countries as they are edible, easily collectable and have high protein content. In a first attempt to combine ant biocontrol with ant harvest we measured ant biomass yields and tested if traditional ant harvest affected the biocontrol potential of the ants in a Thai mango plantation. Yields ranged from 32 to 105 kg ant brood ha<sup>-1</sup> year<sup>-1</sup> (wet weight) according to management intensity of the ant colonies. Moreover, neither worker ant densities nor colony survival were negatively affected by the harvest pressure, suggesting that ants can be concurrently utilised for biocontrol and farmed for food as well. In this scenario, and at no additional costs, plantations functions as “substrates” where damaging pests are eaten by ants and converted to valuable edible ant-biomass. Positive side effects are increased crop yields, independence of chemical pesticides and organic production.

*Oecophylla* ants are present in 37 of the 45 countries identified by FAO as having the highest rates of hunger. This geographic match also match nicely with cultural affinities for insect eating, consequently the implementation of combined ant biocontrol and ant farming may improve food security among the world’s poorest people. With average meat consumption in sub-Saharan Africa of 9.4 kg capita<sup>-1</sup> year<sup>-1</sup> one hectare smallholder plantation may double at least three people’s intake. Further, the introduction of the method to developing countries may be eased by the fact that the technology is readily available and “low tech” - the ants are already present and require no external input, except knowledge.

**Keywords:** Developing countries, food security, perennial crops, pest insects, poverty alleviation, protein food, sustainable agriculture, tropical agriculture, weaver ants

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## Indonesian Food Security Assessment

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In 2008, up to 38 million Indonesian live under poverty. Food supply in some parts of Indonesia up to today is still insecure. Most people rely on their own crops harvest. With stagnating agriculture productivity, many people are unfavourably affected. But the national food production data actually shows contradictive figures. Recent statistic shows that the production from 1999 until 2006 Indonesian food production is stable between 50–57 million tons in total. The total consumption is only 32.7 million tons, assuming per capita consumption is 141 kg year. Therefore, food insecurity in some part of Indonesia is caused by other factors than insufficient production.

This literature review is looking for the potential causes of food insecurity in the household level. There is abundance of statistical data from Indonesian government, Food and Agriculture Organisation and World Food Programme that is sufficient to create preliminary assumption of the potential factors contributing to the food insecurity in Indonesia.

On the production level, the potential factors of food insecurity are decreasing of arable land due to alteration to other purposes than agriculture, long drought season and flood due to the climate change, availability of seed, plant protection and natural catastrophes. On the distribution level, there is a high price disparity between consumers and farmers due to the lack of distribution policy, low transparency of food production and inadequate transportation systems. Furthermore, low post harvest technology decreases the quality and the quantity of the commodity. On the consumption level, low accessibility of food caused by poverty and undesirable dietary pattern stemming from the food culture. The result of Desirable Dietary Pattern (DDP) study shows that the demand of cereals is still high. Even though Indonesians has sluggishly changed their food consumption proportion and energy intake from mainly cereals to include more oil and fat in the diet, resulted an increase in daily calorie consumption from 66.2 to 71.8 (DDP score) between 1993–2002, this may not reflect an increase in animal products consumption since Indonesians consume a lot of fried foods. Therefore following researches will look for the possibility of indigenous knowledge utilisation in reaching adequate nutritional level.

**Keywords:** Food culture, food security, food supply chain

## Elimination of a Precipitated Layer in a Concentrated Baobab (*Adansonia digitata* L.) Squash

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Baobab (*A. digitata* L.) is an important forest tree which grows extensively in semi-arid Africa. The African baobab's fruit has twice as much calcium as milk, rich in anti-oxidants, iron and potassium, and contains six-fold vitamin C of an orange. The seeds produce edible oil and fruit dissolved in water which can be used as drink. However, formation of a precipitate at the bottom and top of Baobab fruit-based drink is a common phenomenon appearing immediately after preparation and seems to negatively affect the consumer demand. This study was conducted to find out a treatment that can help eliminate the precipitated layer, which usually occurs in concentrated Baobab squash. Carboxy Methyl Cellulose (CMC) and Gum Arabic were used at different concentrations as stabilising agents. Optimum conditions for the preparation of Baobab squash with regard to fruit soaking ratio and soaking time were identified. The effect of water type on precipitate formation was also investigated. It was found that 0.1 % of CMC and 0.2 % of gum were the best concentrations to eliminate or reduce the volume of a precipitate of the concentrated Baobab squash without affecting the product quality. It was also found that type of water had significant contribution to the formation of the precipitated layer. Distilled water greatly reduced the volume of the precipitate.

Overall, although treatment with CMC and Gum Arabic produced a clear and good appearance squash which lasts for a relatively long storage period, nevertheless, treated squash does not meet the consumer acceptability. From the taste point of view, the results obtained from organoleptic test obviously revealed that the consumer prefers untreated squash. This was attributed to the fact that consumers are much accustomed to untreated squash.

**Keywords:** *Adansonia digitata*, consumer demand, fruit juice, gum Arabic

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## Including the Culture Component of Food and Nutrition Security to the School Feeding Program in Brazil

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The national school feeding programme in Brazil is one of relevant Food and Nutrition Security policy in the country. Its goal is to satisfy the nutritional needs of the students during the time spent in the classroom, contributing to their growth, development and learning, as well as to the acquisition of healthy eating habits. Awareness that culture is an important component to be considered in food security programs, and also that the Brazilian food culture vary widely within different regions, this research proposes that the menu of the Brazilian school feeding program should include typical foods, taking account the culture factor of food based on a sensory research. This work aimed at evaluate liking for typical meals in the North Region of Brazil (Municipality of Palmas, Tocantins State). All the children involved (n= 120), aged between 5 and 10 years old, supplied liking scores for 20 typical meals of north region of Brazil. A 7-point facial hedonic scale from super good (7) to super bad (0) was chosen to identify the preference for typical foods. Sensory data were submitted to Analysis of Variance (ANOVA) ( $p < .05$ ). Typical foods used in the sensory test were chosen by previous research. All foods were well accepted by children, but mango juice was the most preferred beverage and fish meals had the less preferred dish. The high scores observed to typical food can be explained by their insertion in the children food culture as, possibly, children are used to have these dishes at home. In conclusion, results indicated that food culture develops an important role on food choice and acceptance by children, and that food culture should be taken account by the Brazilian School Feeding Program, including the typical food in its menu.

**Keywords:** Nutritional security, school feeding program, sensory analysis

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# Engineering

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## Material Investigations for an Efficient Auto Regulative Subsurface Irrigation Method with Permeable Pipes

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According to Food and Agriculture Organisation of the United Nations (FAO) irrigation consumes 70 % of surface and groundwater resources of the world. In developing countries this value may attain 95 %. Due to irrigation, climate change and population growth, in many countries water consumption exceeds the renewable water resources, leading to widespread groundwater depletion and water scarcity. It can be assumed that current irrigation methods use only a minor portion of the applied water, and that losses up to 60 % due to percolation, evaporation and water management are common. Thus, there is a crucial need to invest in affordable innovative and effective water technologies for achieving food security and economic growth.

One of an efficient irrigation system is the clay pot (pitcher) irrigation; it is a type of subsurface irrigation. The unglazed porous clay pot is embedded in the ground and filled with water, which eventually drains through the porous pot wall. Savings of up to 70 % compared with conventional irrigation methods were observed, as well as a significant reduction of fertiliser requirements, which greatly improves the economy of small-scale irrigation farming.

The authors present a research project which develops an innovative subsurface irrigation pipe following the pot-irrigation principle. Due to their specific material properties, the irrigation pipes are auto regulative, *i.e.* they release water depending on soil moisture and thus the plants' water demand.

The method offers an easy-to-use low-tech system. Compared with existing irrigation methods, the system owns a high saving potential in terms of water consumption as well as investment and operating costs. It is easy to handle and to maintain and environmentally sustainable. Against the background of the steady worsening of agricultural water supply, the project has a share in providing water and food security and thus prevents the spreading of poverty.

Comprehensive theoretical studies, including numerical modelling have shown the feasibility of the concept. At the Tropentag the authors will present first results of laboratory investigations for an adequate pipe material.

**Keywords:** Water productivity, effective water technologies, efficient irrigation system, irrigation, subsurface irrigation

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## **Biomass Energy Utilisation in Solar Distillation System for Essential Oil Extraction from Herbs**

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Utilisation of solar energy in agriculture provides an extraordinary opportunity to promote small scale agro-based industry especially in tropical countries. Innovative solar collectors have opened several fields of applications of solar thermal energy at a medium and medium - high temperature level in post harvest and food processing. Essential oils extraction from herbs through distillation process is one of the medium temperature agro-based industries which can play a vital role in improving rural development. These oils are very expensive and used in medicines, food, fragrances, perfumery and cosmetics etc. A solar distillation system was developed using Scheffler fixed-focus concentrator but it worked effectively only during sunny days. The degree of reliability desired of a solar process to meet a particular load can be provided by a combination of properly sized collector and an auxiliary energy source. In the most climates, auxiliary energy is needed to provide high reliability and avoid gross over design of the solar system. For this purpose, solar distillation system is integrated with biomass energy to operate during adverse climatic conditions. The auxiliary biomass system comprises of a boiler, biomass furnace, and economiser and equipped with all safety mountings. The boiler operates under natural draught with the help of a chimney for efficient combustion process and can be operated with firewood, dry straw etc. The main object of the work is to utilise solar energy as a primary heat source and the rest is provided by biomass boiler. The steam connection of the biomass boiler is injected into the distiller while bottom of the distiller is always exposed to beam radiations coming from the fixed-focus solar concentrator. The average operating parameters for distillation temperature, power and efficiency of solar distillation system during sunny hours were found to be 100°C, 1.55 kW and 33.21 % respectively as recorded from the sensor system. The fluctuations of these parameters due to adverse climatic conditions are compensated by make-up steam line from biomass system. The paper presents the development, evaluation and experimental results of solar distillation system integrated with biomass energy for on-farm extraction of essential oils.

**Keywords:** Biomass boiler, essential oils, fixed-focus concentrator, herbs, natural draught, solar distillation

## Effect of Ethrel Postharvest Applications on Ripening of ‘Tron’ and ‘Hoi’ Mangoes (*Mangifera indica* L.)

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Mango (*Mangifera indica* L.) is becoming an important fruit crop in the mountainous areas of Son La Province in northern Viet Nam. The two main local varieties ‘Tron’ and ‘Hoi’ have great potential for commercial mango production, but their cultivation is restricted to the hillsides areas of Son La Province. Commercially harvested fruit is relatively soft and has a short shelf life. In contrast, green mangos are firm and withstand well transportation to remote markets but require long time to reach full ripeness. An effective technology for overcoming this production and marketing constraint and thus combining excellent transportability and uniform ripening of fruit could be the postharvest application of Ethrel.

Consequently the research objective was to investigate the effect of Ethrel applied as postharvest aqueous solution on various fruit ripening parameters of ‘Tron’ and ‘Hoi’ mango. In 2008 fruit of five ‘Tron’ and ‘Hoi’ trees from each of five orchards, respectively, were collected at commercial harvest and 10 days prior. Fruits were trenced for 30 min in 0.4 % and 0.8 % Ethrel solution and water as control treatment, then dried at room temperature, kept in sealed plastic boxes and stored at 20°C and 12°C with a relative humidity of approximately 70 %. At each removal date of 1, 3, 5, 7 and 9 days of storage time, fruit samples were kept over 24 h at 20°C before fruit quality assessment commenced. In general, fruit weight loss was significantly less at 12°C than at 20°C. In addition, fruit of both cultivars treated with 0.8 % Ethrel and kept at 12°C had greater weight loss than other treatment fruit at the same room temperature. Flesh firmness of ‘Hoi’ was maintained higher and longer compared to ‘Tron’ but was more reduced at higher concentrations of Ethrel in both temperature regimes. total soluble solids concentration of ‘Hoi’ was considerably increased with increasing Ethrel concentration within five days at 12°C and three days at 20°C. Moreover, skin and flesh hue angle of ‘Hoi’ enhanced significantly at higher Ethrel concentration under both temperature regimes. The results showed that 0.8 % Ethrel accelerated ripening of both cultivars.

**Keywords:** Fruit colour, fruit weight, total soluble solids concentration

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## **Interlinks Between Improved Cooking Stoves, Forests Conservation and Poverty Alleviation: Experience of North Kordofan-Sudan**

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Rural households in Sudan mostly depend on firewood and charcoal as main source of energy. Therefore, greater pressure on forests of Sudan, resulting from firewood and charcoal production represents the major threat to environment and sustainable forests management. Improved Cooking Stoves (ICS) have been developed to reduce firewood consumption and hence forests conservation. Accordingly, this paper aims to compare and contrast between improved and the traditional stoves with regard to firewood energy consumption, energy utilisation efficiency, cost effectiveness and time consumed in firewood gathering, and hence their implications on forests conservation and poverty alleviation. Primary data were collected using structured questionnaires with 66 ICS users and non-users in North Kordofan state. Moreover, an experiment was conducted to measure the efficiency of the improved stoves versus the traditional ones.

The results reveal that all the respondents are totally dependent on firewood as a primary source of energy. Improved stoves users agreed that the new stoves have many advantages over the traditional one such as fast cooking, smoke reduction, and fire lasting long time, sturdy and stable. Moreover, the results showed that using improved stoves reduced per capita wood fuel consumption by 53 percent; household wood energy expenditure by 35 percent and the time spend in firewood gathering by 52 percent, compared to the traditional stoves. It could be recommended that efforts should be made by governmental and non governmental institutions to encourage the adoption and utilisation of the improved stoves so as to conserve forests and consequently improve the livelihood of the rural households.

**Keywords:** Forest conservation, improved stoves, Sudan, wood fuel

## Clarification of *Jatropha curcas* Oil for Direct Use in Plant Oil Stoves

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*Jatropha curcas* cold-pressed oil can contain up to 30 % of impurities of its total volume. These impurities influence the combustion characteristics and performance of plant oil stoves. In this study the efficiency of discontinuous and continuous systems for the clarification of the *Jatropha* oil was analyzed. Viscosity and density of the oil for different temperatures were determined in order to evaluate their influence on the clarification process. The total contamination of the oil and the particle size distribution (PSD) of the sediments were used as parameter to assess the efficiency of the clarification systems.

The PSD of the raw oil varied in a wide range, from 4.25  $\mu\text{m}$  to 735  $\mu\text{m}$ . This wide particle size distribution of the oil resulted in a broad range of required sedimentation time for the particles. The efficiency of the removal of particles using the discontinuous system, *i.e.*, horizontal tank, was about 65 % in 3 days. From this point onwards the reduction of the total contamination was very slow, since the suspended particles in the oil are very small, and therefore the system is no longer efficient. The Weihenstephan continuous system was more time efficient than the discontinuous system reaching 35 % of reduction of particles within 5 hours. The time required for the removal of the particles is dependent on the geometry of the tank, namely, the larger the falling height of the particles the longer the time of the particles to settle. The sedimentation time reduces with the increase of temperature of the oil. Specifically, by increasing the temperature from 20°C to 50°C the time was reduced by factor 10. The results will form the basis for developing clarification systems for village level in rural areas.

**Keywords:** Chemical properties, *Jatropha curcas*, oil clarification, Weihenstephan standard

## Using Radio Frequency to Control Red Flour Beetle (Coleoptera: Tenebrionidae) in Feed

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Radio frequency (RF) was used to control red flour beetle, *Tribolium castaneum* (Herbst), which is an important pest in feed primarily on damaged grain, broken grain, and other cereal products including chicken feed pellets. In experiment I, a sample of 1 kg each out of 5 bags of chicken feed pellet were investigated. All stages of *T. castaneum* were found. Larval stage was the most abundant with  $43.2 \pm 63.1$  insects  $\text{kg}^{-1}$ , followed by egg, adult and pupal stages with  $17.60 \pm 29.5$ ,  $8.40 \pm 11.0$  and  $5.80 \pm 8.1$  insects  $\text{kg}^{-1}$ , respectively. In a second experiment, egg, larval, pupal and adult stages of *T. castaneum* were blended with chicken feed pellet and then exposed to RF with 27.12 MHz at 50°C for 3 minutes. Insect mortalities of egg, larval, pupal and adult stages were  $81.98 \pm 3.8$ ,  $92.06 \pm 4.0$ ,  $72.99 \pm 3.3$  and  $91.58 \pm 1.7$  %, respectively. The result showed that pupal stage was the most tolerant stage to RF-heat treatments. In experiment III, *T. castaneum* pupae blended with chicken feed pellets were exposed to combinations of RF: 4 different temperatures (50, 55, 60 and 70°C) and exposure for 1, 2, 3, 4 or 5 min (20 combination experiment). The results showed that pupae completely died at 70°C already at the shortest time period of 1 min. Although the RF treatment at 60°C could not get completely control of *T. castaneum* pupae, the mortality rate of pupae between 60 and 70°C were not significant different. Feed analysis showed that the quality of the chicken feed was not affected by the RF treatments.

**Keywords:** Chicken feed pellet, chicken feed quality, radio frequency, red flour beetle, *Tribolium castaneum*



## Physicochemical Properties of *Acacia polyacantha* Gum

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Although there are more than 1 100 species of *Acacia* botanically, known distributed throughout the tropical and subtropical areas of the world, the Sudanese major gums of economic importance are gum Arabic, gum talha and *Acacia polyacantha* gum. These gums are used worldwide as food additives in confectioneries, beverages, pharmaceuticals and cosmetics as well as adhesives materials due to their emulsifying, foaming, flavor fixing properties. Most of the research work is directed towards hashab gum of *Acacia senegal* trees and to a lesser extent towards gum talha of *Acacia seyal* trees. Regrettably, *Acacia polyacantha* gum received very little attention.

The main objective of this study was to determine the physico-chemical properties of *Acacia polyacantha* gum.

From Kadogli and Eldamazine areas in Sudan, forty samples of gum nodules were collected from *A. polyacantha* trees (season 2005/2006).

The specific rotation of Kadogli samples was  $-19.6^\circ$ , while that of Eldamazine was  $-14^\circ$ . Intrinsic viscosities were 9.9 and 10.2 ml g. for Kadogli and Eldamazine samples, respectively. Refractive indices of all samples from the two different locations showed the same value of 1.3354. The two samples gave approximately the same moisture (10.5 %) and ash (3.4 %) contents. Nitrogen content of Kadogli samples ranged from 0.30 to 0.42 % (1.88 to 2.63 % protein content), while that of Eldamazine samples varied from 0.36 to 0.48 % (2.30 to 2.90 % protein content). The pH value for Kadogli samples and Eldamazine samples was 4.96 and 5.23, respectively. The concentration of reducing sugars was 0.23 and 0.16 % for Kadogli and Eldamazine samples, respectively. Uronic acid contents of Kadogli samples ranged from 12.02 % to 17.30 % and that of Eldamazine samples ranged from 12.10 % to 19.48 % and significantly ( $p \leq 0.05$ ) affected by location.

Due to the remarkable similarity in the physicochemical properties of gum exudates from *A. senegal* trees and *A. polyacantha* trees more investigations are needed to study the functional properties of *A. polyacantha* gum so as to be considered as one of the main substitutes of gum produced by *A. senegal* trees.

**Keywords:** *Acacia polyacantha*, gum Arabic, physicochemical properties, protein, refractive index, specific rotation, uronic acid, viscosity

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## Optimising Water Use in Irrigated Rapeseed Areas in Brazil

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Rapeseed is the third most produced oilseed in the world. It is also the third major source of edible oil, following soybean and palm. It was introduced in Brazil in 1974 and is currently cultivated in 33 thousand hectares. Rapeseed crop has high potential to contribute to Brazilian agribusiness expansion, as it is appropriate to the second harvest in winter (locally called 'safrinha' - small crop) in grain production systems in Midwest Brazil. However, the crop area increase will definitely depend on generation or adaptation of technology, such as irrigation to raise crop yield, as investments in rapeseed researches have been extremely limited in South America. Therefore, the objective of this investigation is to define management irrigation criteria for farmers, determining time and amount of irrigation especially in the Southern Region of the state of Minas Gerais, Brazil, thus contributing to income raise for farmers, as well as crop expansion. For this purpose, two trials were carried out in a totally randomised experimental design. The first trial, experiment 1, comprised 4 treatments and 4 repetitions, totalizing 16 experimental plots with application of four different water tensions on soil: 20, 40, 80, and 120 kPa. The second trial, experiment 2, comprised 5 treatments and 4 repetitions with application of 5 different irrigation depths: 50; 75; 100; 125, and 150 % of relocation depth up to field capacity. According to the variance analysis, by F test 5 % probability, different water tensions on soil affected number of pods, total green matter, total dry matter, and yield. The highest yield was verified under 20 kPa tension. Different irrigation depths showed no significant influence on assessed parameters due to precipitations during application of treatments. It is possible to conclude that water retained at 25 cm depth under 20 kPa tension is a good indicator of the right time to start irrigating rapeseed crop, as under these conditions we obtain the maximum crop potential yield. Also, we concluded that the determining factor for yield increase in irrigated rapeseed crop is irrigation frequency instead of amount of applied water.

**Keywords:** Irrigation, rapeseed, water depth, water tension on soil, yield

## Anaerobic Digestion of Banana Waste, a Potential Source of Energy in Uganda

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Bananas and plantains are the world's fourth most produced food commodity, after rice, wheat and apple. Bananas are grown in more than hundred countries, mostly in the developing world where they represent an important staple food. Uganda currently produces more than 4.5 million metric tons of bananas every year, accounting for about 10 % of the total world production. However, a considerable part of the harvest is lost. It is estimated that 40 % of the bananas produced in Uganda perish. An effective way to enhance storability and distribution of bananas are drying and processing. Processing of banana results in a huge amount of waste generation, leaves, stems and peels and to some extent the degraded bananas itself. Indiscriminate disposal of these wastes when decomposed produces noxious gases such as hydrogen sulphide and ammonia, which pose serious environmental hazards. The banana waste is a concentrated source of putrid organic waste, ideal for anaerobic digestion to produce energy while fermentation products can serve as fertiliser with high nutritional value, as well as a valuable energy source in form of biogas. Channeling these peels into the production of biogas is an efficient way of waste management. The aim of this study was to compare the amount of methane produced from different fractions of banana (stem, peel, and fruit) through anaerobic batch digestion assays at 37°C for a period of 35 days, using pre-digested manure as inoculums source. For this purpose, the biogas production as well as the methane content in the biogas produced was analyzed. The methane yields of the different fractions were compared to the methane potential of the whole banana. The stem, peel and fruit fractions represented 0.84 %, 17.71 % and 81.46 % of the total methane production potential of the whole banana with specific methane yield of 0.256, 0.322, and 0.367 m<sup>3</sup> kg<sup>-1</sup> volatile solids respectively. Hence, anaerobic digestion of banana waste could generate important amounts of energy, which could be used to cover essential needs of either households or to meet the requirements of the processing industry in developing countries such as Uganda.

**Keywords:** Anaerobic digestion, banana, biogas

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## Convective Hot-air Drying of Banana in Uganda

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Uganda produces annually 615 000 ton of fresh bananas according to FAOSTAT 2007. It is estimated that more than 70 % of the population of Bushenyi district in western Uganda, lives from agriculture and out of this, approximately 60 % of the agricultural activities are dedicated to Matooke banana production and processing. Low and fluctuating prices as well as no added value account more than 50 % of the factors affecting banana marketing. The Presidential Initiative on Banana Industrial Development (PIBID) in Uganda intends to enhance the marketability of banana through processing and value addition, including high quality banana figs production. For the design and optimisation of the current drying applications in Uganda, fundamental research performing laboratory tests in a high precision thin layer laboratory dryer in the Institute of Agricultural Engineering at the University of Hohenheim was conducted. In this work the effect of drying parameters, namely air temperature (40, 50, 60 and 70°C), air velocity (0.5, 0.75 and 1.0 m s<sup>-1</sup>), air humidity (10, 20 and 30 g kg<sup>-1</sup>) and slice thickness (3, 6 and 9 mm) on the drying behaviour and quality of banana were investigated. Prior to drying, bananas were immersed in solution of potassium metabisulfite, or soaked in citric acid solution and compared with the untreated samples. The colour of the dried banana slices was used as quality criterion for the evaluation and determination of the optimum conditions. The individual colour parameters were measured by a CR-400 colorimeter and expressed as L\*a\*b\* and L\*C\*h° colour systems. Statistical analysis of ANOVA was performed using the OriginPro 8 software to determine any significant differences among the experimental data sets. Considering drying time and quality of the dried bananas, a combination of a drying air temperature of 60°C, air velocity of 1.0 m s<sup>-1</sup> and humidity ratio of 10 g kg<sup>-1</sup> seems to be appropriate for obtaining a good dried product. Also, the use of potassium metabisulfite dip helped in reduction of darkening of banana slices during drying.

**Keywords:** Banana, hot-air drying, Uganda

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## Farmers' Strategies and the Constraints of Organic Fruit Drying in the Kayunga District of Uganda

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This study investigates the strategies of farmers and the constraints of organic fruit drying in Kangulumira Sub County of the Kayunga district of Uganda.

Commercial solar drying of fruits such as pineapple, papaya and jackfruit started in the late 90s in this sub county. Most of the fruit drying farmers or processors are small to medium landholders and posses land between 2–4 acres. Farmers dry fruits using simple solar dryers which are made of a wooden frame covered by transparent polythene sheets.

As fruit drying does not require extra physical strength, many women and old age farmers are involved in this activity. Fruit drying is mostly a seasonal activity and during off seasons the dryers mostly remain idle and the labourers are diverted to other agricultural activities.

80 % of the farmers grow fruits for drying in their solar driers and if more fruit is needed, they buy from other farmers. The remaining 20 % of the farmers (can be called 'processors') do not grow fruits and therefore buy all the fruits for drying.

The important strategy practised by fruit dryers are to dry fruits (pineapple) of all sizes during peak harvesting season and during the off season dry only the small sizes. 53 % of the fruit dryers were women and as such fruit drying plays an important role in reducing the economic dependency on men.

Drying of fruits is a value addition and provides an additional and stable income to the household. Furthermore, it increases the shelf life of the fruits which otherwise would have been wasted or would have fetch very little value during peak harvesting season. Unaffordability of the driers, unpredictable weather conditions, lack of knowledge about fruit drying and lack of trust to the exporting company were the important constraints identified by the farmers. In addition to increased role of women in agriculture and decision making of the family, fruit drying has also brought more cohesion among farmers and increase the savings of the families for reinvestment in solar drying or on other activities.

**Keywords:** Farmer strategies, fruit drying, organic fruit, solar drying

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## Opportunities and Constraints at the Processing Level in the Fruit Drying Industry in Uganda

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In Europe, the demand for organic tropical dried fruit such as pineapple, mango and banana is big and increasing. Uganda is one of the countries exporting large amounts of these products, but unable to meet the demand in Europe. This research investigates the opportunities and constraints faced by the fruit drying companies at the processing level.

There are about 15 fruit drying companies in Uganda, of which a few are big and the rest small. The constraints faced by the small companies are primarily the lack of money for investment, small drying capacity and difficulties in finding buyers who are interested their small production. They furthermore have little knowledge about marketing and less experience in running a business.

The bigger companies have fewer problems, the major one being the long period of time it takes to convert conventional out growers into organic. Some companies are run by NGOs and the management here put less effort into making the business efficient and profitable.

Most companies use hybrid cabinet dryers, which has biomass burners to heat up the air. However, many have experienced the fruit being flavoured by the smoke and becoming unmarketable. One company uses simple solar driers which are very environmentally friendly since only solar energy is used. However, large amounts of fruits are wasted when the weather is not favourable.

The seasonality of pineapple is also a problem for companies and out growers. In the high season the companies cannot process all the pineapples and in the low season they cannot always get enough. Cheap and easy technologies which can induce pineapple flowering throughout the year have been developed and introduction of this technology could help both companies and out growers to optimise the utilisation of the fruit.

The government of Uganda is currently fighting malaria by spraying DDT in certain areas. This possesses a big threat to the entire organic sector in Uganda and may also affect the fruit drying companies.

**Keywords:** Fruit drying, organic fruit, processing, solar drying, Uganda

# Participation

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1) Participation

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# Participation

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## Strategies of Women Fish Traders in Ibaka, Niger Delta, Nigeria, in Coping with Cultural and Institutional Constraints

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Women's livelihood strategies in the Niger Delta, Nigeria, have been largely ignored by researchers, who are often more pre-occupied with environmental impact assessments required for establishing new oil fields. This research focuses on the strategies and activities of women fish traders in the Niger Delta for whom fish trade is their principle source of livelihood, within the context of prevailing cultural, institutional and environmental constraints. Hence, the key question addressed in this paper is: What strategies do women fish marketers adopt in carrying out their business in the face of cultural and institutional constraints? Research was carried out during 2007–2008 in Ibaka, Akwa Ibom State, Nigeria. Survey data were collected from a total of 100 purposively selected households and ethnographic methods — life history interviews, focus group discussions, observation and in-depth interviews with key informants — were used to collect qualitative data. The fish traders were categorised based on the type of fish they trade in: Bonga traders, Big Fish traders and Crayfish traders. Data included the characteristics of households, the fish market, fish marketing practices and other livelihood strategies of the women. The coping strategies of the women traders include trading in fish, switching from trading in one species to another depending on the season, subsistence farming, and other economic activities such as renting out rooms. The cultural constraints include polygamy, discriminatory inheritance laws, and traditional fish-smoking practices. Institutional constraints include lack of infrastructural and other facilities that would facilitate their economic and domestic activities. The study tests the relationship between women's coping strategies and their personal and business characteristics (number of years in the trade, amount of capital, assets owned). The paper ends with a discussion on the kind of personal or business factors that contribute to success of coping strategies in the context of the cultural and institutional constraints.

**Keywords:** Coping strategies, cultural and institutional constraints, Ibaka, livelihood security, women fish traders, Nigeria

## Women's Involvement Along the Supply Chain for African Indigenous Vegetables in Uganda and Kenya

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African Indigenous Vegetables (AIV) are an integral part of the diet of the urban and peri-urban population in many countries of sub-Saharan Africa (SSA). Yet, little is known about the economic importance of AIV for income generation and livelihoods in urban and rural areas of sub-Saharan Africa. Writers have highlighted that indigenous vegetables are a valuable food source for the poor, but increasingly there is realisation that indigenous vegetables are a vital component of the rural economy, that they contribute to livelihoods both through their value for consumption and income, and also that there is a large and perhaps growing market for indigenous vegetables. For instance, in Nairobi it is estimated that now 30 % of all vegetables sold are AIV produced in the vicinity of the city. AIV find their way from the field to the market through various channels and one can thus assume that AIV support a large number of small businesses along the supply chain in urban and peri-urban areas. Based on a survey conducted in 2007 that involved 815 respondents, we describe the actors involved, and provide an overview on the value and size of the market for indigenous vegetables in Kampala and Mbale, Uganda and Nairobi and Kisumu, Kenya. Our data shows that AIV provide an important means of livelihood and for many supply chain actors they are a major source of income. We find that women participate in all segments of the chain, and dominate wholesale and retail activities. Low capital requirements for entry allow even the poorest households to participate. Based on a multivariate regression analysis we show that women's income along the supply chain is generally lower than that of their male counterparts. Women face various constraints in their activities and thus need support of policy and decision makers.

**Keywords:** African Indigenous Vegetables, gender, Kenya, supply chain, Uganda

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## Contribution of Farmer-to-Farmer Video to Food Security: Evidence from Bangladesh

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What is the best way to deal with food security and poverty is a major question that agricultural research, extension services, development organisations and donors are currently posing themselves. Video-facilitated farmers' capacity development is a new approach pioneered for scaling-up local sustainable rice seed innovations in Bangladesh. Inspired by earlier experiences CABI collaborated with the Rural Development Academy (RDA) in Bangladesh to build the capacity of the resource-poor rural women for farm-based production and post-harvest management of rice seed. Partnering with two Non Government Organisations (NGOs) Tenghamar Mahila Sabuj Sanhga (TMSS) and Agricultural Advisory Services (AAS), group-based, video-facilitated training sessions had been conducted from 2005 to 2007. Local improved rice seed technologies and knowledge had been internalised through participatory learning and action process. Seven rice seed videos were developed on rice seedling production, rice seed harvest, post-harvest processing and storage with selected experienced farmers who explain and show rice seed innovations before the camera. Unlike conventional training sessions this approach used open-air video shows followed by interactive discussions. This study assessed the development outcome of the farmer-to-farmer video approach from the rice self-sufficiency perspective. From December 2008 to February 2009, 140 randomly selected women farmers were interviewed in 14 villages where RDA and TMSS operated. In addition, two focus group discussions and six qualitative in-depth interviews were conducted in both sites. Data were analysed using descriptive statistics and inferential statistical measures (t-test, chi-square and regression analysis). Analysed data suggest that video-facilitated training sessions increased farmers' knowledge and practice of local rice seed techniques which in turn increased their productivity and rice self-sufficiency significantly as per observed increase of average Rice Self Sufficiency Index (RSSI). After having watched the videos women could produce quality seed, which decreased the seed rate and increased total rice production. Results imply that farmer-to-farmer video has significant implications for organising farmer training and capacity building events at local and regional level. Sharing of knowledge and skills is more effective when farmers watch their peers explain the 'why' and 'how' of a locally grounded technology in the video.

**Keywords:** Bangladesh, farmer training, innovations, rice self-sufficiency, video

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## **Agricultural Innovations towards Smallholder Participation: Evidence from Central Java, Indonesia**

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The postulation for agricultural development programmes and projects to target pro-poor growth is of continuing relevance throughout the developing world. Indonesia's poor population is predominantly rural, with small-scale agriculture constituting the main source of income. Since poverty alleviation of smallholders is closely linked with the increase in productivity of traditional farming systems, innovations are required to improve people's livelihoods. Yet, innovations do not only refer to mere technical aspects, but also to "soft" ones, including changes in former practices. The study investigates the role of an agricultural innovation and its course of adoption for the case of high-value crops in Central Java, Indonesia. Semi-structured interviews were conducted among farmers applying papaya cultivation as a new farm element in Purbalingga Regency. Key informant interviews, focus group discussions and workshops were held to clarify the perspective of all stakeholders and identify sensitive moments, which have the potential to both hinder or facilitate the adoption process of innovations. Methods included the analysis of the farmers production environment, existing extension or advice services and approaches, as well as social networks and communication patterns. The study concludes that the inclusion of adopters' problems, needs and knowledge into the course of development and adoption of an innovation significantly depends on the active involvement of stakeholders. Evidence suggests that enhanced networks, communication flows and platforms are crucial for the diffusion of innovative ideas. At the same time they are linked with the reduction of farm risk through the mitigation of information gaps, the creation of knowledge and integration of know-how from all stakeholders into developed innovations. Capacity building nevertheless remains a basic requirement to support the adoption process of innovations and their adaptation to local farmers' needs and skills in order to achieve productivity increase for smallholder farming systems.

**Keywords:** Adoption, agricultural innovation, extension, Indonesia, Java, participation, small-scale agriculture

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## Empowering Smallholder Producers in Integrated Agricultural Research for Development in Lake Kivu

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The sub-Saharan Africa Challenge Programme (SSA-CP) has adopted the IPs as the structure for bringing stakeholders together to innovate and tackle the challenges of agriculture research for development in the region. It is expected that the IPs will improve interactions between stakeholders, increase their knowledge on research for development issues, improve effectiveness of implementation of agricultural interventions and that research emanating from these interactions is more responsive to the needs to stakeholders compared to research from conventional research approaches. This paper describes the functioning innovation platforms – the implementation module of Integrated Agricultural Research for Development (IAR4D) and the participatory process of identifying critical research issues to be addressed by these innovation platforms. It further discusses the empowerment of the smallholder farmers as major actors in the IP's and the project implementation structures. Essentially, this paper also discusses how the implementation of a monitoring and evaluation process has resulted in the empowerment of smallholder farmers, in the establishment and functioning of the Innovation platforms. We describe the process for the development of indicators for these three key areas and the implementation of a data collection, analysis, reflection and learning process for the 7 innovation platforms in the Lake Kivu region. There are challenges however in the functioning of IPs that bear on their implementation, which include how to increase the active participation of different actors in the processes of the innovation platforms a critical factor in their outcomes. Others include eliciting meaningful farmer participation given power balance between different types of stakeholders, achieving coherence of process in the monitoring and evaluation across the 7 innovation platforms given differing capacities and institutional arrangements. The paper concludes that IP's are a forum through which bottom up decision making can result in the sustainable improvement in smallholder livelihoods.

**Keywords:** Empowerment evaluation, innovation platforms, Lake Kivu, livelihoods

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## **Agricultural Extension in the Mekong Delta of Viet Nam: The Case of Integrated Agriculture-Aquaculture**

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In the Mekong Delta of Viet Nam, agriculture is primarily characterised by small-scale, rice-based farming systems. Even though integrated agriculture-aquaculture (IAA) is a common production system in the Delta with a considerable potential for poverty reduction, farmer's adoption rate of IAA remains slow. Former research and extension models to support IAA activities have mainly focused on a top-down approach for the transfer of technology, yet farmers' needs have not been met. Hence, the key question of this study centres on agricultural extension and suitable concepts to ease the development of IAA systems in the region. Findings show that IAA systems are complex and affected not only by the selection of promising production technologies but also by the households' access to capital assets, markets for agricultural inputs- and outputs as well as the policy environment. Among other aspects, IAA systems mainly require a high level of knowledge relating to technical and management skills. Today, research and extension agents in the region often aim at increasing productivity by merely addressing single elements of a multitude of interrelations adherent to IAA systems, following a reductionism ideology. In order to cope with both the inherent complexity of IAA systems as well as issues emerging from the countries' recent WTO membership, the prevalent extension approach is required to change. In response, a concept towards the inclusion of participatory and multi-disciplinary issues such as participatory technology development (PTD) is perceived as a promising option. However, evidence suggests that the integration of PTD into daily extension services can only be realised if an appropriate policy set-up is in place. Extension efficiency may be then strengthened via an enhanced linkage between national extension authorities and local governments. In addition, a comprehensive collaboration between professional agricultural extensionists and other stakeholders (*e.g.* research institutes, NGOs, private enterprises, mass organisations, mass media, other governmental organisations) is a key concern and may open up new avenues towards a facilitation of IAA development in the Mekong Delta.

**Keywords:** IAA, integrated farming systems, Mekong Delta, participatory extension, participatory technology development

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## Why Include Women in Community Forestry: To Include Differences or to Make a Difference?

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Including women in local forest management has become an essential part of the rhetoric surrounding community forestry programmes in Nepal and elsewhere. However, the rationale behind women's inclusion is often poorly defined. Often, women's participation in decision-making is argued as a way to promote ecological management by integrating women's specific, local knowledge about forest resources and thus, improving the ecological sustainability of forest management. In other cases, women are recognised as those providing a large share of the labour involved in silvicultural operations, thus women's participation ensures the economic sustainability of the community forestry. Finally, women's participation is argued as a way to develop democracy and an engaged citizenship. The wide range of reasons to include women often leads to a lack of clarity as to what framework will allow achieving them, so that disparate and isolated measures are implemented. Based on existing literature and on the result of fieldwork in two Community Forest User Groups in Nepal, I argue that women's integration in a community forest user group need to be pursued within a coherent framework. The aims cannot be solely focused on ecological and/or economic sustainability, i.e. including women to provide the labour needed to protect the forest and to collect forest products, or to include some diversity in local knowledge to manage the forest towards multiple uses. If community forests are to contribute to the sustainable management of natural resources, social sustainability needs play a central role. The socio-economic framework needed for sustainable management of community forests needs to include measures to enhance the social capital of women. Only self-confident, vocal women will be able to ensure that their voices are heard and their views are taken into consideration before reaching a decision. Ensuring women's participation can increase diversity of knowledge and thus, more sustainable management decisions, but only if the framework allows women to make a difference.

**Keywords:** Ecological sustainability, Nepal, participation, social sustainability, sustainable management

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## **Changes in Agricultural Development as Perceived by Local Farmers in the Bie Province, Angola**

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The Bie province is one of the most affected provinces by the long-lasting civil war in Angola. The agricultural sector was significantly damaged in terms of availability of arable land, agricultural inputs, and technologies of storing and processing of agricultural products as well as rural population which was dislocated, violated and suffered from heavy fights. Since the ceasefire in 2002 the country has been rapidly changing due to external aid and outstanding income from oil and diamond production. However, the local rural population fully dependent on agricultural and related activities is not still self-sufficient in terms of food security and safety.

The survey was focused on local farmers who were asked to identify and rate the principle changes occurring in agricultural or rural development. The agricultural development issues and solutions were identified on the basis of questionnaires by the farmers themselves. At the same time the farmers were asked to order the changes in accordance with their perceived intensity and importance (in case of obstacles, solutions and priorities). The identified agricultural development issues were further defined as internal and external. The internal changes are changes in farmers' behaviour regarding their agricultural career. The external changes are those that considerably influence farmers' behaviour (internal changes) and can therefore indirectly support or hinder a farmer's development. The survey results were organised into five subjects mapping the agricultural development changes in the last five years, the most developed agricultural development issues, the least developed changes, the agricultural development issues of high priority in next five years, and the principle obstacles and suggested solutions for agricultural and rural development.

The conclusions then helped in the identification process of farmers' needs to be effectively addressed by extension services.

**Keywords:** Agricultural development, Angola, rural communities

## The Global Horticulture Initiative as a Common Innovation Platform for Horticultural Research, Development Actors and the Private Sector

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Food insecurity, low income and malnourishment remain key issues in developing countries in the 21<sup>st</sup> Century. Much of the research and development focus over the past decades has been placed on staple crops to achieve improvements. Despite its tremendous potential to combat poverty and malnourishment, the horticultural sector has been largely neglected. Horticultural development and marketing are very knowledge-intensive and require human capital and technical inputs. Therefore, small producers and processors are often eliminated from markets for failure to understand market dynamics or due to their inability to meet production, sanitary and quality standards. Hence, opportunities of the sector are only marginally utilised. Up to now, interventions in the horticultural sector are rather fragmented and actors and stakeholders act independently or in competition with each other.

To address these issues, the Global Horticulture Initiative was established in 2006 as a consortium of prominent stakeholders in the horticultural sector. It understands itself as a common innovation platform for research, development actors and the private sector. It acts as a catalyst by linking diverse partners with each other. Core principles are multi-stakeholder partnerships and participatory approaches. Its four key activities are **(1)** Advocacy and Lobbying, **(2)** Coordinating training and capacity building, **(3)** Networking, and **(4)** Facilitating Research-for-Development programs.

By the end of 2008 and in line with its key activity (4), GlobalHort launched an international call for concept notes on global horticultural issues. Project ideas could be submitted to one of the following themes: **(a)** Nutrition and Human Health, **(b)** Protected Horticulture, **(c)** Fruit Fly Management, and **(d)** Linking Farmers to Markets. The overall response to this call was overwhelming: A total number of 187 concept notes were submitted up to the deadline on 27 February 2009. Due to limited funds for this call only one project per theme can be financed. The large number of concept notes submitted clearly demonstrates the need for further support of this rather neglected sector. GlobalHort maintains a database of the project concepts and is looking for additional financial support for granting the most innovative and outstanding proposals it has received.

**Keywords:** Horticulture, innovation platform

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## Potential and Constraints in Institutionalizing Group-based Participatory Extension in Northwest Viet Nam

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Viet Nam's northwestern mountains have undergone rapid economic, institutional and social changes and need a vital and adaptive extension sector to improve rural livelihoods and enhance sustainable development, particularly in ethnic communities. Diversification of production through enhancing pig husbandry is considered a viable option by many actors. Yet, despite high growth rates, the sector is insufficiently supported by state extension services, struggling to shift from conventional top-down to approaches that view innovation as a product of multi-stranded interaction among multiple actors. We argue that such a paradigm shift requires the promotion of knowledge and innovation partnerships (KIPs) to familiarize farmers with new breeds and breeding schemes, progressive management and marketing strategies, and support in adjusting information to local conditions.

Employing an interdisciplinary research approach that integrates perspectives from animal sciences and innovation studies, we address the question how KIPs in Viet Nam's smallholder pig husbandry can be sustained and how such partnerships are viewed as compared to 'conventional' approaches. Five recently-evolved forms of extension groups, varying in set-up, actors' participation and state involvement were assessed along three focal points, namely a) concept of knowledge dissemination b) farmers' motivation to participate and learning effects, and c) advantages and disadvantages in comparison to conventional extension approaches as perceived by farmers.

The paper draws on data of two ongoing subprojects of the 'Uplands Program' (SFB 564) in Son La province, combining ethnographic methods with a review of reports from extension providers involved in the KIPs.

Results show that involvement of government actors plays a vital role in both initiating and sustaining KIPs, even though farmers' linkages to public organisations are limited by ethnic and cultural boundaries. KIPs respond better to individual needs than conventional extension; however, opportunities for revising extension curricula through enhanced participation are still underutilised, mostly due to misperceptions of group members as regards the potential of group-based approaches and the lack of communication between KIP initiators and other stakeholders. We conclude that group-based extension requires further institutionalisation to enhance effectiveness, in combination with changes in organisational cultures to strengthen linkages among actors and support scaling out of KIPs to a wider area.

**Keywords:** Knowledge and innovation partnerships, Northwest Viet Nam, smallholder pig production

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## Social Science as a Catalyst for Participatory Planning in Natural Resource Management: The Case of Kakamega District in Western Kenya

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The Kakamega District in western Kenya is only one of many remote areas in Eastern Africa which has to cope with a host of environmental, economic as well as social challenges. It is the most densely populated district in Kenya with over half of its people living below the poverty line. Although livelihoods are highly diversified, agriculture predominates. Income from main crops and other on-farm use of household assets barely suffices to sustain rural households. Food insecurity is a common feature for many of them, hunger one of the most mentioned shocks badly affecting households across income strata, and remittances sent by family members working abroad are mostly used for compensating poor harvests in terms of buying additional food and caring for essential household needs.

In trying to cope with and adapt to this fundamental challenge, people put heavy pressure on Kakamega rainforest by extracting fuelwood and timber and by using it as a grazing ground for their cattle. In addition to that, the land use in forest adjacent communities is partially changed to other on-farm income generating activities like agroforestry or bee keeping practices. But not all rural households do have the individual adaptation capacity to re-direct their activities. In an effort to stimulate self-assessment of problems and potentials, participatory land-use planning workshops were conducted in several communities near Kakamega Forest. Starting with an assessment of assets and resources at household as well as community level, people went ahead identifying alternatives and options in line with their needs and capacities. They started to discuss and develop community-based projects which serve the double purpose of income generation and natural resource protection. The paper gives an insight into how social scientists can assist to re-frame socio-economic conditions for sustainable management of land resources while acting as an intermediary between local communities, regional administrations, and international partners.

**Keywords:** Adaptation capacity, food insecurity, participatory land use planning, pressure on forest

## **Barriers to the Adoption of Non-certified Organic Agriculture by Smallholders in sub-Saharan Africa: Evidence from East Mau Catchment, Nakuru, Kenya**

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Food insecurity continues to be pervasive in sub-Saharan Africa. Agricultural productivity is very wobbly mainly due to soil fertility problems. In the stir of the resource constraints for external farm inputs faced by smallholder farmers in the region, sustainable agriculture that relies on on-farm or local resources presents desirable option for enhancing agricultural productivity. Organic agriculture is frequently promoted as an exit strategy from food insecurity and poverty for small-scale farmers in these regions. Potential benefits include affordable and enhanced soil repletion, environmental health, poverty alleviation among others have been widely documented. However, uptake has been slow and promotion and research into sustainable technologies has had little impact on its adoption. This paper investigates the barriers to adoption of non-certified organic agriculture technologies by smallholder farmers in Kenya. Economic, demographic, institutional as well as farm characteristics are explored to unravel their role. The Mau catchment was purposely selected as a case study because of unprecedented land use change representative of a typical fast degrading high agricultural potential highland. A comprehensive smallholder farm survey of 292 households provides data for this analysis. A set of 14 organic farming techniques were evaluated on the farms. The most important techniques found were: intercropping, crop rotation, use of animal manure and composting, soil conservation techniques (terracing, agroforestry). Other techniques practised by farmers included: double digging, use of biopesticides, mulching, zero-tillage among others. However, their adoption displayed a wider inter-household and inter-technique variation. Based on these variations farmers were clustered into three adoption levels: low, medium and high adopters. While there is heterogeneity with regard to the factors that influence adoption across the groups, results from an ordered probit model underscored the importance of membership of farmer groups on adoption decisions. Particularly results indicate that farmers' experience, household size, distance to the road, religion and ethnicity play an important role in the adoption of organic farming techniques among smallholders. Recommendations to facilitate adoption of different techniques include: the creation of more awareness among farmers of soil fertility effects and long-term benefits of organic soil fertility management, market linkages and support the development of farmer groups.

**Keywords:** Food insecurity, Mau catchment, organic agriculture non-certified, smallholders, soil fertility, zero-tillage

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## Role of the Facilitator in the Emergence and Scaling up of a Geographical Indication Initiative

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Geographical Indications (GIs) have become a negotiation stake at the WTO since their recognition by the TRIPS agreements in 1994. Nevertheless their protection and the support they benefit from are at the centre of sharp controversies. Though a collective organisation is not a pre-condition for the registration of a GI, the registration implies a delimitation of the territory of the GI as well as negotiations among producers to define the product and the practices accepted for its production. For these reasons, the registration procedures require a more or less formal structure of animation or networking piloting.

Numerous practical guides are dedicated to facilitators and there has been a wealth of academic research on the subject of broker in the field of political sciences, regional sciences and management. In agricultural socio-economics, research underlines the determining role of external actors and leaders in the emergence and the scaling-up of local agri-food initiatives, as well as the specific needs in terms of management.

This article focuses on the role of the facilitator in building collective agri-food organisation which valorized a Geographical Indication. These roles cover a large field from technical expertise to the coordination of networks, as well as conflict manager. Moreover, these roles evolve during the scaling up of the initiative.

By comparing case studies of emergent GI initiatives in Serbia and satellite French and Swiss cases of established GIs, we specify the values, the mobilisation of competencies and the roles of the facilitator during the translation cycles of the GI initiative. Moreover we analyse the leadership style, the types of challenges and dilemmas that they face and typical ways in which they respond to these.

**Keywords:** Facilitator, geographical indication, transition countries

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# Microeconomics: methodological approaches

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## Analyzing Soil Nutrient Balance in Hills of Nepal: Do Socio-economic Factors Matter for Sustainable Land Use?

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Soil Nutrient balance studies have become increasingly influential in policy discussions for soil fertility management and sustainable agriculture. However, debates on such issues often bypass the fact that besides biophysical factors, socio-economic characteristics of farm households may demonstrate significant impact in shaping the processes of balancing soil nutrients. This study is, therefore, an attempt to analyse the influence of socio-economic factors on soil nutrient balance in the context of mid hill farming system of Nepal. With primary data collected from 280 households in 2007, the study estimates balance of three macro-nutrients, namely; Nitrogen, Phosphorus and Potassium as indicators of sustainability of the farming system. The study further employs Ordinary Least Squares (OLS) regression model to find out the significant factors that influence each nutrient balance. The findings of this study show that average farm households in the study area show annual surplus of 31 kg ha<sup>-1</sup> nitrogen but annual deficit of 20 kg ha<sup>-1</sup> phosphorus and 45 kg ha<sup>-1</sup> potassium indicating the trend of mining for the later two nutrients. Depletion of phosphorus and potassium is of great concern for sustainability of farming system in study area. It is estimated that value of phosphorus and potassium mining is equivalent to 9 % and 10 % of the gross margin received by the farmers respectively. With regards to socio-economic factors, distance of households from market centres, land holdings and possession of sloppy lands show negative influence on balance of nutrients. On the other hand, family size, household with male head, use of biogas slurry, use of composting and engagement in cash crops such as potato and vegetables positively influence nutrient balance. Based on the findings, the study suggests that future soil fertility management strategies should consider not only biophysical factors but also socio-economic attributes of farmers in the mid hill region of Nepal.

**Keywords:** Nepal, socio-economic factors, soil nutrient balance, sustainable land use

## Towards Comparative and Aggregate Vulnerability: Analysis of Welfare Distributions in Rural Areas in Thailand and Viet Nam

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The concept of vulnerability to poverty continues to gain attention among researchers and practitioners of development because it captures the dynamics and complexity of poverty better than static FGT-type poverty indicators, which are based on retrospective cross-sectional survey data. So far a multitude of concepts of vulnerability and associated indicators have been developed without, however, reaching a consensus on their relative merits. Applied studies, thus, appear to invite criticism for their choice of specific concepts of vulnerability or poverty lines. Our idea is to utilise the concept of stochastic orderings to compare income distributions. With an application to a large household sample from Thailand and Viet Nam, we study whether and to what extent the vulnerability of different target populations can be compared independently of specific definitions of vulnerability indices and poverty lines. We exploit the fact that dominance relations for stochastic orderings are closely related to the comparability of income distributions for large classes of measures of vulnerability and poverty.

In the context of the DFG research project “Impact of Shocks on the Vulnerability to Poverty: Consequences for Development of Emerging Southeast Asian Economies”, in 2007 and 2008, a panel survey of 4400 households was conducted in six rural provinces of Thailand and Viet Nam. The extensive database allows us to establish, for two consecutive waves, distribution functions of income and consumption at provincial levels. We search for stochastic dominance relations between these distributions. Such comparisons allow for initial, but quite robust conclusions on welfare; they provide benchmarks for assessing the vulnerability of the target population.

Results show that for per-capita consumption, measured in purchasing power parity adjusted US\$, the sample distribution for Thailand dominates that for the Viet Nam sample according to first degree stochastic dominance (FSD). This suggests that rural households in Viet Nam are more vulnerable than in Thailand according to all commonly used indicators of vulnerability and poverty. Provincial distributions within Thailand and Viet Nam can, up to certain thresholds, be ranked by second (or third) degree stochastic dominance criteria, implying that the dominated distributions exhibit, below the thresholds, higher degrees of vulnerability for all inequality-averse (respectively, downside inequality-averse) measures.

**Keywords:** Inequality, poverty, Thailand, Viet Nam, vulnerability

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## A Multi-agent Model Simulating Agronomic Income Sources in the North China Plain

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Farmer incomes in the North China Plain are highly variable considering the agronomic situation each agricultural year. However environmental and economic side-factors influence the actual yield situation and the upcoming growing season. Budget calculations of farmers, *e.g.* for fertiliser are annually highly variable, too. These together affects the frame conditions of cultivated land in the North China Plain tremendously. Additionally the recently socio-economic innovations by Chinese government change the public anticipation of agriculture and propagates, *e.g.* the probability of “off-farm” income. This together with a growing urbanisation rate is believed to aggravate the aerial features of Hebei province agricultural landscapes.

In order to investigate the spatial features of agricultural activities we identified the farmer decision to generate income as the key research variable. Factorial impact on income is achieved by the rate of urbanisation or percentage of off-farm income and specific data *e.g.* on household structure. Further more the size and crop composition of arable land is an important issue to consider.

We designed a local version of the agent model NetLogo a cross-platform computing environment written in Java. Primarily geo-referenced data with a map of soils and infrastructural data at county level are included. These data sets provide a unique geo-data basis on which simulations will be conducted. Secondly agents are introduced acting at the residential areas found in the research area. These agents are individually configured by household and agronomic variables and have pre-defined radii of activity. Variables considered to primarily affect income and yield are labour, household size, crop area, percentage of “off-farm”, leased and under-leased land. Our approach accounts for zones of interactivity between agents. These areas are of special interest as representatives of competition and convergence fields in the inter-agent-relationship. The multi-agent spatial approach was chosen to simulate inter-farmer decision making with diverse constitution of households and external driving factors, *e.g.* the off-farm income. Expected outcomes of this study will be predicted yield and income and the identification of pathways and interconnected relationships of agent decisions generating these two.

**Keywords:** Agent decision, agent interaction, agronomic income, multi agent modelling, North China Plain

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## The Role of Shocks on the Diversification of Rural Households: A Comparison between Thailand and Viet Nam

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The paper analyses the relationship between diversification strategies and different types of shocks and risks experienced by rural households in Thailand and Viet Nam. The data for this study were collected from a household panel survey conducted within the scope of the DFG research project “Impact of Shocks on the Vulnerability to poverty: Consequences for Development of Emerging Southeast Asian Economies”. In these surveys some 4400 rural households in six provinces in Thailand and Viet Nam were interviewed during 2007 and again in 2008 using a questionnaire aimed at measuring vulnerability to poverty. In a first step of the analysis presented in this paper a fixed effects model has been used to identify the major driving forces for income diversification of the rural households in both countries. Next, using the Simpson diversification index households were grouped according to their main diversification strategies namely land or labour diversification, combinations of these and rather specialised households. Through a multi-nominal logit model factors that determine the choice of a household’s diversification strategy was developed. Results indicate that in spite of differences in institutional and policy conditions between the two countries diversification is used as a coping strategy both ex post and ex ante, especially against covariate shocks. However specialisation of lower degrees of diversification is more likely among households in Thailand. On the other hand, in spite of differences in infrastructure agricultural shocks are dominant in both countries. Households experience with shocks and their risk expectation households were found to be the two major factors that have a positive effect on diversification. In addition access to credit and markets, the household’s endowment with labour resources, the education of the household head, and the wealth status of the household are also factors that favour diversification.

**Keywords:** Viet Nam, diversification, poverty, risk coping strategies, risk management, Thailand

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## A Latent Class Model for Basic Water Services in the Middle Olifants sub-Basin of South Africa

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Using household survey data, this study investigates preferences for domestic water services and estimates willingness-to-pay for different groups of households in the Middle Olifants sub-basin of South Africa. In order to detect households' preferences, a choice experiment (CE) was conducted. Respondents are asked to choose one among several alternatives proposed to them. An important part in the choice construction process is the identification of the relevant alternatives and their respective characteristics ("attributes") from which the respondent is supposed to choose the most preferred alternative. When respondents compare alternatives with different attribute levels, they are forced to make trade offs and marginal rates of substitution between attributes and thus willingness-to-pay-estimates can be isolated. CEs are analysed using discrete choice models based on random utility theory. Data analysis suggests the presence of preference heterogeneity and violation of the typical assumption of independent and identically distributed (IID) error terms and therefore, a latent class discrete choice model was applied.

Latent Class (LC) models allow classifying respondents according to their characteristics ("covariates") and their choice behaviour simultaneously into homogeneous groups ("classes"). For policy recommendations this classification is helpful, since policies can be designed to address different classes of people. Especially when socio-economic variables are important factors influencing class membership, knowing a person's socio-demographic variables helps understand his or her preferences and likelihood to choose certain services over others.

This information is helpful for policy-makers to enable the design of water services in the Middle Olifants according to preferences of local households and it can provide a basis for setting water tariffs.

**Keywords:** Choice experiment, latent class model, South Africa, water services

## **Economics of Nonprofit Organisation: Case Study of Rural Extension in Cameroon**

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In recent years, the importance of nonprofit organisations as the third sector of the economy has been increasingly recognised; stimulating economists to attempt a definition and theoretical explanation on how such firms emerge and why some are sustained over time and others are not. Traditionally, two types of theories have offered explanations to the emergence, operation and existence of not-for-profit firms. One strand of theory holds that nonprofit firms emerge and exist as a result of market failures. A second strand of theory views nonprofit firms as outlets for altruism, ideological entrepreneurship and the practicing of social values. More recently, a third theory has been proposed: an integrative approach that understands and describes the existence of these firms as encompassing combination of some aspects of the aforementioned two theories.

Using the case of Cameroon we explore the historical roles of the state and the market in the smallholder farming sector and their influence on the proliferation of nonprofit firms. We observe that the failure of state and market institutions to adequately direct services to smallholder farmers triggered the demand for nonprofit firms. However, an in-depth analysis of a case study smallholder service-providing nonprofit organisation reveals that its supply is not only as a responsive to market demand, but explicitly to meet the altruistic, ideological and pecuniary motivations of its creators and managers, while contributing minimally to social amelioration and poverty reduction. Our findings go beyond a mere support of an integrative theory of nonprofit firms as pecuniary objectives are found also to be important. However the heterogeneous nature of the nonprofit sector leads us to conclude that a case by case study is inevitable.

**Keywords:** Cameroon, nonprofit organisations, rural extension

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## **Social Risk Management of Vulnerable Livelihoods — The Example of Surviving Households of the Lake Nyos Natural Disaster in Cameroon**

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The globe witnessed an escalation of natural disasters in the later part of the 20<sup>th</sup> century and the early 21<sup>st</sup> century with the period between 1990 and 2005 alone accounting for more than half of the total recorded natural disasters, leaving behind strong negative impacts especially in developing countries. Cameroon's geological setting and tectonic history makes her one of the worst countries affected by rapid onset natural disasters in Africa.

A natural gas explosion from Lake Nyos in the northwest of Cameroon in 1986, killed over 1,700 inhabitants and almost all livestock in a diameter of over 25 kilometers around the lake. Investigations on lake Nyos after the disaster discovered huge amounts of carbon dioxide (300 million cubic meters) that is being added in such a rate that saturation could be reached within years in the deeper layers of the lake. Since it is impossible to guarantee the perennial stability of the lake, survivors were resettled in seven camps and the Government of Cameroon, with foreign partners, embarked on a degassing project in 2001. Scientific evidence on Lake Nyos concludes that another disaster is possible within the next five to ten years. This would inflict severe damage on the livelihoods of an estimated population of over 10,000 in the villages around Lake Nyos and in neighbouring Nigeria.

This research aims at (1) analysing the livelihoods of households around Lake Nyos, (2) assessing social risk management strategies and vulnerability to natural disasters, and (3) understanding and making policy recommendations on the role of social networks as one possible social risk management instrument.

A standardised questionnaire will be used to randomly collect cross sectional data for 400 households from five camps and three villages, supplemented with qualitative methods. Data will be compared with a matching sample of 150 households. The Principal Component Analysis will be used to analyse household poverty and vulnerability indices, while network analysis will facilitate a quantification of social networks and possible implications in a comprehensive social risk management strategy. This will contribute scientific knowledge on social risk management of disasters and valuable instruments for policy implementation

**Keywords:** Cameroon, risk, natural disaster, poverty, vulnerability

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## Poverty Determinants in the Rainfed Traditional Farms in Western Sudan: Rural Kordofan State

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This paper attempted to assess the extent of poverty situation in rural Sudan. It was conducted in the traditional rainfed farming system (covering rural Kordofan Sate in western Sudan). The study relied on primary data sets collected during agricultural season 2005/2006. the aim of the study are: To establish poverty lines, indicators and profiles in the rural household focusing on the traditional farms and to identify the main causes of poverty of the poor rural tenants in traditional farms.

The results show that the incidence of poverty was higher among the rural households. However the southern parts of the traditional farms had more vulnerable than the northern parts. A household depending on farm income alone accounts for a great part of the probability of being poor. The illiterate household-headed are more vulnerable to poverty than the educated ones, and similarly, the female-headed households are poorer than the man-headed households. High incidence of poverty was also linked to poor households not having their own livestock. The poor households suffer from lack access to safe drinking water, poor health, with wide spread of diseases.

The risk of poverty was on average higher in households with a large number of individuals and of being households suffering from the ill health increase the likelihood of being in a higher poverty status category. The risk of poverty was on average lower in households with male head and young of the households head. The household of being with extra occupation and of being more working family members in the farms are reduce the likelihood of being in a higher poverty.

**Keywords:** Binary regression, poverty measures, Sudan

## **Short-term Poverty Dynamics of Rural Households in Central Sulawesi, Indonesia — Evidence from Panel Data of 2005 and 2007**

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The temporal component of poverty is an important part in poverty analysis. For the goal of poverty reduction – which is a main target of development policies, programs and projects – it is important to know whether poverty is chronic or transitory, because appropriate poverty reduction strategies differ. Insurances or income stabilisation programs are particularly suited for protecting transient poor from idiosyncratic shocks. The direct transfer of income or assets could instead help the chronic poor. Also for potential poverty reduction projects in Central Sulawesi – a rather poor area – it is important to know whether they are dealing with chronic or transitory poor. Therefore, we want to find out about poverty dynamics in the region and about the characteristics of chronic and transitorily poor households.

The data for the study was collected in 13 villages in the vicinity of the Lore Lindu National Park in rural Central Sulawesi, Indonesia. In 2005 and 2007 the same 264 randomly selected households participated in the survey. To analyse poverty dynamics, we calculated the Foster-Greer-Thorbecke poverty measures as well as the Sen and Sen-Shorrocks-Thon Index to draw a general picture of the poverty situation in both survey years. Regarding the 1 US\$ poverty line, the situation in the study area slightly improved: The headcount index declined insignificantly from 19.3 % in 2005 to 18.2 % in 2007. In contrast, we observed an increasing number of people living on less than 2 US\$ PPP. In 2005, 47 % of the population felt short of this threshold. In 2007, this were 59.1 %. Furthermore, we created a transition matrix including both international poverty lines (1 and 2 US\$) to show the movement into and out of poverty and to identify how many percent of the households are chronically or transitorily poor. Moreover, we conducted several regression analyses to trace factors that influenced the movement into and out of poverty. The results are used to draw policy conclusions with respect to the alleviation of transitory and chronic poverty.

**Keywords:** Indonesia, poverty dynamics

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## Using Stochastic Frontier Approach to Assess Technical Efficiency in Brazilian Agriculture

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Brazil is one of the most important countries in relation to agribusiness. Agribusiness represents about 25 % of Brazilian GDP, 36 % of exports in 2008 and 37 % of jobs in 2008. The states of the South and Southeast historically, and more recently, the Center West use more technology, such as improved varieties of plants, fertilisers, irrigation (Center West), mechanisation and chemicals. Brazilian agriculture differs regionally, due, primarily, to the differences in geographical area, such as climate and natural resources, and thus production characteristics. The objective of this study was to assess the technical efficiency of the agricultural sector in the 27 Brazilian states in the years 1995/96 and 2006. The data on land and labour were obtained from the agricultural census of the two considered years. Data on credit for investment and running costs were obtained at the Brazilian Central Bank. In the analysis we used a DEA CCR-O model and a stochastic frontier model. The second model better adjusted the data with 99 % of correlation between predicted and observed values. The results show Distrito Federal with the highest technical efficiency in agriculture in 2006 and the second highest in 1995/96. The lowest technical efficiency was found in Piauí in 2006 and in Tocantins in 1995/96. The estimated elasticities show that increases of 1 % in per capita income would increase the technical efficiency by 0.77 % in the North, by 0.76 % in the Northeast, by 0.59 % in the Center West, by 0.56 % in the South and by 0.49 % in the Southeast region. We fitted a DEA Model (CCR-O) and a stochastic frontier model to state agricultural production data in Brazil. The second fit was very good as measured by a correlation of about 99 % between observed and predicted values. The technology seems to show constant returns to scale.

**Keywords:** Agriculture, stochastic frontier production, technical efficiency

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## **Factors Affecting Loan Repayment Performance of Farmers in Khorasan-Razavi Province of Iran**

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There is no doubt about the crucial roles of credit in economic development. Agricultural household models suggest that farm credit is not only necessitated by the limitations of self-finance, but also by uncertainty pertaining to the level of output and the time lag between inputs and output. Recent studies show the growth rate of investment in agriculture is less than other economic sector. So financing agriculture is one of the most important factors to develop rural areas in developing countries. Banking system payment is a way of financing. Generally, credit accessibility is important for improvement of quality and quantity of farm products so that it can increase farmer's income and reduce rural migration. In the other hand, Lending is a risky enterprise because repayment of loans can seldom be fully guaranteed. Generally In spite of the importance of loan in agricultural production, its acquisition and repayment are fraught with a number of problems especially in the small holder farming. It is reported in empirical studies that large rate of default has been a perennial problem in most agricultural credit schemes organised or supported by governments. Most of the defaults arose from poor management procedures, loan diversion and unwillingness to repay loans. For this reason, lenders devise various institutional mechanisms aimed at reducing the risk of loan default (pledging of collateral, third-party credit guarantee, use of credit rating and collection agencies, etc.). This study investigated the factors influencing on repayment behaviour of farmers that received loan from agricultural bank by using a logit model and a cross sectional data of 175 farmers of Khorasan-Razavi province in 2008. Results showed that loan interest rate is the most important factor affecting on repayment of agricultural loans. Farming experience and total application costs are the next factors, respectively.

**Keywords:** Agricultural bank, credit, logit model, marginal effect



## **Social and Economic Implications of Land Use Change on Agricultural Production and Food Security among Smallholder Farm Families in Nigeria**

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Land is the base on which production and all other human activities take place. The landscape functions are strongly connected with the type and intensity of land use, as a result of complex network of economic, social, biotic and abiotic interactions. Land use is being shaped under the influence of two broad sets of forces – human needs and environmental features and processes. These forces, which are driven by social, economic, climatic and ecological factors, interact and constantly change the features and characteristics of land. Changes in the use of land are dynamic, as they occur at various spatial levels and within various time periods. Human-induced disturbance has been described as one of the major causes of land use change. Socio-economic forces that determine the mode of development in many countries play an important role in the process of land use change. Integrated modelling, involving socio-bio-economic economic models to study land use change in an integrated manner is a practical way to achieve the objective of sustainable and sound land use practice and management. With this modelling framework, it is possible to minimise conflicts so as to make the most efficient trade-off and to link socio-economic development with sustainable land use. The integrated land use modelling approach is crucial to arriving at sound land use planning and management practices, given that both biophysical and socio-economic factors are the major driving forces for land use change. Also, increasing resource scarcity in the developing country such as Nigeria increases the urgency to understand the social and economic implications of land use change on food security and environmental sustainability. This paper builds on the concept of integrated regional land use analysis to provide a framework for integrating social, economic and biophysical factors in the modelling of land use change. In addition, the paper identifies food security and environmental management challenges arising from land use change particularly in a developing country like Nigeria.

**Keywords:** Agricultural production, food security, land use change

## Food Security, Income Generation and Natural Resource Management of Afro-Colombian Communities from the Colombian Pacific Region through Market Access: The Case of Peach Palm (*Bactris gasipaes* K.)

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Peach palm (*Bactris gasipaes* K.) is a palm tree native to humid Neotropical forests providing nutrient rich fruits, which are usually consumed after being boiled in water. Preliminary nutrient analysis of 46 cultivars resulted in starch (70 %), lipids (11.5 %), protein (6.2 %), crude fiber (4.7 %), total sugars (3.3 %), and ash (2.7 %), with an average dry matter content of 48.7 %. Peach palm is cultivated throughout Colombia in regions with a per-humid climate at altitudes of less than 1500 m asl. One important area of cultivation is the Colombian pacific region, which is mainly inhabited by Afro-Colombian communities, who cultivate the fruit in small-scale agroforestry systems. Apart of playing an important role as food in its original area of cultivation, it is also highly demanded in urban centres such as the provincial capital Cali. It is estimated that more than 2000 women street vendors in Cali earn their livelihoods by selling peach palm fruits. However, there is evidence of deficits in crop management, harvest methods and product quality as well as in market chain inequalities, whose improvements could increase the economic well-being of the people involved in this activity. Likewise not much is known about management practices and the flow of farm resources within this cultivation system. To address these issues CIAT is conducting a project in five villages in the municipality of Buenaventura on the Colombian Pacific coast. It aims to analyse peach palm production systems from a socio-economic as well as an ecological point of view, in order to quantify farm inputs and outputs as well as ecosystem services generated within this type of land use. The project further supports the formation of farmer research teams, with the aim to strengthen the capacities of farmers to address important issues such as secure harvesting methods, better cooking protocols, reducing post-harvest losses and a better access to the market in relation with consumer preferences and consumption patterns. A stable income from peach palm agroforestry systems is seen to have a strong potential to reduce poverty as well as the pressure to cultivate illicit crops in this remote area.

**Keywords:** Agroforestry, *Bactris gasipaes*, Colombia, consumer preferences, market chain, peach palm

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## Reveal Quality and Price Determinants of an Orphan Crop in India and Nepal

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The Ricebean (*Vigna umbellata*) has been an established pulse in India and Nepal. Its nutritious value and its adaptation to the low-input conditions typical of marginal areas render it a comparative advantage in places where modern crop varieties can barely survive. The ricebean has a high protein content which is important for poor people who cannot afford to buy protein rich food such as animal products or who are vegetarian because of religious reasons. Ricebean is found in many parts of Nepal and in the Indian States of Uttarakhand, Orissa, Madhya Pradesh and Chhattisgarh. Areas where the ricebean is grown today are characterised as remote regarding the access to markets and prevalence of subsistence households.

Crops, like the ricebean are also known as ‘orphan crops’ because they have been largely overlooked by the research community despite their importance to rural livelihoods particularly in poor areas. Until today, there are no improved ricebean varieties. In the frame of the EU funded project ‘Food security through ricebean research in India and Nepal’ (FOSRIN) an improved ricebean variety will be developed by breeders. Improvements will be in terms of quality as well as quantity. Higher yields meet farmer’s needs and good quality suits consumer’s preferences. To determine quality performance for certain characteristics ricebean samples were collected at Nepalese and Indian markets. These samples were analysed in laboratories for the following cryptic (non-visible) characteristics: moisture, protein, fat, crude fibre, ash, carbohydrates, swelling capacity and water uptake. Further, evident (visible) parameters as, colour, colour diversity, share of foreign matter, shape and 100-seed weight were quantified in the same in-country laboratories.

Multivariate regression was used to relate ricebean prices to the selected characteristics and further to estimate the influence of characteristics on prices. The estimated coefficients are used to calculate a market-based Consumer Preference Index (CPI). With this index breeders can assess the expected price of an improved ricebean variety at an early stage in plant breeding as quantities of 100 to 200 grams per sample are sufficient to calculate the CPI.

**Keywords:** Consumer preferences, India, Nepal, ricebean

## Does Market Accessibility Affect Household Food Security? Evidence from Malawi

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There is consensus that the scourge of global-food insecurity is morally unacceptable and that it has to be defeated. The Food and Agriculture organisation (FAO) of the United Nations reports that for the past 5 years (2002–2007) about 850 million people around the globe have been going hungry each year. The United Nations (2008) further indicates that in 2009, and for the first time in history, one billion people will go hungry as the international financial crisis deepens.

A key issue for the development and enhancement of food security in developing countries is to make product and input markets work better. A reduction in transaction costs through, for example, investments in infrastructure and market information systems are crucial in improving access to input and output markets for farmers and hence improving access to food. While the link between market access and agricultural development appears to be common knowledge, empirical studies examining the impact of differential access to markets on household food security in the developing world are uncommon. Using data from Malawi, collected through the national integrated household Survey (IHS-2) in 2004, we investigate the effect of market accessibility on household food security. Using the recommended daily per capita consumption of 2000 kcal, the results of the analysis indicate that 1 out of every 5 households were food insecure and that the rate of food insecurity is higher among rural households than urban households. Results further indicate that the extent of food insecurity increases with distance to the market. An interesting finding is that, households in rural areas, but with access to markets derive most of their food from purchases while those without market access obtain most of the food from own production. The over reliance on own production can potentially undermine household food security, and increase household vulnerability to food insecurity in the presence of crop failure. The findings provide justification for public support in improving market access for farmers. The findings also suggest that there is scope for improving food security of households through improvements in market integration.

**Keywords:** Food security, Malawi, market access

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## Risk Management Strategies in Agriculture: A Case Study of Swine Producers in Thailand

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Risk is an inevitable and important feature farm business. The consequences of decisions or events in farming are often not known with certainty until after those decisions or events occur, resulting in outcomes that may be better or worse than expected. Whereas, Thailand is an important world net food exporter and the agriculture sector employs about half of the countries labour force. But, pork is produced mainly for domestic consumption, only 1 percent of the total output is exported due to many constraints within the industry.

Keeping the prevailing situations in mind, research questions have been raised: 1) What degree does risk matter to the swine producers in northern Thailand? 2) What are the relationship patterns of risk sources and risk management strategies? 3) What are the factors that influence risk sources and the use of risk management strategies?

The study applied multi-stage sampling method to obtain data at 95 percent confidence level and used many types of analysis which include descriptive analysis, profitability analysis, risk attitude analysis, factor analysis and OLS multiple regression analysis.

There were 408 respondents from the provinces of Chiang Mai (218), Lam Phun (46), and Chiang Rai (144) participated in this survey. The study results show that 27 percent of them raise pigs for family consumption (non-commercial) and the rest 73 percent are raising pigs purely for family income (commercial). Non-commercial farmers hold average number of pigs much less ( $p < 0.01$ ) than the commercial farmers *i.e.* for breeding sow, boar, feeding hog and total pig with 39, 1, 330, 370 heads respectively. Besides, there are significant differences in pig farm practices and management of feed use, vaccination, stable organisation, waste handling, personal management, procurement of production inputs, swine farm performance and pig marketing.

Swine farming is profitable business in Thailand for long term investment, though pig price is greatly fluctuated and the swine producers are low risk averter. The most important risk factor is price and production factor. Farm specialisation is the most important strategy using to mitigate risk among the commercial swine producers and it is affected by farm organisations and risk sources.

**Keywords:** Risk attitude, risk management, risk sources, swine

## **Livelihood Choices, Diversification and Poverty in Fisheries Dependent Communities in Cameroon and Nigeria**

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This paper assesses the relationship between livelihood choices, diversification and poverty in fishery-dependent communities in Cameroon and Nigeria using cross-section data that was collected in April and May 2007. Data was collected from stratified samples of 282 households in Cameroon and 277 households in Nigeria.

The impact of livelihood choices and the degree of income diversification are expected to have an impact on welfare indicators such as the poverty incidence and the poverty gap.

The study identifies farming as a major livelihood activity for both Cameroon and Nigeria. Apart from farming, more households obtain most of their income from fishing and livestock sales in Cameroon than in Nigeria and more households depend on other off-farm activities in Nigeria than in Cameroon. The differences in the focus of livelihood activity portfolios in the two samples are mainly explained by constraints to access to resources and market opportunities.

The results show significant differences between sub-populations, depending on their choice of the primary livelihood activity and income diversification. We find that fishing households generate the highest income per capita, which results in low poverty incidence as compared to other livelihood groups. Income diversification is highly elastic to income changes for poor households, while the increase in diversification becomes less sensitive to income changes for better-off households. This shows that for poor households diversification is driven by low income, while risk mitigation plays a more dominant role for households above the poverty line.

It is therefore necessary to consider initial levels of poverty and livelihood choices of fisheries communities to design effective development interventions.

**Keywords:** Livelihood choices, poverty, small-scale fisheries, sub-Saharan Africa

## Household Food Security in Malawi: Measurements, Determinants, and Policy Review

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At the World Food Summit in 1996, Malawi was one of several developing countries that committed to halving its number of chronically undernourished people by the year 2015. To achieve this goal, the Malawi government enacted a number of policies, such as free distribution of agricultural inputs and the recent fertiliser subsidy programs. Despite these actions, food scarcity and hunger remain a challenge. Recent estimates suggest that 50 % of the Malawi population runs out of food four to six months before harvest and 40 % are unable to satisfy their basic calorific needs.

This study assesses the determinants of food security In Malawi. The research seeks to achieve the following objectives: i) identify the determinants of household food security, ii) review past food security policies applied in the country, and iii) assess the poverty outreach and household perceptions on starter pack programme designed to fight food insecurity.

The research uses the Second Malawi Integrated Household Survey data (IHS-2). In addition, data were collected on household perceptions and opinions on past food security policies from six villages of the Zomba district. A binary probit regression was used to model the determinants of household food security, whereas the outreach of past food programs was assessed by their undercoverage and leakage rates.

Findings suggest that the main determinants of household's food security in Malawi are landholding size, education level of household head, livestock holding size, household size, access to credit, infrastructure, and off-farm enterprise. The policy review reveals that the Government has mainly focused on input provision to poor smallholder farmers. However, past programs have been badly targeted; 53 % of the poor did not receive programme benefits, whereas 48 % of the non-poor were wrongly targeted. This low targeting efficiency is attributed to the poor design and management of the programs. Given the high level of food insecurity and the multiplicity of the factors affecting household food security, an integrated approach is recommended.

**Keywords:** Calorie intake, determinants, food security, Malawi, outreach, policies

## **Assessing the Determinants of Collective Action in Common Property Brackish Water Management for Shrimp Farming in Bangladesh**

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Shrimp production ranks second in Bangladesh in terms of the sector's ability to earn foreign exchange after the garment industry. Shrimp farming is dependent on tidal flow of brackish water which passes through the main canals and sub-canals and the supply of water at the farms behind the sub-canals is usually done by using the others farmland. Thus, problem of a head-enders and tail-enders arose. Due to high sedimentation, the depth of the canals and sub-canals loaded by silts and the tidal flow of water decreased. These problems are creating negative externalities like poor water exchange, degradation of water quality, which ultimately affect on yield and increased cost of shrimp production and reduce profit to the shrimp farmers. In principle, there is a general consensus about water that all stakeholders need to be involved in its management. The empirical evidences allow to hypothesise that collective action can be an excellent solution for excavating the canals and managing brackish water very well. A number of NGOs as well as government of Bangladesh took initiative for collective management of water resource. Some farmers followed it and some not. Cooperation in collective action is the key of its' success. The main goal of the study is to determine what are the characteristics of the individuals that they agree to cooperate? Tobit regression analysis is used to assess these factors. The result of the study shows that education, annual non-farm income, land holdings, group size and involvement in NGO of the shrimp farmers are influencing to contribute in collective management. The study is constituted 120 tail ender shrimp farmers for the crop year of 2007–2008 from the south west region of Bangladesh.

**Keywords:** Brackish water management, collective action, tobit regression analysis



## Profitability of Certified Small-scale Coffee Production Systems in Nicaragua

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The growing market for organic coffee and fair trade coffees has contributed to governments, donors and NGOs promoting group-based, certified market channels as a viable business model for poor small-scale coffee farmers as certified channels are assumed to offer more stable and higher prices than conventional ones. However, while coffee certification schemes have existed for more than fifteen years, there are few quantitative studies on their actual production and welfare impacts on small-scale producers.

This research analyses the profitability of certified small-scale coffee production including the direct and indirect costs of group certification, through an innovative combination of qualitative and quantitative methods. Data for all analyses are gathered by a structured questionnaire from 327 randomly selected farm households organised in conventional, organic, and organic-fair trade certified cooperatives, in northern Nicaragua. Qualitative data collection consisted of 48 key-person interviews, 33 semi-structured producers' interviews and 21 focus group discussions.

In the research region, farmers generally pursue low input production systems. At given yield levels, the income derived from coffee production in all chains is not high enough to enable farm households to meet basic livelihood needs. Though statistical analysis comparing gross margins and profits of conventional and certified coffee production shows differences, the profitability of certified coffee production is strongly influenced by conventional coffee prices and the cooperative's pricing schemes. Among the different cooperatives, the organisation and direct costs of group certification are similar while more variation exists regarding the internal inspection schemes for the organic certification.

Concluding, economic benefits from certified coffee are similar to those from conventional production, at least in times of good global coffee prices. In order to lift farmers out of poverty, a policy shift towards alternative business models, such as the gourmet coffee sector, as well as the establishment of public extension and production support systems is recommended.

**Keywords:** Cooperatives, fair trade, gross margins, organic coffee, sensitivity analysis

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## Experimentally Validated Survey Evidence on Individual Risk Attitudes in Rural Thailand

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There is a wealth of experimental studies on individual risk attitudes of farmers in developing countries which provide a comprehensive picture. However evidence on risk behaviour is mostly based on experiments. These smaller samples often do not have enough variation (and scope) in their socio-economic variables to be useful in broader micro-econometric analyses. There is thus an urgent need to generate information about individual risk attitudes in a simpler way so that it can be implemented for example in the increasingly popular large panel studies. In a sample of over 900 respondents in the province of Ubon Ratchathani in Thailand we combined questionnaire based measures and an experiment as part of the DFG research project “Impact of Shocks on the Vulnerability to poverty: Consequences for Development of Emerging Southeast Asian Economies” (DFG FOR 756).

In this novel research, the stability of the fit between survey and experimental evidence has been investigated. The survey shows that a simple self-evaluation of the respondents’ risk attitudes could be validated by an experiment as shown by appealing correlates. Results also show that the fit between survey and experiment is closer for better educated respondents raising the question, if less educated respondents find it more difficult to fully understand the experiment. Thus less educated people do state their preferences less consistently than others and make experimental results noisier. Therefore, while it seems possible to integrate risk assessment questions in larger surveys in developing countries, experiment and survey instrument have to be adjusted to meet the respondents’ capabilities.

**Keywords:** Experiment, risk attitude, survey technique

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# Microeconomics: applied approaches

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## Smallholder Cooperatives in the Coffee Value Chain: What Are the Requirements for Participation?

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While sales in conventional coffee markets have been stagnant, specialty and sustainable coffees recorded continuous growth over the last five years. Coffee cooperatives pursue increased participation in these high-value chains as this is considered a promising means of reducing the livelihood vulnerability of small-scale coffee producers. Since the coffee value chain is buyer-driven, importers, roasters and retailers play major roles in defining quality and in shaping rules and conditions of participation. Development projects and research which are trying to achieve better integration of smallholder coffee cooperatives in the value chain usually neglect the requirements and necessities of the actors at the importing and processing stages. This research addresses this knowledge gap by identifying the prerequisites importers and roasters call for when undergoing a business relationship with coffee producers. The findings are based on quantitative and qualitative interviews conducted with importers and roasters of the conventional, specialty, fair trade and organic coffee sectors in Germany.

Analysis shows that the different coffee sectors have both similar and diverging prerequisites regarding coffee quality and business relationships. Apart from coffee quality, an important criterion for all sectors is the trading partner's business conduct including leadership skills of management and working behaviour of staff. Since the fair trade and organic coffee sectors focus on production techniques and/or social criteria, they are more tolerant regarding quality issues or a lack of business behaviour such as delays in communication. Roasters and importers of conventional and specialty coffee focus more on coffee quality and professional business practices. Additionally, the specialty sector calls for a large variety of different coffees with the possibility of buying small amounts and a business partner that can be held accountable for the product sold. Smallholder cooperatives have difficulty fulfilling these requirements.

Meeting the criteria of constant or high quality, respectively, and professional business conduct remains the most promising means of increasing the cooperatives' participation in all value chains. Therefore, smallholders' knowledge about ensuring coffee quality and the management and business skills of cooperative staff calls for enhanced training that could be provided by privately funded business associations or by non-governmental or governmental organisations.

**Keywords:** Coffee, fair trade, high-value chains, organic, small-scale producers,

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smallholder cooperatives, specialty coffee

## Overuse of Agricultural Inputs and Awareness of Environmental Consequences: The Case of Hebei Province, PR of China

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The declining quality of natural resources especially of water and land, is a growing concern across most areas of China. In areas of intensified agriculture there are concerns about the contribution of farming practice on soil and water pollution. The present case study on Hebei province assesses farmers' fertilisation behaviour, the socio-economic factors influencing it, the local institutions for knowledge transfer, and the awareness of farmers about the relationships between the quality of natural resources and agricultural output.

Different quantitative and qualitative methods were applied: (1) From a secondary panel data set summary statistics were used to obtain the overall use level of urea fertiliser from 1995 to 2002. (2) These data were also used to identify determinants of urea fertiliser use via panel data Tobit regression models. (3) Qualitative interviews with farmers, village heads, extension workers and fertiliser sellers were conducted. One aim of these interviews was to identify information sources regarding farming practices and input use as well as the awareness of environmental problems. (4) To evaluate the recent use of agricultural inputs in rural Hebei with respect to environmental effects, fertiliser samples were collected and analysed in a laboratory. The results of the analysis were then compared with the content ratios stated on the fertiliser bags.

The results prove that the quality of nitrogenous fertiliser is distorted. In addition, there is evidence of the overuse of nitrogenous fertiliser. The price of fertiliser, the area of farm land available per household, and the household size have a significant effect on the amount of fertiliser purchased. Farmers are not always provided with sufficient and current information on fertiliser use for sustainable crop management. The results indicate the necessity of systematic soil analysis and fertiliser quality control. It is important to strengthen local institutions with well trained staff and sufficient funding in order to provide recommendations and raise awareness about the environmental consequences of intensive agriculture.

**Keywords:** Extension service, fertilisation practice, panel data, sustainable agriculture

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## **Determinants of Agricultural Technology Adoption under Incomplete Population-Exposure in Eastern and Southern Africa: The Case of Pigeonpea in Malawi**

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There is little disagreement regarding the benefits of improved agricultural technology among the poor. In Eastern and Southern Africa, dryland legumes offer enormous opportunities for income growth and poverty reduction. Consequently, a number of improved cultivars of high value legumes such as pigeonpea have been released and are being disseminated to increase productivity. ICRISAT has released a number of improved cultivars of pigeonpea which include two of long duration type (ICP 9145 and ICEAP 00040) and two of short duration type (ICPL 93027 and ICPL 87105). Some years after they were released, it is important to assess the extent to which they have been adopted by farmers.

A limited number of studies that have attempted to assess their adoption rates and determinants do not adequately control for technology exposure as well as population selection biases. This paper uses the Average Treatment Effect (ATE) estimation framework that corrects for both forms of bias to document the actual and potential adoption rates of improved pigeonpea varieties and their determinants using data from a sample of 594 farmers in Malawi. The study is based on a household survey data collected by the International Crops Research Institute for the semi-Arid Tropics (ICRISAT). The results indicate that only 26 % of the sample households were exposed to improved pigeonpea varieties (ICEAP00040 and ICP 9145) in 2007. Furthermore, about 10 % of the sampled farmers grew at least one of the improved pigeonpea varieties. The potential adoption rate of improved pigeonpea for the population is estimated at 41 % with the adoption gap (difference between the 41 % potential adoption rate and the 10 % actual adoption rate) resulting from the incomplete exposure of the population to the pigeon peas at 31 %. Furthermore, results indicate that farmers with access to credit have a higher propensity to adopt pigeonpea than those without credit access. The findings suggest that there is scope for increasing the adoption rate of improved pigeonpea varieties once the farmers have access to the seed, which also indicates a relatively large unmet demand for improved pigeonpea varieties in the study areas.

**Keywords:** Adoption, agricultural technology, average treatment effect, Malawi, pigeonpea

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## **Estimating Water Use Efficiency in Agricultural Production: A Case Study of Dry Season Vegetable Production by Resource-poor Farmers in Benin**

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In many sub-saharan countries, the dry season is a period characterised by food shortage and low income among resource-poor farmers. To address these problems and reduce poverty in rural areas of Benin, vegetable production in the dry season has been recently promoted by both government and NGO. Vegetable production is an important opportunity of income because fresh vegetables are sold at higher prices during the dry season. Furthermore, vegetable can play a vital role in supply of balance diet. However, due to increasing scarcity of water, the limited factor of vegetable production remains water resource. Therefore, improving water use efficiency is a plausible means of increasing productivity of vegetable in the dry season when water is at its scarcest level. Accordingly, the aim of this study was to quantify the efficiency of water use to produce vegetable in the dry season and analyse factors explaining the difference of water use efficiency among resource-poor farmers in Benin. The study used an input-specific Data Envelopment Analysis and a bootstrapped Tobit. Bootstrapped Tobit allows taking care of the dependency problem between efficiency estimates which has been until recently ignored in the literature. Additionally, to avoid bias due to omitted variables, the study considered not only socio-economic characteristics but also environmental variables as determinants of water use efficiency. Data are collected from 105 households in Benin.

Water use efficiencies were estimated to be on average 0.38 and 0.50 under constant and variable returns to scale specification, respectively. This implies that significant amounts of water could be saved if farmers become more efficient. In addition, many farmers operated at an increasing return to scale, revealing that most farms should be larger to produce efficiently. Based on robust standard errors, the important determinants of water use efficiency were: market access, land fragmentation, contact with extension service and water expenditure. Water use efficiency was also affected by environmental conditions such as rainfall. We conclude that policy programs should focus on raising farmers' access to training and market in order to increase water use efficiency and thereby reduce the food security problem and poverty among resource-poor farmers.

**Keywords:** Resource-poor farmer, vegetable production, water use efficiency

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## Farm Household Adjustment to Price Shocks in Thailand

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The 2008 price crisis in the world markets for fuel, chemical fertiliser and agricultural commodities, including rice, came as a shock to producers and consumers. While rice producers in principle will gain from high international prices of rice these price effects were not completely translated to equivalent increases in farm gate prices. However, the 2008 food price crisis may have raised the expectations of rice farmers even in low productivity areas of Northeastern Thailand and prompted them to intensify production in spite of price hikes for chemical fertiliser and fuel. The data collected in three provinces in Thailand (Buriram, Ubon Ratchathani, Nakhon Phanom) under the DFG research project “Impact of Shocks on the Vulnerability to Poverty: Consequences for Development of Emerging Southeast Asian Economies” provides a good basis to study adjustments of rural farm households to these recent price changes. On the basis of a mathematical programming model using the concept of typical farm households, the effects of adjustments decision on household income-generating activity to changes in relative prices was simulated. Results show that adjustments are strongly influenced by the household’s resource endowment and their objective function. Households with a high share of non-residential household members and those who put emphasis on household food security are unlikely to show a strong supply response. Under a profit maximisation regime, however, an expansion of rice production is more likely to take place. Incorporating risk into the model allows the analysis of the effects of price changes on expected poverty by comparing cumulative distribution functions of household income with existing provincial poverty lines.

**Keywords:** Farm households, household adjustment, price shocks, typical farms

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## Efficiency of Water Use in Groundwater Markets: The case of Peninsular India

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In the hard rock areas of India, overdraft of groundwater is resulting in cumulative interference and thus leading to negative externalities, increasing cost of groundwater irrigation and causing welfare losses. Groundwater markets are slowly emerging as niche markets. They are believed to have the potential to improve water distribution and to mitigate water scarcity by stimulating more efficient use. The effect of groundwater market introduction on the efficiency of water use is studied in this paper using Data Envelopment Analysis (DEA). A sample containing three categories of farmers was collected to test the hypothesis of more efficient water use. The first category consists of farmers who only use the water of their own tube wells for irrigation and are thus not selling or buying groundwater. This is the control group. The second category consists of farmers who apart from using the water from their wells for irrigation also sell part of the water to neighbouring farmers. This group is called 'water sellers'. The third group contains farmers who buy all or part of the water they use for irrigation. This group is called 'water buyers'. From each category 30 farmers were included in the sample.

The calculated subvector efficiencies for water use show that water buyers use water most efficient. But also water sellers are more efficient in their water use than the control group. Differences in average efficiency between these groups are shown to be significant using a Kruskal-Wallis test. This finding confirms that groundwater markets can add to improving efficiency of water use. Moreover results indicate that the existence of groundwater markets offers resource poor farmers, who do not have the capacity to invest in their own well, the opportunity to benefit from the improved agricultural productivity created by irrigation. In the light of proposed changes in groundwater legislation and policies for improving water use efficiency these empirical results provide crucial information to policy makers.

**Keywords:** Data envelopment analysis, groundwater markets, India, water use efficiency

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## Obstacles Affecting the Implementation of Organic Vegetables in Thailand

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Organic agriculture is the most dynamic and rapidly-growing sector of the global food industry. In Thailand, production of organic crops is undertaken mainly by smallholders, farmer groups or by large agro-enterprises using organised groups of contract farmers. Estimates indicate that certified organic production increased from 2,147 ha in 2001 to 22,550 ha in 2006, equivalent to 0.11 % of the country's total agricultural area (21 million ha), representing a 9.5 fold increase since 2001. Constraints to limited implementation of organic vegetables need to be found.

The objectives of the research were to investigate constraints of organic vegetable production and market in Thailand and to formulate recommendations for improving the system. Data were collected from the best practice of 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. The techniques of semi-structured interview and observation were used. Empirical analyses and documentary analysis were applied.

The results showed that constraints of organic vegetable production consist of 1) bio-physical constraints, low soil fertility, water shortage, irregular rainfall and pest, 2) economics constraints, high initial cost, high labour cost, high transport cost, and market, and 3) knowledge constraints lack of understanding about problems on farm such as nutrient balance, crop-environment, post harvest management, waste management, and consumers' perception. The important problems of organic vegetable farming are the farmers know what are problems on farming, the fundamental cause of all problems, problem solving, the way leading to problem solving, the problems mentioned in vegetable system are obstacles to extend organic farming to conventional vegetable farms. Sharing problems, knowledge and exchanging the know-how should be considered.

**Keywords:** Organic farming, organic vegetables, Thailand, vegetable system

## **Spatial Differentiation in Farming Practices and their Impact on Rural Livelihood: A Case from Nepal**

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Farming practices adopted by the farmers in the hills of Nepal differ owing to spatial differentiation leading to differential resource availability, infrastructure development and external intervention. This paper presents the spatial differences in farming practices and their impact on rural livelihood in a small hilly transect from urban centre to rural areas in central Nepal. Farming practices and rural livelihood were assessed through farming system approach and spatial differentiation was assessed by means of GIS. Socioeconomic data were collected through household survey from spatially randomly selected farm households and linked to GIS using household's geographical position.

Spatial differentiations are noted in adoption of farming practices. In remote rural villages where lands are sloppy, irrigation facility is lacking and livestock keeping is almost default, maize-dominated subsistence farming is available. Farmers in the lower hill villages are following intensive inorganic farming especially in rice and other vegetables. In the mid hill villages most of the farmers are following organic practices at least in small parcel of land for themselves and for the niche market. These differences in farming practices are mainly due to the spatial location of the settlement, land quality, infrastructure and resource availability and external intervention. As one moves from higher to lower altitudinal gradient and from remote to urban centres, these factors start becoming favourable. Yields of food crops are higher in the lower altitude as compared to that of higher altitude. Income differentiation in the space shows a higher farm and family income in the most favourable zones- villages nearby market centres and in lower altitudinal gradient. Off-farm income, which contributes much on family income, is appreciably higher in lower hills as compared to higher hills where agriculture is the mainstay of livelihood. Spatial results show higher level of living standard parameters over the space. Opportunities for quality education, health and housing are better as one moves from remote to urban area while provision of quality drinking water is better in rural villages. In order to deliver the benefit to the distant inhabitants, there is the need to develop infrastructure and hammer future strategies of increasing land productivity.

**Keywords:** Family income, farming zones, GIS, spatial differentiation, standard of living

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## Socio-economic Determinants of Sources of Drinking Water: Some Insight from Ghana

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The provision of safe drinking water is enshrined in one of the key facets of the MDGs- “to halve by 2015 the proportion of people without access to safe drinking water and inadequate sanitation”. However, access to clean and safe drinking water which is an inalienable right remains a challenge in many developing countries. It is estimated that the lack of clean water for drinking, cooking and washing, and the lack of sanitary waste disposal are the cause of over 12 million deaths annually, many of whom are children aged under-five in the poorest regions of the world. In Ghana, barely 16% of households have access to piped water in their residence. This paper investigates the socio-economic covariates of sources of drinking water among a cross section of 531 Ghanaian households. The study finds that income is a significant determinant of piped water in residence while access to electricity is invariant with source of drinking water. Additionally, access to clean cooking fuel significantly influences access to piped water in residence while distance is inversely related to same. There is also compelling evidence that rural residents are less likely to have access to piped water, public outdoor tap and protected well. Thus access to good drinking water is an urban phenomenon. While we could not detect any strong statistical relationship between education and the use of piped water, we report weak evidence albeit inverse between education and use of unprotected well as source of drinking water. The policy implications of the findings are discussed.

**Keywords:** Household income, MDG, multinomial logit, safe drinking water

## Frame Conditions for a More Sustainable Pesticide Use: Evidence from Smallholding Potato Producers in Boyacá, Colombia

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Environmental, economic and health effects deriving from pesticide overuse are considered among the most relevant threats to agricultural sustainability and understanding farmers' pesticide use is fundamental in fostering a transition towards more sustainable agricultural practices.

The present paper addresses the issue of pesticide overuse and its determinants among smallholder potato producers in four communities in the Department of Boyacá, Colombia. Firstly, pesticide use is analysed to determine which farmers are overusing crop protection products and to what extent. In doing so, a measure of overdosage and one of efficiency estimated through a damage abatement function approach are compared. Secondly, the factors affecting farmers' behaviour are investigated through a multinomial regression approach, based on the integrated agent-centred (IAC) framework. The analysis shows that relevant differences existed between and within the four communities and that these also depend on the product considered (i.e. fungicide or insecticide). Moreover, while the two definitions of overuse tended to converge, inefficiency has to be preferred to overdosage, because it better represents farmers' crop protection strategies.

The analysis also shows that external conditions tended to prevail over internal factors in influencing farmers' decisions. Technical aspects (the area of the parcel), training and educational level, membership in a cooperative and income level were among the most influential aspects for determining farmer level of efficiency.

Finally, the analysis suggests that frame conditions for a more sustainable pesticide use are not static. Instead, feedback processes exist in the agricultural system between the environmental and social subsystems (i.e. farmers' adaptive behaviour to perceived pest resistance) and between the micro and macro level (i.e. farmers' conformity to the social norm). Such feedback processes need to be addressed extensively both at conceptual and methodological level (e.g. IAC framework and simulation modelling respectively), in order to support a transition towards more sustainable agricultural practices.

**Keywords:** Colombia, farmer feedbacks, integrated agent-centred framework, pesticide use, transition towards sustainability

## Environmental and Economic Assessment of Bioethanol Production from *Musa* spp. Waste

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Waste generated within the production cycles of starch and sugar crops has a promising potential to be processed into bioethanol by means of enzymatic fermentation. This is especially due for *Musa* spp. production systems, in which large amounts of fruits with no sufficient quality for the market accumulate. The present study aims to conduct an environmental and economic assessment of the potential to process *Musa* spp. waste into bioethanol within the region of a coffee cooperative in the province of San José, Costa Rica. The study area comprises 1 500 ha small-scale coffee plantations at altitudes between 1 500–1 900 m asl providing livelihood to ca. 780 families. Within the coffee fields *Musa* spp. are grown mainly to provide shade to coffee trees, and therefore are not harvested for either human or animal consumption. Due to the stringent seasonal production cycle of coffee, alternatives for income generation during the off-season are urgently needed and demanded by the community, and bioethanol production has been identified as a suitable alternative. The cooperative already operates a pilot bioethanol processing plant for coffee pulp, which accumulates at a rate of 3 Mio. t year<sup>-1</sup> and needs to be disposed properly. Although coffee pulp provides an excellent biomass source, it is also highly seasonal, and biomass from *Musa* spp. fruits could become an important source of biomass to sustain bioethanol production all year around. It is intended that the obtained biofuel will be distributed to the cooperative members for use in their vehicles.

By means of farmer interviews data is being collected on management practices, the availability of *Musa* biomass, and fuel demands of the farm households. Experiments with the processing plant are conducted in order to calculate its processing capacity. With this data we want to (1) estimate social as well as economic costs and benefits for the farmers, (2) evaluate the banana-coffee production system, and (3) calculate the ecological footprint of the entire bioethanol production chain.

**Keywords:** Bioethanol, Costa Rica, ecological footprint, life cycle analysis, *Musa* spp.



## Value Chain Development of Exotic Fresh Fruits in South-East Asia

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Producing fresh fruit and vegetables for overseas markets can create more value added and income to small scale farmers than selling it at local markets. E.g. a Thai farmer gets for 1 kg of export mango at farm gate 1,1 € compared to less than 0.20 Euro, selling it to local trade intermediaries. Switching to lucrative overseas markets is a charming idea for countries, in which a significant percentage of the population is engaged in agriculture and where small scale farming is widely spread. Additionally, international certification requirements can significantly enhance environmentally sustained farming practices, which are in many newly industrialised countries at the top agenda of national development. These are good arguments for local development actors and the technical assistance community to have a closer look.

However, switching to overseas markets is not that easy. To match consumer preference, a combination of several adjustments is needed:

- behavioural changes of farmers (integrated pest management, group management, certification and standard compliance, harvesting techniques),
- innovations at packaging house level (post-harvest treatments, packaging materials and packing techniques), within the supply chain (cool chain integrity, specialised logistic services, efficient ways of transportation, reduced carbon footprints)
- fair and more direct trading approaches (producer-consumer platforms).

Who can drive this switch? Local governments and public services are overwhelmed. Commercial services and those of associations are rarely available at province or district level. Demand driven initiatives by foreign traders lack of local presence and understanding of farmers' interests and behavioural pattern. In consequence, success and functional trading mechanism depend on effective collaboration of chain actors, policy makers and local development agents and the understanding of shared economic, ecological and social benefits.

The Asia Invest Initiative on "Integrated Supply Chain Management of Exotic Fruits from the ASEAN Region" presents experiences, current practices and lessons learnt.

**Keywords:** Exotic fresh fruits, South-East Asia, value chain development

## **Socio-economic Characteristics of Rice-based Agroecosystems in Mazandaran, North of Iran**

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Sustainability of agricultural systems can be defined as a set of activities which results in supplying food and fiber demands of current generation, while not limiting future generations' ability to meet such their needs. In order to study the socioeconomic characteristics of rice-based agroecosystems and its implications for sustainability of these systems, a survey was conducted in Mazandaran, northern Iran. Data were collected using 278 questionnaires. The questionnaires passed the validity test and filled by interview with farmers in the rice-based agroecosystems. Social indicators were farmers' age, educational level, family size and family working, land tenure and farm size, accessibility to production inputs, financial supports and education and extension services. Economic indicators were farmers' income from crop production, animal husbandry, handcrafts and non-agricultural income. Results showed that the mean farmer's age of rice growers in Mazandaran was 54.5 years. 58 percent of farmers were 51 and older. More than 30 % of farmers are illiterate and only 4.6 % of them having academic education. Mean family size in the present study was 5.4 and size of more than 82 % of families was 4 and bigger and in 73.4 % of agroecosystems, farmers act as family working. Results of the present study showed that mean farm size of rice growers in Mazandaran was 0.95 ha. More than 86 % of rice farms were less than or equal 2 ha. In average, 73 % of farmers' income was earned by crop production. Results of present study draw a comprehensive picture of socioeconomic condition of rice-based agroecosystems in Mazandaran, Iran.

**Keywords:** Education, farm income, sustainable agriculture

## A Holistic Approach for Analysing Sustainability in Dairy Farms Worldwide

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The expanding world population and increasing per capita consumption have led to rapidly increasing demand for milk, hence intensification in resource use for its production. For this reason, sustainability issues have been very prominent in international debates, aiming at ensuring that current practices don't compromise chances for future generations to meet their own needs. Measurement of sustainability is challenging as it involves several parameters which are sometimes hardly quantifiable. The aim of this study is to initiate the development of a methodology to estimate a holistic sustainability of typical dairy production systems worldwide.

The TIPICAL (Technology Impact Policy Impact Calculations model) of the International Farm Comparison Network (IFCN) was used to collect and calculate variables. The IFCN approach is holistic as it considers three main aspects: economic sustainability (farm profitability, stability, prices, etc), environmental sustainability (life cycle analysis of milk, resource use, greenhouse gas emissions, etc) and social sustainability (living standard of family, farm succession, etc). In total, 30 Key Performance Indicators (KPIs) were developed and weighted for different dairy farms using either real or implicit units. The method was tested on four farming systems, extensive grazing and intensive zero grazing systems in developing countries and free stall and feedlot systems in developed countries.

Results were presented both collectively and separately for the different KPIs using tables and traffic light charts (green for very sustainable, yellow for marginally sustainable and red for unsustainable). The results show that, when considering production per kg of milk, the overall sustainability of farms is higher in developed countries than developing countries. However, when considering the sub-components of sustainability, farms from developing countries have higher social sustainability grades and lower economic and environmental sustainability grades. The main reason for the lower sustainability in developing countries was their lower milk yields which led to lower profits and higher environmental degradation per kg of milk. Meanwhile, social aspects such as the contribution of these farms to family income, rural employment and family health status accounted for higher social sustainability grades in these farms. Therefore, improving the productivity of farms from developing countries will greatly increase their sustainability.

**Keywords:** Dairy, environmental, holistic approach, social, sustainability analysis

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## **Economic Success of Bedouin Sheep Production under Different Resource Endowment in Jordan and the Palestinian Territories**

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Lack of pastures and short grazing periods forced Bedouin sheep keepers in Jordan and the Palestinian territories (PA) to practice hand feeding most of the year and intensify production. The marked increase in fodder prices during the season 2007/2008 resulted in an increase at the cost side forcing sheep keepers not only to sell the offspring at early age but also part of the breeding ewes at low prices, thus widening the gap between sheep keepers able or not to cope with the intensification process.

To study the efficiency of current sheep husbandry, a farm survey was conducted in 2007 in two study areas in Jordan and the PA, each. The study area in Jordan was divided into two sites, west and east (Badia) of Mafraq Governorate. The study area in PA was divided into Ramallah-Jerusalem and Bethlehem-Hebron districts covering a range of production conditions. Twenty-four sheep keepers from Jordan and 20 from the PA were interviewed using a semi-structured questionnaire on household and herd data.

The analysis of economic success of the existing sheep systems, using Gross Margin (GM) per ewe and benefit cost ratio (BCR) analysis, revealed a positive GM value in the PA (19.5 and 13.0 JOD in Ramallah-Jerusalem and Bethlehem-Hebron respectively). Sheep keepers in Jordan generated negative GM in both areas. Both groups in the PA achieved higher BCR with 1.4 and 1.2 per ewe for Ramallah-Jerusalem and Bethlehem-Hebron districts, respectively than sheep keepers in Jordan, being economically ineffective with low BCR (0.92 for west and 0.96 for east). Breeding ewes and new lambs were sold at lower prices in Jordan than in the PA reducing the revenues severely.

Feed purchases comprised around 82 % of the total variable cost per ewe in Jordan and even more in the PA with 92.7 %. Sheep keeping was executed by family members in the PA, while hired labour was the second contributor to the costs in Jordan. On contrary to Jordan, water contributed a very small amount to costs in the PA since 55 % of sheep keepers had free access to water sources compared to none in Jordan.

**Keywords:** Bedouin, benefit-cost, economic success, gross margin, sheep

## Small Scale *Jatropha curcas* and *Ricinus communis* Production: A Living Standard Approach in the Brazilian Legal Amazon Region

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Brazil has around 4.5 million of small scale farmers (family farmers), and the majority of them lives and works in the south and southeast of Brazil, where the social capital is stronger and the access to goods and services is more consolidated. However, there is a part of Brazilian family farmers who live in the north of the country, within a region so-called Brazilian Legal Amazon, and need to survive in an environment of difficult access to services and lack of opportunities. After the launch of Brazilian Program of Biodiesel use and production (PNPB) in 2004, the oil seed production became an alternative for family farmers once they might have the chance to improve their income and supply the biodiesel enterprises with raw material. Theoretically speaking this picture is easy to draw but until recently no scientific research was carried out to identify what farmers are being included in the biodiesel chain. Aiming at understand the link between family farmers' living standard and the adoption of oil seed activity, the present research assesses the *Jatropha Curcas* and *Ricinus communis* small scale seed production within a region of transition between Cerrado and Amazon rain forest, so-called Ecotone. A comprehensive survey was carried out in 2008 in Tocantins State and comprises family farmers who cultivated the oil seeds as well as family farmers who had the opportunity but decided not to go through the activity. A range of socio-economic indicators were collected and the preliminary results point towards a direct relationship between family income and the adoption of oil seed activity in case of *Jatropha Curcas* and a weak and negative link in case of *Ricinus communis* production. Other indicators such as food security, federal transferences and capital assets were analysed and pointed out different directions on decisions about adopt (or not) the oil seed activity. The results are unprecedented in the region and are extremely important to subsidise the PNPB in order to integrate efforts and achieve one of its goals that are promote new income alternatives to family farmers, especially those in worse conditions and therefore alleviate rural poverty

**Keywords:** Biodiesel production, Brazilian legal Amazon region, *Jatropha curcas*, living standard, *Ricinus communis*

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## Comparative Advantages of Cotton Production with Respect to Irrigation Systems in Syria

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The scarcity of natural resources, in particular water, and the ongoing opening of the Syrian economy to the world markets call for an urgent need to reallocate domestic resources. In this paper, we refer to comparative advantage as compromise between economic efficiency, social equity and environmental conservation. Therefore, policy makers need information on comparative advantages and costs of their policies in order to allocate the domestic resources efficiently in agricultural production. In Syria, Cotton is the most important strategic crop, representing the foremost agro-industrial crop and contributes about 20–30 % to the foreign agricultural exchange earning in the country.

This study aims to know whether lint cotton in Syria has comparative advantage or not, considering the different irrigation methods that are used to produce cotton. To do so a Policy Analysis Matrix (PAM) was built and employed as an analytical technique. The PAM's data was collected targeting firstly, the farm level, where farms were classified according to irrigation systems: public river irrigation (Furrows Irrigation) and private wells irrigation (Furrows and drip Irrigation), obtaining information related to the cost of agricultural operations. Secondly, information about post harvest and off-farm processing and operation was also gathered from the Cotton Market Organisation and the National Agricultural Policy Centre.

Results showed that lint cotton does not have comparative advantage in public irrigation system; while it has comparative advantage in the drip irrigation system commonly used in the well regions. Therefore, this study recommends (1) reconsidering the currently applied policies concerning prices and subsidies especially in public irrigation region, (2) using of drip irrigation technologies.

**Keywords:** Comparative advantage, cotton irrigation system, Syrian agricultural policy

## Hopes and Threats for Successful Rural Livelihoods: The Role of Social Capital among Small-scale Goat Farmers in Central Mexico

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Social capital of small-scale farming systems matters to farmers livelihoods. Little empirical evidence exists, however, on the role of social capital for livestock farming systems. The objectives of this study were to identify diverse forms of social capital present in small-scale goat farming systems in Central Mexico, as well as to identify the factors that contributed to the creation or destruction of social capital.

Methods included consultancy of historical archives to identify the origins of goat farming in these regions and the socioeconomic conditions which favoured its consolidation. To characterise the production systems and to identify diverse forms of social capital involved in present goat keeping, we combined a cross-sectional and longitudinal quantitative survey among 40 stakeholders, with qualitative methods, mainly group discussions, open ended interviews, field trips guided by farmers and participant observation.

Small-scale goat farming systems had limited land assets, but could manage successfully a goat flock in the recent past through horizontal social capital, like connectiveness with large crop farmers. Here, livestock assets and outputs played a role because often goat kids served as payments in kind or as gifts for letting goat flocks graze neighbours crop residues. Milk production as a main production output gives a farmers a reputation to deserve small credits from neighbours and from the milk middlemen or milk factory. A downside of horizontal social capital was related to unsolved land conflicts and even worsened in a background of increasing drug violence. Similarly, a case of governmental corruption linked to a local development project for goat keepers, to some extent illustrates the destruction of vertical social capital among small-scale goat farmers.

We conclude that different forms of social capital have been essential for the consolidation and permanence of goat farming in the past. During the last decade, however, a strong erosion of social capital can be observed in these communities, a situation which compromises strongly the important contribution of goat farming to small farmers livelihoods.

**Keywords:** Goat farming, livelihoods, livestock production systems, Mexico, social capital





# Approach of GTZ

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# Development of biophysical and socioeconomic frame conditions for the sustainable management of natural resources in practise - The approach of GTZ

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## Sustainable Management of Resources in Agriculture — A New GTZ Program

STEPHAN KRALL

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With a steadily growing world population the worldwide demand for food is increasing. Simultaneously the arable land and the access to freshwater are becoming scarce. Moreover agriculture is increasingly suffering from the effects of climate change. As 40 % of the worldwide food production originates from smallholder agriculture these factors have a direct effect on the poverty situation in rural areas. A new challenge putting further pressure on agricultural resources is the growing demand for agricultural raw material e. g. for the production of biofuels.

With the aim of increasing agricultural production often short-term non-sustainable measures are used. The objective of the new GTZ programme “Sustainable Management of Resources in Agriculture” therefore is to promote sustainable methods of agricultural production and to incorporate these in national and international strategies. The programme covers the following topics:

**Sustainable production systems:** For the sustainable use of resources in their farming systems farmers need best practices for implementation. The programme collects best practices such as conservation tillage, organic farming, agroforestry systems from different parts of the world and offers this consolidated information.

**Genetic resources in agriculture:** Genetic diversity is a key factor for the breeding of new and adapted varieties on a local level and therefore the protection of agrobiodiversity is of crucial importance. The programme will raise awareness on the importance of biodiversity in agriculture.

**Renewable resources:** Agricultural raw material can offer opportunities for new income sources but as well be in competition with food production as in some cases of biofuel production. The programme therefore investigates framework conditions for a sustainable use of such raw materials in consideration of the right for food.

**Soil:** Soil is the basis for biodiversity and at the same time one of the key factors for agricultural production. Taking measures to protect soil and improve soil fertility is therefore an integral part of sustainable agriculture. The objective in the light of food security is to increase agricultural productivity.

**Water and agriculture:** In most development countries 70 to 90 percent of the available freshwater is used for agriculture. Due to the limited availability of freshwater the potential for conflicts between different users is increasing steadily. The objective in this field is to prevent over-use and degradation of the natural resource water.

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Climate change and agriculture: Projected changes of our climate will heavily influence the agro-ecological conditions and the production of food. Therefore farmers will have to adapt to these changes in order to safeguard their nutrition. With the help of models, endangered regions shall be identified and projections be made on the nature of regional climate changes. Only then well-directed adaptation measures can be suggested.

**Keywords:** Climate change and agriculture, genetic resources in agriculture, renewable resources in agriculture, soil management, sustainable production systems, water and agriculture

## The Case of African Cashews & the African Cashew Initiative

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Cashew nuts are highly prized in international markets for their taste and nutritional value, above all in Europe (market share — 32 %) and North America (21 %). Demand for good quality nuts is on the increase in China and India, whereas the local market in Africa is developing only slowly. By-products include oil from the shell, used as industrial oil, and the press cake, used as fuel. Cashew apples are used to produce juices, wine and brandy. The global market, which is currently growing at an annual rate of 2.5 % to 4.0 %, has a turnover of over €1 billion per annum. The trade in unprocessed cashew nuts amounts to 40 % of this volume.

In Africa approximately 2.5 million small farmers produce 39 % (587,000 tonnes per year) of the global cashew crop. Of these, 90 % are poor households living in rural areas. From this they generate annual revenues of between €90 and €<sup>3</sup>30, making up roughly half their family income. Linking African smallholder cashew operations to the global marketplace will enable farmers to achieve higher incomes and facilitate poverty reduction.

Less than 5 % of African raw cashew production undergoes further processing in Africa. Production and processing have so far seen little in the way of improvement, since it is difficult for producers to get access to advice, loans and information on current market developments. The sector is therefore relatively uncompetitive in Africa. Opportunities for poverty reduction and job creation are not currently being exploited.

The goal of the programme is to increase the competitiveness of African cashew smallholders and achieve a lasting reduction in poverty in Benin, Burkina Faso, Côte d'Ivoire, Ghana and Mozambique. Within four years 150,000 cashew farmers will earn an additional annual income of at least USD100 per family from cashew nut production. In addition, the measure will create 5,500 new jobs — 70 % of them for women — providing an average annual income of USD900 per job in cashew nut processing. A further goal is to increase the percentage of raw cashew nuts sent for processing in each of the countries by at least 10 %.

**Keywords:** Agricultural extension services, Bill & Melinda Gates Foundation, capacity development, Ghana, market-driven approach, value chain development

## Sustainability of Renewable Resources in Developing Countries

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The production of renewable resources is one of the main tasks of agriculture since time immemorial. Renewable resources are defined as agricultural products, which are not used for food and feed purposes (non-food use). Renewable resources can be divided in two subgroups, those which usage is for energy purposes and others that are used for material purposes. Stimulated by debates over climate protection and security of energy supply the production of renewable resources has increased in recent years.

The increase of production has led to a controversial discussion about sustainability aspects in production and the impact for developing countries. Some people argue that the increasing demand for renewable resources can be a possibility for people in rural areas, in order to get new marketing opportunities and to achieve higher incomes. In contrast to this opinion there are more critical voices, which mentioned a lot of risks for people in developing countries. Main points of criticism in this context are the utilisation rivalry with the food production (food vs. fuel) as well as social and ecological sustainability aspects. The loss of biodiversity due to monoproduction, bad CO<sub>2</sub> balances arising from change in land use, land conflicts (illegal land seizure, land grabbing), the squeezing out of smallholder production systems or bad working conditions on energy crop plantations are some of often mentioned problems in context of renewable resource cultivation.

The presentation deals with general facts and figures about renewable resources in order to explain the importance of renewable resources in global context. Further the 3 dimensions of sustainability in renewable resource production and resulting problems will be presented and solutions for a possible production of renewable resources under the compliance with sustainability criteria will be demonstrated.

Rural population could only benefit from new income possibilities in case that economic, social and ecological sustainability are guaranteed. Therefore the focus of development cooperation has to be: the establishment of sustainability criteria and certification systems, the development of biomass strategies with focus on food security and the support for construction of value chains with the integration of smallholders (e.g. outgrower schemes, contract farming).

**Keywords:** Bioenergy, biofuels, certification systems, food vs. fuel, land conflicts, renewable primary products, sustainability

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## Valuelinks: Engaging the Private Sector in Development

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Market development and economic growth are essential for successful poverty reduction in developing countries. Only a functioning economy can guarantee self-sustained development.

The promotion of value chains has been on the development agenda since many years. The aim is to improve the competitiveness of targeted economic sectors in national and international markets, and to generate greater value added within the country or region. The key criterion is broad-impact, pro-poor growth that benefits the poor to the greatest possible extent and thereby reduces poverty. In the past, interventions were often limited to specific aspects of the value chain, while coordination between interventions was lacking. In order to have a more systematic approach to economic development, GTZ developed the “ValueLinks” methodology. This participatory approach is entirely private sector driven and action oriented, thereby ensuring sustainability.

ValueLinks is a freely available toolbox that has been developed by GTZ, but is now used by a wide network of development organisations and consultants. It can be applied to various economic sectors, including agriculture. The toolbox consists of 12 modules for a step-by-step approach, which builds on existing knowledge of the participants, especially the private sector. 6 modules have been designed for concrete fields of action for value chain upgrading, while the remaining modules serve for preparation, process back-up and monitoring and evaluation.

GTZ is using the approach in about 40 programs for almost 80 different value chains. National facilitator networks have been formed so far in Benin, Ethiopia, Nepal, The Philippines, and Indonesia. A network of 250 ValueLinks facilitators and trainers is now supporting value chain development internationally. The CAADP (Comprehensive Africa Agriculture Development Programme) lead institution, the Conference of Ministers of Agriculture in West and Central Africa, is considering using the approach Africa-wide. In June 2009, a ValueLinks association has been formed to further develop and promote the approach.

**Keywords:** Market development, private sector, value chain development, ValueLinks

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# Summer Schools

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1) Summerschools

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# Summerschools

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## Enhancing Networking and Partnerships for Biodiversity

STEFAN BIENEFELD

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Capacity building in developing countries in the field of sustainable management of natural resources is an important and significant issue in development policy. Training in higher education and networking among research institutions, enterprises, scientists and students worldwide cannot be valued high enough in achieving the goals of the Convention on Biological Diversity. The DAAD already offers a large number of programs to increase scientific experiences, to exchange knowledge and to support and transfer information and technology. The DAAD promotes the worldwide co-operation and exchange between institutions of higher education as well as between these institutions and politics and economy, particularly the co-operation with developing countries. In this context, the topics of partnerships between higher education institutions and professional alumni networks are gaining a key position.

A cooperation between German institutions of higher education and one or several higher education institutions in developing countries can be a driver for enhancing the competences of the future decision makers and consultants in sustainable biodiversity management. Good experiences have been made with means of structural development at the foreign higher education institutions, like curriculum or module development as well as through initiating international study programmes, and the mutual recognition of academic degrees.

Such kind of partnerships often lead to the establishment of professional networks. Interdisciplinary or disciplinary networks enable alumni, German and foreign universities and representatives of the governments and businesses to interact and collaborate. Knowledge can be spread, up-to-date information provided and solutions to environmental, ethic, economic and geopolitical problems can be reconciled. Within the alumni program, designed for postgraduate continuous training of the DAAD scholars, summer schools, expert-conventions and regional workshops are organized.

The networks GAFOON (German Alumni Food Network) and GAWN (German Alumni Water Network) serve as examples for fruitful capacity building in the fields of sustainable resource management through networking. Similar networks for Biodiversity are in their initial stages at several universities and for several regions.

DAAD is supporting these kind of networks and partnerships for biodiversity through a new package of funding measures, which were launched for the first time in 2009. Measures for biodiversity are funded by the Federal Ministry of Economic Co-operation and Development (BMZ). Particularly of interest are academic co-operations, to anchor or improve the subject biodiversity in research and teaching, services and management, and/or stimulate and intensify the research transfer and scientific dialogue in higher education institutions with the goal to reach a sustainable effect in the developing countries (see [www.daad.de/entwicklung/index.en.html](http://www.daad.de/entwicklung/index.en.html)).

**Keywords:** Alumni-networks, co-operation, higher education, partnership, scientific exchange, funding measures

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## Farming and Rural Systems Economics and Biodiversity in the Tropics

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Farming and rural system researches generally focus on the development and managements of rural resources for the well-being of the people living in rural areas. In the past research concepts have changed from partial to complex, from complex to spatial systems and tend toward an integration of natural science and social science concepts to holistic systems. This Summer School discussed the issue in the context of its relation to biodiversity. In a symposium in Hohenheim participants have discussed these issues from a general point of view in the development in the tropics as well as on regional implications in Africa, Asia and Latin America.

The main objectives of the Summer School have been to exchange professional experiences and discuss problem solving strategies in farming and rural systems economics and biodiversity in the tropics, to improve and promote research and teaching co-operation and to evaluate activities of the past and intensify and establish new relations. The topic includes natural resources availability and sustainable use, product and input markets and rural infrastructure, living standard of rural families and livelihood in rural areas, and administrative regulations, policy decision-making, credits, ownership, cultural impacts. Systems concepts, integrating GIS and micro level economics. Variation of the types of biodiversity under different economic and administrative environments. The relation between sustainable use of natural resources and diversity in farming, diversification in farms and risk, farmers and markets, resources and biodiversity, socio-economic impact analyses for future strategies.

The Summer School was taken place from September 28 to October 4, 2009. School was supported by the DAAD. Following the international announcements, 168 applications with finally 45 participants including 25 funded by DAAD have been selected for the events. After the several presentation and discussion school was concluded that the systems and holistic approach is more adequate to reality than partial approaches. With increasing biodiversity in farm production risk of production and marketing can be reduced, but extreme high and low incomes are also reduced. The higher the level of biodiversity the more comprehensive knowledge of farmers in production, processing and marketing is needed. The higher the level of biodiversity the higher the level of ecologically integrated systems would be.

**Keywords:** Summer school

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## DAAD-International Alumni Summer School on “Conservation and Management of Biodiversity in the Tropics”

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This Summer School has taken place in Göttingen from 27 Sept.-05 Oct. 2009 within the framework of the Tropentag 2009 conference and was organised by CeTSAF within the Göttingen-Kassel-Marburg German Alumni-Network (CGKM-AINet). It complemented the ongoing series of Summer Schools with biodiversity related issues, which are aimed to bring together alumni of German universities with a biodiversity-related professional background. Through the establishment of GAINBiNet (German Alumni International Biodiversity Network) in 2008, series of symposia are held which are addressing biodiversity related issues. Thus, GAINBiNet opens for a global audience of biodiversity experts.

The main objective of this Summer School on “Conservation and Management of Biodiversity in the Tropics” was the discussion of challenges and perspectives in conservation of biodiversity, the reduction of ecosystem degradation in the tropics and the contribution of biodiversity in achieving the millennium development goals (MDGs). The regional Summer School with its presentations, workshops and an excursion, and the participation and presentation at the Tropentag 2009 in Hamburg gave all participants the opportunity to share their experience and in-sights into biodiversity conservation issues in the tropics. The participants were professionals, academicians and practitioners in biodiversity related fields from developing countries.

At the World Summit on Sustainable Development in Johannesburg in 2002, the Heads of State and Government committed to reduce the rate of loss of biological diversity significantly by 2010. This Summer School focused on economic aspects of biodiversity addressed by the sustainable management and use of ecological resources, the value of biological diversity in politics and economy and the fair and equitable sharing of its benefits. The following were the major thematic areas:

- Ecosystem services
- Economic significance of the global loss of biological diversity
- Biodiversity and economy
- Biodiversity and corporate sustainability management
- Monitoring biodiversity
- Biodiversity information systems
- Managing biodiversity in developing societies
- Education and biodiversity.

**Keywords:** Summer school, biodiversity

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## Recording, Monitoring and Managing (Agro-)Biodiversity – Implementation Oriented Research

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The main topic of the international DAAD-Alumni-Summer-School in Witzenhausen was the demonstration and discussion of classical morphological field methods and of advanced molecular lab methods for recording and characterisation of (agro-)biodiversity. 25 scientist from different tropical and subtropical countries such as Brazil, Cameroon, Côte d'Ivoire, Indonesia, Iran, Kenya, Mexico, Mongolia, Nepal, Nigeria, Peru, Philippines, Sudan, Syria, Tanzania and Viet Nam came together. A special focus of the summer school was on agroforestry/homegarden agro-ecosystems under arid and semi-arid climatic conditions. The role of *ex-situ* and *in-situ* conservation concepts for Plant Genetic Resources for Food and Agriculture (PGRFA) was discussed as well as conservation measures in governmental and non-governmental organisations and institutions. Questions of how to record and document (agro-)biodiversity in the home countries of the participants were embedded in the discussion about the international conservation concepts. The summer school qualified the participants in the fields of *ex-situ* and *in-situ* (agro-)biodiversity conservation concept, promoted the scientific exchange between the participants and will facilitate international research and teaching cooperation.

Presentations and workshops provided the theoretical background for the topic, which were balances with practical morphological field and molecular lab courses. In order to experience the implementation in conservation projects, excursions to the IPK-Genebank in Gatersleben, the Seed Saver Gardens in Schönhagen as well as to the Botanic Garden in Witzenhausen were integral parts of the programme and completed the insight of the participants into the topic of (agro-)biodiversity conservation. The gained knowledge of the international DAAD-Alumni-Summer-School in Witzenhausen were summarised and are posted at <http://www.agrar.uni-kassel.de/opats/summerschool/>

**Keywords:** Biodiversity, summer school

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322	226	405	245	501	242
323	43	406	192	502	352
324	67	407	427	503	72
325	255	408	503	504	446
326	239	410	205	507	462
328	135	415	368	512	429
330	188	418	145	515	291
335	514	420	492	518	482
343	408	421	428	525	411
345	372	422	193	526	94
346	204	423	69	528	248
347	88	425	206	529	480
349	89	426	160	530	170
350	136	428	93	532	493
351	49	438	466	535	311
352	13	439	70	536	196
353	212	443	180	537	360
355	288	445	306	538	390
360	491	446	104	542	146
362	137	448	310	545	391
367	59	451	278	546	28
368	189	452	243	550	112
369	90	457	71	551	361
371	254	458	61	552	228
372	515	461	246	553	319
373	60	462	351	554	147
374	289	463	290	557	304
376	409	464	387	559	339
377	143	465	516	560	120
378	373	466	214	565	375
379	256	468	247	566	127
385	350	469	435	569	113
386	451	471	194	571	412
387	190	472	374	574	413
388	68	473	253	581	331
389	91	474	378	582	422
390	410	477	195	584	29
392	191	481	388	585	265
393	125	485	379	587	266
396	92	486	169	588	382
398	121	491	279	589	207

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590	430	685	51	806	321
591	224	688	322	807	281
593	50	690	30	808	381
595	332	691	163	811	32
597	494	692	31	812	298
598	444	695	468	814	22
600	208	696	415	816	396
602	128	697	96	817	397
603	414	699	25	819	215
604	171	704	294	823	463
606	229	707	314	825	481
610	44	711	240	827	502
611	467	714	231	828	417
615	292	715	164	830	452
616	293	717	504	831	363
619	333	719	436	833	99
620	312	723	174	834	138
624	197	724	478	836	181
625	95	728	209	841	418
630	517	729	199	845	82
633	313	735	469	846	233
634	249	736	261	847	16
635	172	739	73	850	165
637	198	740	416	851	45
638	114	741	470	853	340
639	27	742	267	856	268
640	320	743	496	858	100
643	280	744	307	861	370
644	380	748	74	863	175
645	24	750	362	869	342
647	392	752	506	872	315
649	252	759	232	873	419
650	230	763	250	875	420
651	334	767	223	877	437
653	12	773	518	878	421
657	81	778	97	879	398
659	62	779	505	881	83
660	129	787	117	884	130
661	495	789	148	885	399
665	353	792	395	887	498
667	393	798	497	888	139
670	173	800	98	891	400
682	369	801	376	892	52
684	394	805	445	893	53

894 .....	479	923 .....	151	953 .....	221
895 .....	471	928 .....	296	954 .....	216
896 .....	401	930 .....	54	955 .....	176
898 .....	354	932 .....	234	956 .....	533
899 .....	402	934 .....	282	959 .....	534
900 .....	355	935 .....	297	960 .....	535
901 .....	75	936 .....	519	961 .....	222
904 .....	131	937 .....	283	962 .....	525
905 .....	532	938 .....	336	963 .....	526
908 .....	106	939 .....	335	964 .....	527
911 .....	102	944 .....	235	965 .....	528
912 .....	295	945 .....	263	966 .....	303
913 .....	316	946 .....	167	967 .....	41
914 .....	23	948 .....	269	968 .....	110
915 .....	149	949 .....	453	969 .....	76
917 .....	150	950 .....	454	970 .....	14
920 .....	166	951 .....	341		