Tropentag 2012

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

Resilience of agricultural systems against crises

Book of abstracts

Editor: Eric Tielkes

Impressum

Preface

The annual TROPENTAG, the largest European conference of scientists working in Tropical and Subtropical Agricultural and Natural Resource Management, rotates between the universities of Bonn, Göttingen, Hohenheim, Kassel-Witzenhausen, Hamburg, ETH Zurich and the Czech University of Life Sciences in Prague.

On-going organisational support for the event is provided by the German Institute for Tropical and Subtropical Agriculture (DITSL) in Witzenhausen and the Council for Tropical and Subtropical Research (ATSAF e.V.) in co-operation with the GIZ Advisory Service on Agricultural Research for Development (BEAF). Mr. Dirk Niebel, Federal Minister for Economic Cooperation and Development (BMZ) is the patron of TROPENTAG 2012.

TROPENTAG provides a unique platform for scientific and personal exchange for a wide spectrum of the science and development community from students to junior and senior scientists and to development experts and funding organisations. This development-oriented community values TROPENTAG as an interdisciplinary scientific event with attendees from 80+ countries contributing to the stimulating debate.

TROPENTAG 2012 takes place on the central campus of the Georg-August-Universität Göttingen on 19-21 September. It has been jointly organised by the Faculty of Agricultural Sciences, Faculty of Forest Sciences and Forest Ecology, Georg-August-Universität Göttingen and the Faculty of Organic Agricultural Sciences, University of Kassel (Witzenhausen).

The theme of the 2012 conference is "Resilience of Agricultural Systems Against Crises". This is a particularly relevant theme in today's world with most of the 2 billion poorest people who face on-going food insecurity being smallholder farmers living in tropical environments. Sustainably producing food and fibre in the face of climate change, population growth, urbanisation and social change requires innovative and systems based research to help people living in rural and urban areas build resilient and food secure livelihoods. With the current focus of many development initiatives on intensification strategies for favourable environments, research and development efforts are lacking to support the highly vulnerable communities located in fragile, remote and usually semi-arid to arid regions. It is in these environments

that the effects of inadequate system resilience are most acute. This conference will provide the platform for discussing and planning new research and development initiatives.

From the many abstracts received, a panel of reviewers selected contributions that present new information on:
- How agricultural systems can be made more resilient to cope with crises such as high climate variability, volatile markets, biotic and abiotic stresses.
- What do resilient farming systems look like?
- Scientific approaches that are practical, innovative, scalable and integrative.
- Model approaches that provide insights to system resilience.

These aspects will be addressed in TROPENTAG 2012 by several internationally renowned keynote speakers, via 19 oral sessions presenting almost 100 talks and 24 guided poster sessions presenting 360 posters. A special session to commemorate the International Center for Tropical Agriculture's (CIAT) 45th anniversary is also planned.

Our special thanks goes to the Universities of Göttingen and Kassel for providing substantial financial and logistical support, and TROPENTAG's regular donors whose financial contributions ensure conference costs are kept low.

We welcome you to the university town of Göttingen and wish you an enjoyable and rewarding stay

The organising committee of the TROPENTAG 2012

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Göttingen, September 2012

Message

Almost one billion people worldwide suffer from hunger. Another billion are malnourished. This is an unacceptable situation. By 2050, we will probably have to feed nine billion people while taking care not to overstretch our planet's ecological capacity.

Hunger and malnutrition have many causes. One central cause is undoubtedly the fact that agricultural productivity in most developing countries is too low to give the majority of the rural poor adequate income opportunities or to ensure food security for them. This is the very factor that we need to address. So when I assumed office in 2009, I made rural development and food security a political priority of the Federal Ministry for Economic Cooperation and Development (BMZ) again, considerably increasing the Ministry's financial commitments in the sector. The volume of relevant commitments is now more than 700 million euros a year. This is more than 10 per cent of my Ministry's total budget.

The *Tropentag* is a renowned international forum for development and agricultural research experts to share information and experience as well as knowledge. Numerous organisations and experts from a variety of fields from more than 80 countries are represented. The event provides a good networking opportunity, especially for younger experts. It is intellectual input of this kind that makes a huge difference in whether development policy and development cooperation are successful or not. So it was my pleasure to accept the role of patron for this *Tropentag* .

The three departments that are jointly organising this year's *Tropentag* (the Faculty of Agricultural Sciences and the Faculty of Forest Sciences and Forest Ecology of Göttingen University and the Faculty of Organic Agricultural Sciences of Kassel University) all look back on a long tradition of research and teaching. Time and again, they have accepted new challenges. And they are leaders when it comes to interdisciplinary research.

This year's topic, "Resilience of Agricultural Systems against Crises", is a highly topical issue. Small farmers in particular are vulnerable to risks such as drought, floods, erosion, plant disease and pests. But if small farmers' capacity is enhanced in line with needs, there are many ways in which they can deal effectively with such risks.

Development-oriented agricultural research can contribute decisively to enhanced resilience, for example through the breeding of drought-tolerant plant varieties.

For many years now, the BMZ has been supporting development-oriented agricultural research at international agricultural research centers with an approximate 20 million euros per year. In all these projects, partners from German research institutions are part of the effort. We will further increase our efforts to transform the valuable, encouraging outcomes of international agricultural research in such a way that they can inform agricultural practice in our partner countries. This is especially true for the outcomes of agricultural research with regard to adaptation to climate change. I clearly highlighted this need in the Ten-point Programme for Rural Development and Food Security which I presented in the beginning of this year. We have now launched a Technical Cooperation project to address this issue.

I wish the *Tropentag* every success. I am convinced that its participants' dedication to research, their capacity for innovation and their creativity will contribute a great deal to the improvement of global food security.

Dirk Niebel
Federal Minister for Economic Cooperation and Development

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Plenary speeches

Looking Ahead: Mega Trends in the Rice Sector

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Contrary to earlier predictions, global consumption of rice has hovered around 65 kg per capita since the early 1990s. So far, the global rice equation has not changed much yet: for every additional 1 billion people on Earth, we need to produce another 100 million tons of rice (paddy). Future demand, but also how rice and other food will be grown, will depend on structural transformation processes such as a declining share of agriculture in gross domestic product and employment, rural to urban migration, the rise of an industrial and service economy, and demographic transitions from high rates of birth and death to low rates.

Some mega trends are already emerging in the rice sector. Land is scare and inputs costs have risen, requiring further increases in productivity as well as greater efficiency of labor, water, fertiliser and energy. This also provides an incentive for more skilful, more precise agriculture through one can also better adapt to the environment, or even control parts of it. Rural to urban migration has made labor in the agricultural sector scarce and expensive, driving mechanisation as well as the development of new service sectors. Traditional smallholder farm management is being replaced with outsourcing of farming operations or the formation of small enterprises. Rice value chains are becoming more tightly integrated because processors and consumers demand more information and control over how food is being produced. Farmers increasingly turn to the private sector as a source of information, but also as a direct buyer of rice and other products, requiring to produce agricultural raw materials with new, higher standards. Access to interactive, tailored information is greatly increasing, creating wider communication networks.

Rice science needs to be re-oriented towards these mega trends. We need to anticipate what is needed 10 or 20 years from now, and we need to take full advantage of these new opportunities, particularly in developing countries.

Keywords: Agriculture, mega trends, rice, transformation

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Soils and Resilience, Much More Than a Slow Variable

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In resilience science soil properties are classified as a 'slow variable' or a factor that changes slowly in response to long-term processes. These slow variablesin part determine the resilience of an ecosystem. The slow variable concept in resilience is much too limited a lens to understand the role of soil in resilience of agricultural systems and livelihoods. Panarchy theory enriches this simple concept by using the metaphor of the adaptive cycle, that better explains why apparently stable systems may become unstable quite rapidly and how drivers from other domains (social, economic, institutional) may critically affect ecological processes. In this paper we explore the role of soils in resilience by taking a view through the holistic lens of ecosystem services. A whole range of services depends on soil function - water cycles - carbon cycles - nutrient cycles. These ecosystem services, in cases where human and ecological systems are closely coupled, such as small scale farming communities in developing countries, directly impact the resilience of the population. It is possible to understand resilience and the role of soil function and soil health better by breaking down the elements that can be considered contributing to resilience - response diversity, adaptive capacity and ecological buffering capacity.

Keywords: Resilience science, soil science

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Agrobiodiversity Management for Food Security

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World population increases by approximately 78 million people annually. About 1 billion humans suffer from hunger and 3 billion malnourished people live with <US\$ 2 daily. Anthropogenic climate change continues affecting food output and quality while the world continues facing an increasing demand for nutritious and quality food, feed, fiber and fuel. There will be 1.7 billion more people to feed by 2030, but with a declining ratio of arable land between 40 and 55 %. Agriculture needs eco-efficient and resilient systems to meet end-user demands. Such agro-systems should provide enough and safe food, enhance human health through better nutrition for the poor and well-balanced diets for the rich, diminish the use of fossil fuels, adapt to extreme weather and water stresses, reduce environmental degradation and decline in the quality of soil, water, air and land resources in an increasingly urbanized world, and be a source of raw materials for bio-energy and a bio-based economy in this 21 st Century. Agro-biodiversity components act similarly in agro-systems than biodiversity in other ecosystems: genetic diversity or genetic variation within the species, species diversity or variation existing for species in a specific region, and ecosystem diversity comprising variation between agro-systems within a region. Agrobiodiversity provides means for intensifying sustainably crop yields and for adapting crops to climate change, *e.g.* genetic broadening helps introgressing new genes in breeding populations, intra-specific crop diversification (*i.e.*, mixture of landraces or cultivars) provides a means for controlling effectively pathogens and pests over large areas, and genetically enhanced seed-embedded technology contributes to adapt to variable environments due to changing climate. Sustainable crop genetic enhancement consists of Identifying a useful character, manipulating its genetic variation, putting genes into a usable form, using DNA markers to monitor chromosomal changes and as selection aid, and genetic engineering to enhance useful variation if not available in crop gene pools.

Keywords: Genetic engineering, genomics, germplasm enhancement, plant breeding

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Animals

Pastoralism and rangelands

Strengthening Resilience of Pastoralists through Improved Economic Integration

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Many arid and semiarid environments are rapidly approaching a precarious ecological state. The session on 'Pastoralism and Rangelands' will look at potential solutions for a range of problems that affect pastoralist livestock production at present; these include:

1. The need for an ecologically balanced Natural Resource Management in the face of rapidly increasing human and livestock numbers in the drylands, sustainable utilisation of tropical rangelands being a major focus for this session
2. The need to improve market access and provide a more robust marketing infrastructure (agricultural value chain approach, public-private partnerships in the management of livestock markets)
3. Workable mechanisms to buffer pastoralist livelihoods against external shocks (Early warning systems, Livestock insurances)
4. Full utilisation of new opportunities created through the advance of modern communication technology, banking services and electronic cash transfer systems in remote regions

This paper proposes that increased and more stable incomes are a major contribution to buffer pastoralist households against external shocks and to strengthen the resilience of pastoralist communities. Too little has been done to improve market access, to lower transaction costs and to improve the profitability of producing and selling animals and livestock commodities in pastoralist regions. Insufficient economic integration and poor market access perhaps pose the same risk to pastoralist livelihoods as the losses related to environmental degradation, recurrent natural disasters and climate change. Based on experiences by VSF-Germany, KARI and other development actors in the pastoralist regions of Kenya and Somalia we review selected development interventions in terms of their economic viability and their impact on economic integration and incomes of pastoralist households.

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Increased Climate Change Resilience of Semi-Arid Regions Based on Collective Environmental Governance with Landscape Approach

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For 20 years seasonal grazing has been discontinued in semi-desert areas of Uzbekistan. As a result the region faces significant loss of important perennial shrubs and forage plants. Rangeland degradation puts livelihoods at risk. Additionally climate change 40 % above global average indicates rapid governance changes. Current production systems are already and will be even more threatened by water scarcity, increasing number of days with very high temperature causing partial crop failure, hails and strong rains effecting devastating mudflows from eroded foothills. Present coping strategies are commuting of men in labor age and out migration of youth, as an individual adaptation is hardly possible.

Facilitated by participatory research, local communities in three villages overcame their deep rooted fatalistic acquiescence in the tragedy of the commons leading foreseeable to an environment that cannot sustain livelihoods anymore. Local population is now ready to introduce new collective governance systems including share of tasks and benefits, enforcement of rules and management tools in common rangelands and on foothills. Villages developed a common purpose to collectively rehabilitate their ecosystems. Results from two participatory socio-economic research projects in different areas of Uzbekistan are presented. One village decided to introduce spatial planning, reforest foothills, stop free grazing, start collective forage production on rangelands based on social fencing and start alternative income options. Two other villages decided to establish pastoral user groups, fenced seed isles and seasonal grazing on limited rangelands based on strictly prohibited free grazing. In these two villages during last 15 years rangeland degradation had induced a shift from collective use of rangelands for small ruminants towards individual cattle rearing based on forage production on up to 80 % of the household plot. This will be terminated by climate change induced severe future water scarcity. Now villagers try to shift back to collective rangeland use for sheep and towards diversification on their household plots.

The findings show (1) critical importance of an integrated ecosystems research and development approach with clear focus on collective landscape governance, (2) remarkable self-help-potential of local communities if it is addressed adequately, (3) importance of a process of social learning over some period.

Keywords: Climate change adaptation, fenced seed isles, pastoral user group

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Nomadic Pastoralism in Southern Iran

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The nomadic pastoralist system in Baft district, Kerman province, is well known in Iran for producing cashmere from Raeini goats. However, there is little information on the production system. Interviews were carried out with 30 Siahjel nomad families of Raen origin in proximity of about 20 km to Baft in 2010 to characterize the production system considering family labor force, work sharing, livestock numbers, management and marketing practices, and diseases. The nomads move their livestock over large distances within the rangelands of the region from May to November and the majority migrates to the South during winter and early spring. 87 % of nomad families stay and manage their animals together with one or more other related families. All household heads are males, and only 17 % at maximum 30 years old. All family members are involved in raising livestock; male family members and hired labor dominate the physically harder jobs like shepherding and breeding, and women are involved in milking and caring. 80 % of the animals are owned by adult or young males, none by daughters. Siahjel nomads mainly rely on goats and average proportion of goats, sheep and monodactyl per family are 89 %, 8 % and 3 %, respectively. Adult breeding females constituted with 44 % the largest group within the goat herds, female yearlings, bucks and male yearlings constituted 12 %, 8 % and 7 %, respectively. The rationale for keeping a high number of males may be related to their higher production of cashmere. Diseases accounted for 57 % of adult and 88 % of young animal deaths. The most prevalent diseases were enterotoxaemia, foot and mouth disease, pneumonia, agalactia and diarrhoea. Animal sales, meat, cashmere and milk production are the major reasons for keeping goats. Nomads sell their animals directly to abattoirs or butchers whenever cash is needed. While 41 % and 32 % of nomad farmers receive cashmere marketing information from traders and neighbouring farms, 14 % and 13 % of farmers receive their information from livestock associations and markets, respectively. Rangeland is the main source of feeding (85 %), the remaining 15 % are provided by stubble grazing.

Keywords: Livestock, herd management, nomads, products, rangelands

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Collective Management on Communal Grazing Lands: Its Impact on Herbage Production and Land Degradation in the Upper Blue Nile Basin, Northwestern Ethiopia

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Collective action on communal grazing land has evolved in the highlands of northwestern Ethiopia to mitigate the critical problem of land degradation caused by overgrazing and to ensure sustainable production of natural pasture mainly for draught oxen feeding. However, large portions of the communal grazing lands are still managed under free grazing which has been practised continuously in the past. This study was undertaken to assess impacts of three different types of grazing land management (GLM) viz. a) freely open communal GLM, b) traditional collective management of communal grazing land locally named as 'yebere sar' GLM and c) private holding GLM. These were coupled with two slope gradients ($<10\,\%$; 15–$25\,\%$). Parameters studied were water erosion and vegetation dynamics at Maynet Kebele in the upper Blue Nile basin, Ethiopia. The interaction effect of GLM and slope was found significant ($p < 0.05$) for hydrological responses. The average runoff coefficient was more than $20\,\%$ implying that about a quarter of the rainfall amount turns to surface runoff on grazing lands. Freely open communal GLM on a steeper slope of 15–$25\,\%$ resulted in consistently highest cumulative runoff and soil loss amounting to 491 mm and $32\,\mathrm{t\,ha^{-1}\,y^{-1}}$, respectively. When the vegetation cover was below $40\,\%$, runoff and soil loss dramatically increased. This suggests that freely open communal GLM is typically having a higher risk of water erosion in the study area. As expected, yebere sar GLM appeared to reduce surface runoff by more than $40\,\%$ and curb the rate of soil erosion by more than $50\,\%$ compared to freely open communal GLM. Its vegetation cover persisted above $70\,\%$ all the time, meeting a threshold level recommended to keep surface runoff and soil loss to minimum. Ground cover was the most significant factor determining the level of runoff and sediment loss on pastureland. Adequate resting of a pasture from grazing at the right time is an extremely important component to improve vegetation cover and herbage production that in turn arrest land degradation for which any grazing land management practice needs to give due emphasis.

Keywords: Collective action, communal grazing land, herbage production, land degradation, northwestern Ethiopia, vegetation cover, water erosion

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Responses of Communities Plant Functional Traits Along Grazing Gradients on South African Rangelands

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Vegetation communities fulfill certain tasks in the ecosystem which can be expressed by their plant functional traits. By representing species of plant communities with their trait attributes rather than by species names, one can focus on the ecological functions and on the adopted plant strategies of communities which success under imposed conditions of the environment. In rangelands of South Africa we studied the response of Community Plant Functional Traits (CPFT) to grazing gradients on transects which started at the water point on grazing land. One transect per farm was established and along each transect, six plots ($5\,m \times 5\,m$) were placed at equal distances.

We found that the trait-line sampling, a taxon-free method, was appropriate to record 15 CPFT in both standing biomass and on the regrowth. Close to water points grazing was more intense. Here, plant communities exhibited higher specific leaf area and higher leaf nitrogen content suggesting a higher photosynthetic capacity. Furthermore, communities close to water points exhibited less cell wall components (cellulose, hemicelluloses, and lignin) similarly favoring capture of photosynthetically active radiation. Communities exposed to intense and frequent grazing are successful by possessing quick-return strategy of nutrients invested into leaf tissues via higher rates of light capture.

We conclude that in these so-called "sacrifice areas" on livestock farms (or piosphere) there is an ecological niche for vegetation communities with quick-return strategies which are not only well adapted to intense and frequent grazing but also provide forage of high quality to the benefit of animal husbandry.

Keywords: Piosphere, plant strategies, taxon-free method, vegetation communities

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Strategies of El-Kababish Camel Herders to Cope with Adverse Climate Conditions in Sudan

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The study aimed to study strategies of El-Kababish camel herders to cope with adverse climate conditions in North Kordofan State, Sudan. A total of 122 farmers owing 10,386 heads were randomly selected and a semi-structured questionnaire was applied in 4 different areas (Sodary, Jabra, Umgrfa and Almuwelih) dominated by camel herders. The results indicated that 59 % of camel farmers were owners, while 41 % were shepherds. Illiteracy among camel owners and shepherd was 49 % and 56 %, respectively. Camel herders divided their camels in small herds with an average size of 85 ± 37.2 heads which were distributed into different regions as a mean of avoiding diseases and nutritional crises. Herders tended to keep high percentages of breeding females (74.2 %) while breeding males amounted for 25.2 % in the different herds. The majority of herders (49.2 %) were found to rear camels only while some herders raised sheep and goats separately besides camels. Seasonal migration to the northern and southern parts of the state lasted on average 6 ± 1.2 months, depending on the availability of water and pasture. The watering interval was long during winter and short during summer which enabled wide utilisation of rangeland. Castration of males was practised for fattening purposes by 40 % of the farmers. The interviewees reported the presence of twelve camel diseases, and local knowledge was extensively practised to combat diseases.

Keywords: Camel, climate conditions, El-Kababish herders, seasonal migration

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Can an Improved Dual Purpose Groundnut Cultivar Increase Milk Production in Crop-Livestock Systems in India?

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Groundnut is an important crop in dry areas of South Asia where it is grown for oil production. In addition, it also serves as valuable source of livestock fodder. In Anantapur, one of the poorest districts in southern India, groundnuts occupy 70-80 % of the cropped area. A new groundnut cultivar ICGV 91114, developed by scientists from ICRISAT1 and ILRI2, with superior grain and fodder traits, was introduced to this district in 2003. The present study was designed to capture the impact of this new cultivar on milk production on farm compared to the dominant traditional cultivar TMV 2.

Two participatory feeding trials were conducted with 52 farmers from 4 villages, animals with average milk yield of 2-5 l day^{-1}. First, 17 dairy animals were fed with groundnut fodder harvested in the rainy season (July to November) together other common feeds (rice straw, rice bran, broken rice etc.). The animals were offered one groundnut fodder variety for 10 days and then fed with the other groundnut fodder variety for the following 10 days, keeping the overall feeding regime constant. Subsequently, a similar experiment was conducted with 37 animals and groundnut haulms harvested during the winter season (January to April). Milk yields and feed amounts were recorded daily. Milk composition was analysed locally while feed samples were analysed by Near Infrared Reflectance Spectography at ILRI.

The results show no significant effect on milk yield of groundnut cultivars based on kharif fodder. However, for winter fodder a significant increase in milk yield (400 g) can be attributed to feeding ICGV91114. This is supported by the laboratory analysis which for this season shows higher levels of nitrogen, metabolisable energy and lower lignin and fibre content compared to the traditional cultivar. In contrast, the quality of haulms from both cultivars harvested in the rainy season was poor, possibly because of rain damage. The results highlight the potential of including the nutritional quality of crop residues in crop breeding programmes. However, the results of the present study may not be generalised due to the small scale of the trials.

Keywords: Dual purpose crop, feeding trial, groundnut, mixed farming

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Effects of Management Practices on Carbon Allocation in the Semi-Arid Savannahs of the Borana Region, Ethiopia

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Grassland systems cover 3.9 billion ha, 25 % of the earth´s terrestrial area, and could, according to FAO (2009), sequester up to 2 GT CO_2 equivalents worldwide if appropriate management of vegetation and soil resources would be applied. Carbon is stored in different pools: dead and alive biomass like plant roots in the soil, and living biomass (grasses, shrubs and trees) and litter aboveground.

Livestock production has been a major source of income generation and food security in the semi-arid savannahs of the Borana region, Ethiopia, ever since. The dependency on traditional livestock-based pastoral and agro-pastoral livelihoods under ecological and economic pressures (droughts, population growth, overgrazing, etc.) is no longer sufficient to sustain food security. To overcome vulnerability of these communities, diversification of income is of crucial importance. Payment for environmental services (PES) based on reduction of carbon emissions and carbon allocation linked to livestock production could be one tool to diversify income of the vulnerable group of Borana pastoralists. Range and herd management may have exceptional impacts on carbon fluxes in the grass- and bush-land savannahs of southern Ethiopia.

Four vegetation types; namely grassland, tree savannah, bush land and tree-grass-bush savannah, have been distinguished in the research area. The pastoralists differentiate between year-round and seasonal grazing by installing "enclosures". Seasonal grazing patterns were found in grass and tree savannah. Therefore, five 900 m^2 plots each were located in year-round grazed and seasonally-used grass and tree land. Soil samples were taken in four different depths up to 100 cm to analyse for total carbon, soil organic matter and soil organic carbon content as well as to examine bulk density, pH and texture of the soil. Aboveground biomass was harvested and tree biomass was calculated by using allometric equations. A regression analysis was run to portray changes in organic carbon pools and allocation across vegetation type, management practice and soil depth.

The results will help to evaluate the impact of management practices on carbon fluxes in the soil and on aboveground biomass production. Carbon allocation processes will be better understood and information can be used to improve these grazing systems towards higher sustainability and crisis resilience.

Keywords: Carbon allocation, enclosure, grazing, savannah, vegetation type

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Mammalian Herbivores as Designers of African Savannah Ecosystems

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African savannahs support a large proportion of the world's human population, heavily relying on resources provided by an intact savannah. Mammalian herbivory is one of the major factors regulating savannah ecosystems. However, research quantifying and comparing the impact of domestic and wild mammalian herbivore assemblages and their densities on the vegetation is rare. In the Kruger National Park (KNP) and adjacent communal grazing lands we assessed the vegetation under different grazing and browsing regimes in a close-to-natural savannah *versus* communal grazing land. We studied woody plant species composition and structure under browser presence and absence. We additionally analysed herbaceous vegetation and soil properties to understand the role of grazer densities and assemblage types.

We found that herbaceous species richness was higher on communal farmlands compared to protected areas inside Kruger Park, as was forb cover. The lowest Shannon Wiener diversity index was found under mono-specific grazing at wildlife and livestock sites. Grass leaf nutrient content was significantly higher and annual grass species were less abundant under multi-species wildlife and livestock herbivory. Inside KNP, the mono-specific site showed with 311 trees ha^{-1} and 140 trees ha^{-1} the highest density of bushes and small trees. In contrast, bush density at the livestock sites was found to be higher under multi-species herbivory, whereas small tree density was significantly lower there.

Our research showed that certain grass species were strongly resistant against high mono-specific grazing pressure. Multi-species herbivory in contrast decreased pressure on herbaceous vegetation, enhanced biodiversity and improved grass quality. Bush and small tree growth could efficiently be suppressed by multi-species herbivory. Different herbivore assemblages show strong impacts on vegetation and soil conditions, thus, play an important role as designers of savannah ecosystems.

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Comparative Analysis of Ruminant Grazing Itineraries and Foraging Behaviour Across Three Agro-ecological Zones of Burkina Faso

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Mobility is key for livestock production in the agro-pastoral systems of West Africa. Population growth and increased climatic risk of crop failure lead to cropland expansion which affects herd mobility and access to forage resources to varying degrees across agro-ecological zones. Therefore we studied the spatio-temporal variation in the use of grazing areas and the foraging time of ruminants in the southern Sahelian, northern and southern Sudanian zone of Burkina Faso by monitoring three herds each of cattle, goats and sheep in three village territories during a one-year cycle. Grazing routes were tracked using a Global Positioning System; coordinates logged at 10 s intervals were overlaid on land use maps from where time and activity on different land units was derived.

Maximum itinerary lengths (km/d) were observed in the hot dry season (March-May); they were longer for sheep (18.8) and cattle (17.4) than for goats (10.5, $p < 0.05$). Total time on pasture (h/d) ranged from 6–11 with cattle staying longer on pasture than small ruminants ($p < 0.05$). Feeding time accounted for 0.52–0.72 of daily time on pasture irrespective of species. Herds spent longer time on pasture and walked farther distances in the southern Sahelian than the two Sudanian zones ($p < 0.01$), while daily feeding time was longer in the southern Sudanian than in the other two zones ($p > 0.05$). Proportional time spent resting decreased from the rainy (June-October) to the cool (November-February) and hot dry season ($p < 0.05$), while in parallel the proportion of walking time increased. Feeding time of all species was to a significantly high proportion spent on wooded land (tree crown cover 5–10 %, or shrub cover >10 %) in the southern Sahelian zone, and on forest land (tree crown cover >10 %) in the two Sudanian zones, irrespective of season.

We conclude that with the expansion of cropland, remaining islands of wooded land, including also fields fallowed for 3 or more years, are particularly valuable pasturing areas for ruminant stock. Measures must be taken that counteract the shrinking of wooded land and forests across the whole region, including also active protection and (re)establishment of drought-tolerant fodder trees.

Keywords: Agro-pastoral system, global positioning system, livestock, Sahelian zone, Sudanian zone

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Cattle and Sheep Foraging Behaviour in a Heterogeneous Subtropical Grassland

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Analysis of foraging behaviour is central to understand grazing distribution and to optimise grassland management. Our objective was to analyse the effects of environmental variables upon foraging behaviour of cattle and sheep co-grazing heterogeneous grasslands of tall and short grasses. Three cows and ewes grazing in a 130 ha paddock of north-eastern Argentina (INTA Mercedes) were fitted with GPS collars during 6 consecutive days in fall, winter, spring and summer 2009. Stocking rate was 0.67 AU ha^{-1} (cattle:sheep ratio = 3:1). Foraging behaviour was assessed by daily foraging time, speed, sinuosity and daily displacement. Climate and vegetation were also characterised. Behavioural variables were analysed by ANOVA, and its relationships with environmental covariates were explored. Daily foraging time was similar for cattle and sheep in all seasons (10.9 ± 1.5 hours). Cattle moved faster than sheep in spring and summer (7.8 ± 1.8 vs. 4.5 ± 1.8 m min^{-1}), showing similar speeds in fall and winter (6.4 ± 1.2 and 5.7 ± 1.7 m min^{-1}). Displacements were predominantly straight, irrespective of speed. Daily displacements were higher for cattle during spring and summer (5439 ± 1979 vs. 3114 ± 1090 m day^{-1}), being similar between herbivores in fall and winter (4122 ± 770 and 3611 ± 896 m day^{-1}). Since there were no variations in daily foraging time, the displacements were a consequence of the speed, which was confirmed by its positive correlation (rcattle = 0.77, rsheep = 0.71). Cattle walked faster when soil vegetation cover of the tall grasses was 90 %, decreasing above and below this value. On the other hand, sheep walked faster when standing dead biomass of short grasses increased. This could suggest that both herbivores increased their speed tending to increase the encounter rate of the preferred forage as it becomes less abundant. For cattle, lower speeds when soil vegetation cover decreased below 90 % could reflect a threshold where speed increments are not enough to efficiently graze preferred forage, probably causing changes in diet selection to sustain the daily intake. Our results may help to develop criteria based on seasonal herbivore´s foraging behaviour to optimise grazing management.

Keywords: Argentina, GPS collars, grazing distribution, mixed grazing

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Ecological and Economical Aspects of the Intensity of Sheep Grazing in the Inner Mongolian Steppe

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An increasing human population and the growing demand for food of animal origin intensified sheep production and lead to widespread overgrazing of the grassland in Inner Mongolia, China. Hence, strategies for a sustainable livestock husbandry that protect the steppe vegetation and at the same time, satisfy farmers' economic interests are strongly needed. We therefore analysed the effects of different grazing intensities (GI) on herbage organic matter intake (OMi) and liveweight gain (LWG) of grazing sheep.

During July to September 2005–2010, a grazing experiment was conducted in the Xilin River Basin (E 116°42'; N 43°38') using 15-months-old, female sheep (31.5 ± 2.0 kg liveweight). Six GIs were tested on two plots each. Plots were alternately used for grazing and hay-making year-by-year. Stocking rates ranged from very light (GI1: 1.9 ± 0.3 sheep ha^{-1}) to very heavy grazing (GI6: 9.7 ± 1.6 sheep ha^{-1}) and were monthly adjusted to maintain similar herbage allowances. In six animals per plot (2009–2010: 4 animals plot^{-1}) titanium dioxide was used to determine fecal excretion, while digestibility of ingested organic matter was estimated from fecal crude protein concentrations. Feces samples were collected on 5 d each in July, August, and September every year. Sheep were monthly weighed to determine their LWG.

Daily OMI ranged between 68 and 89 g kg$^{-0.75}$ liveweight and was not affected by GI ($p = 0.120$). Nevertheless, LWG decreased from GI1 (101 g d^{-1}) to GI6 (70 g d^{-1}; $p < 0.001$) maybe due to higher physical activity of sheep at highest GIs. GI effects differed between years ($p < 0.01$ for both parameters) depending on the amount and distribution of rainfall. Across all years, mean daily LWG per hectare linearly increased from GI1 to GI5 ($p < 0.001$), but was similar at GI5 and GI6. Moreover, OMi of GI5 and GI6 sheep during the 90-d-grazing period reached 763 and 985 kg ha^{-1}, equivalent to 58 % and 75 % of the mean annual herbage production, respectively. Increasing GI raises output per unit of land area and hence, income for farmers. However, herbage mass at the end of the grazing period limits further increases in LWG at very high GIs and is insufficient to prevent soil erosion during winter months, and thus to maintain long-term grassland productivity.

Keywords: Grazing, inner Mongolia, sheep, stocking rate

Effects of Alternating *versus* Continuous Grazing on Feed Intake and Performance of Sheep in the Inner Mongolian Steppe, China

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Many studies evaluated the effects of different grazing management systems (GS) on biomass production and the nutritional quality of the rangeland vegetation. Less work has been done on their effects on feed intake and performance of grazing animals. We therefore analysed the effects of two GS on digestibility of ingested organic matter (dOM), organic matter intake (OMI), and liveweight gain (LWG) of sheep in the Inner Mongolian steppe and whether they may differ between grazing intensities (GI) due to differences in the amount and quality of herbage on offer.

A grazing experiment was established in the Xilin River Basin of Inner Mongolia (E 116° 42'; N 43°38') in 2005 that tested two different GS and six different GI from very light to very heavy grazing. While in the alternating grazing system, grazing and hay-making were alternated annually between two adjacent plots, sheep grazed the same plots every year in the continuous grazing system. In July, August, and September 2009 and 2010, four sheep per plot were selected to determine feces excretion on 5 d per month using the external marker titanium dioxide, while dOM was estimated from fecal crude protein concentrations. Sheep were weighed at the beginning of each month to determine their LWG.

Across both study years, GS did not affect dOM ($p = 0.101$), OMI ($p = 0.381$), and LWG of sheep ($p = 0.701$). However, LWG of sheep decreased with increasing GI ($p = 0.014$). Nevertheless, there were no significant interactions between GS and GI for all measured parameters ($p > 0.05$), indicating that differences between GS were similar at all GI and/or that alternating grazing was not able to compensate for the negative effects of very high GI on animal performance.

In summary, our study showed that despite positive effects on herbage, alternating grazing does not increase dOM, OMI, and hence, LWG of sheep irrespective of GI.

Keywords: Feed intake, grazing system, growth rates, ruminant

Variety, Harvest Date after Planting, and Fraction of Napier Grass Influence *in vitro* Gas Production

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An experiment was conducted to assess the effect of variety (V), harvest date (HD) and plant fraction (PF) on *in vitro* gas production (IVGP) of Napier grass cultivated and harvested in the humid zone of Ghana. The varieties were Local, 16798, 16786 and 16840. Except for the Local variety, all were improved varieties from ILCA (now ILRI). The HD was at 60, 90 and 120 days after planting and leaf and stem fractionswere tested separately. A randomised 4*3*2 factorial design was used to evaluate the amount and rate of IVGP using the automated AnkomRF system.

The results from IVGP showed multi-phasic curves indicating differential microbial degradation rates. Therefore the results were separated into three phases (0–7, 7.5–24.5 and 25–48 hours) based on the mean rate of gas production. Effects of V, HD and PF and interactions on amount and rate of IVGP were tested with linear models (significance: $p < 0.05$). There was significant difference in the rate of IVGP in phase III among varieties with V16798 showing highest values. Rate of V and HD significantly interacted in phases II and III. V and PF interaction was significant in phase III for rate. There was a significant difference in absolute IVGP after 48 hours, with V16798 highest. There was significant difference in the rate for HD in all 3 phases. The rate was highest for HD120 in phase I and HD60 higher in phase II and III. Interaction between HD and PF was significant in phase I and II for rate of IVGP. Total amount decreased with increase in HD (60>90>120). The difference in absolute IVGP was significant for HD after 48 hours. There was a significant difference in the rate of IVGP for PF in all 3 phases. The rate of IVGP was higher for stem in phase I and II, with the leaf taking over in phase III. The overall IVGP for the PF was higher for the leaf but the difference was not significant.

The study revealed that improved and local varieties degraded differentially with large differences in PF and HD and could potentially provide complementary fermentation substrate throughout 48 hours.

Keywords: AnkomRF gas production system, mean rate of gas production, napier grass variety

Influence of Plantation Species on Quality and Quantity of Honey Prodution

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This study was carried out to assess the influence of tree species on the quality (taste, aroma, ash content, protein content, moisture content, density and viscosity) and quantity (yield) of honey production. Three mono-species plantation (*Tectona grandis, Cassia siamea, Eucalyptus glubulus*) situated at the Forest Research Institute of Nigeria, Ibadan, Oyo State, were used for the study. Kenya Tor bar hives replicated three times were placed in each of the plantations for a period of 20 weeks. Monitoring of the hives was carried out at two weeks interval. At the end of 20 weeks the honey combs were harvested. Extraction was carried out manually and proximate analysis was conducted to test for the taste, viscosity, aroma, ash content, protein content, and moisture content. The result of the analysis revealed that the yield of honey was significantly ($p \leq 0.05$) higher in *E. glubulus* plantation (522 ml) while the yield was significantly ($p \leq 0.05$) lower in *T. grandis* plantation (322 ml). The honey obtained from *T. grandis* plantation had the best taste, aroma and texture, while the honey obtained from the *E. glubulus* plantation had the least acceptable taste, aroma and texture. The ash content of the honey from the *E. glubulus* plantation was significantly higher (1.8 cp). The viscosity of the honey from the *T. grandis* plantation was significantly higher (715 cp) than the one of the two other plantations (603 cp and 555 cp) Unite Cunti Poisie. The protein content of honey from the *C. siamea* plantation was significantly ($p \leq 0.05$) higher than the protein content of the honey obtained from the other plantations. It was concluded that the higher the yield the lower the quality of honey that was produced and vice versa.

Keywords: Colony, honey, tree plantation, quality, viscosity, yield

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Effects of Rangeland Management on Soil Properties in a Grassland and a Bush Savannah, South Africa

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The grassland biome and the bush savannah of South Africa are the major resources for livestock farming; yet, the soils of these rangelands are increasingly threatened by overgrazing. The aim of the present study was to investigate how soil properties respond to intensified rangeland management under different property right and management system. For this purpose we sampled different types of rangeland under communal (continuous grazing), commercial (rotational grazing) and landreform (mixture of grazing systems) farming, and within each of these systems we differentiated good, moderate and poor rangeland conditions along a gradient of increasing grazing pressure with decreasing distance to the water points. The analyses comprised the assessment of C, N and inorganic nutrient contents as well as physical fractionation (aggregates, particulate organic matter). The results showed differences between the bush savannah and the grassland in the response of the soils to different rangeland management. In the grassland, the commercial farms exhibited higher nutrient contents for especially C, N and Mg than the other farm types. The communal farms were generally depleted in the respective nutrient stocks. The nutrient depletion increased from good to poor rangeland conditions, *i.e.*, with increasing grazing pressure. Along that line there was an increased breakdown of macroaggregates with losses of the C and N stored therein. In the bush savannah heavy grazing removed more or less all vegetation at the poor sites nearby the water points in communal farms. As a consequence, C, N and most nutrients were depleted. But, and in contrast to the grassland biome, the moderate and partly also the good rangelands exhibited elevated nutrient stocks in the very surface soil (0–5 cm) under intensified grazing pressure, and bush encroachment in the communal and landreform farms, which exceeded those of the commercial ones and the nature reserve. We attribute these findings to increasing bush encroachment at the communal and landreform farms, which is negative for cattle feeding but apparently offers a chance for improving the soils under these management systems.

Keywords: Bush savannah, grassland, overgrazing, rangeland management, soil degradation, soil improvement

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NIRS Prediction of Neutral Detergent Fiber Digestibility (NDFD) of Tropical Forages

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Near infrared reflectance spectroscopy (NIRS) is a method to obtain rapidly information on plant compounds at low cost. It is environmentally friendly as it avoids the use of chemical reagents for analysis. Neutral detergent fiber digestibility (NDFD) is used to estimate energy content of feedstuffs and also as an important criterion in forage breeding. Thus the aim of this work was to develop a NIRS calibration equation for NDFD of tropical forages as a necessary step towards a quick tool for decision making in breeding and in diet formulation to increase productivity on farm. The study was conducted with 238 forage samples (154 grasses and 84 legumes, of which 42 were herbaceous and 42 shrubs). Different plant parts were collected with different cutting ages, vegetative stage and from varying localities forming a group with a high heterogeneity (CV of 36.63 %). They were then scanned and subject to standard laboratory analysis. The groups were analysed by the mathematical treatment 2,4,4,1, complete wavelength, and the mathematical model MPLS (Modified Partial Least Squares). The results of the equation shows an R^2 of 0.95, error of 2.1, 3.2 and 3.6, for standard error of the calibration (SEC), standard error of cross validation (SECV) and standard error for prediction (SEPcalibration) and the RPD (ratio of performance deviation) of 4.4 meaning a high predictive ability. This is associated with a correlation coefficient of 0.96 with a P <.0001 and confidence interval of mbox95 %. Validation of the equation was conducted with a total of 40 external forage samples (grasses and legumes) showing a SEPvalidation calibration of 4.3, R^2 of 0.93, a correlation of 0.96 (P <.0001) with a 95 % confidence interval. In conclusion, the study showed that is possible to obtain a calibration curve for NDFD to predict this trait with high accuracy and reliability for tropical forages, which facilitates decision making by breeders and farmers in suitable time frames.

Keywords: Calibration, neutral detergent fiber digestibility, NIRS, prediction, tropical forages

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Issues and Challenges of Current Agricultural Patterns in India: A Step Towards Sustainability

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The gains of the green revolution in India of the late sixties, which led to a phenomenal increase in crop yield, are slowly losing ground. Intensive agriculture under the green revolution led to depletion of soil productivity, water logging, salinity and ground water degradation. High-valued crop production and diversification with commercial value chains, particularly by large farmers, especially for export markets, may also undermine resource sustainability. With the recent spurt in food prices in the wake of other uncertainties arising out of declining growth in global food production, financial and economic slowdown, climatic variability besides massive land grabbing in parts of the developing world, the challenge is to provide for the food security of 75–105 million new poor globally without depleting land or water resources. In this context, this paper tries to analyse the negative externalities of intensive agriculture in the face of promoting food security to the ever growing population. The study will examine various approaches to meet these challenges. One such method would be integrated farming systems, which are pro-poor, pro-environment and believed to ensure economically beneficial and environmentally friendly agriculture. The study will examine organic farming as an approach to address these challenges. There are ample evidences in the literature to suggest that this would be adopted as an approach to promote economically profitable and environmental friendly agriculture. Using empirical studies already carried out by scholars in India, this paper aims to understand how far such an intervention would promote higher yield and ecologically sustainable agriculture. It also highlights the need for empowering agriculture extension services to promote scientific knowledge to farmers blended with their traditional wisdom.

Keywords: Integrated farming, organic farming, sustainable agriculture

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Rangelands Ecosystems of the Tibetan Plateau: Their Current Status and Sustainable Development Strategies

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Rangelands on the Tibetan plateau support a unique society and culture on the roof of world. Climate change is predicted to worsen the already hars environmental conditions on the Tibetan plateau. Kobresia meadow is the dominant vegetation on Tibetan plateau, and yak is the key livestock species. Already today, degradation of rangelands and deterioration of livelihoods lead to herders out-migration. Livestock numbers have increased over the last 60 years, though stagnated during the last 10 years; especially yak numbers decreased due to warming and degradation effects. Rangeland degradation is expected to increase with global warming effects, especially in winter. Spots of barren land provoke heavy carbon losses from top-soil: the conversion of 1 ha alpine meadow to barren land result in a loss of 10 cm top soil and about 20–46 tons of soil organic carbon (SOC). It is estimated that close to 5 Mio hectares barren land exist in the headwater region of the Yangtze and Yellow river on the Tibetan plateau, which are estimated to have lost around 247 Mio tons SOC. In consequence of the above, ecological restoration is of first importance to improve Tibetan livelihood. Seed banks for rangeland species and active re-sowing of barren land is important to restore degraded areas. In addition, the pastoral value chain must be integrated, and large, privately managed areas should be dedicated to forage production. Supplying enough and nutritious feed and enhancing the value of livestock products is expected to enable a reduction of livestock numbers and increase herders' income. In addition, fostering the development of biological control of rangeland pests (*e.g.*, grasshoppers) and keeping the ecosystem in balance is needed as well. Overall, the philosophy of sustainable development needs to be incorporated into the regional policy and become as important as economic development. In particular, more 'bottom-up' programs and approaches need to be applied for the improvement of livestock and rangeland management, to ensure the effectiveness of government investments in maintaining the productivity of the Tibetan rangelands.

Keywords: Alpine meadow, degradation, restoration, sustainable development, tibetan plateau

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Animal breeding and health

Management Strategies for Small Ruminants among Pastoralists in Semi-Arid Kenya: Do They Lead to Genetic Progress?

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This study was carried out in Marsabit County of northern Kenya among the Rendille and Gabra communities, and aimed at characterising management strategies in order to optimise and expand community-based breeding programmes for small ruminants. Qualitative information on milking, watering and feeding strategies were categorised through identification of various themes each answering the specific research questions, and organised into coherent categories for inference. Quantitative data generated from the survey, which included livestock ownership patterns and flock sizes, were numerically coded for the purpose of computer entry and subjected to General Linear Model Procedure (PROC GLM) of SAS for statistical analyses. Further, attempts were made to predict genetic gain in traits perceived by the pastoralists to be important, namely, live weight (LW) and milk yield (MY) using selection index procedures. The results showed that the herders owned and kept small stocks in multispecies herds. However, the average flock sizes differed between the Rendille (sheep, 141; goats, 225) and the Gabra (sheep, 88; goats, 98). Additionally, herders had elaborate feeding and watering regimes that were essential in the management of the pastoral rangelands, especially during the present times of unprecedented climate variability. Genetic gains in LW and MY were higher in the sires to breed sires (SS) than in the dams to breed sires (DS) pathway. The projected population size (3000 does) in the nucleus would be attained in the 7th year after the start of the breeding programme. In conclusion, the herders' intricate knowledge on management of important genotypes was critical and should be incorporated with conventional approaches in planning and executing any community-based sheep and/ or goat genetic improvement initiatives.

Keywords: Breeding programmes, genetic gain, herders, traits

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The Origin of the '*Mycoplasma mycoides* Cluster' Coincides with Domestication of Ruminants

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The '*Mycoplasma mycoides* cluster' comprises the ruminant pathogens *Mycoplasma mycoides* subsp. *mycoides*, the causative agent of contagious bovine pleuropneumonia (CBPP), *Mycoplasma capricolum* subsp. *capripneumoniae* the agent of contagious caprine pleuropneumonia (CCPP), *Mycoplasma capricolum* subsp. *capricolum*, *Mycoplasma leachii* and *Mycoplasma mycoides* subsp. *capri*. These pathogens are obligate parasites of goats, sheep and cattle and cause diseases characterised by clinical symptoms including pneumonia, mastitis, septicaemia, meningitis, wound infections, and arthritis. CBPP and CCPP are major livestock diseases and impact the agricultural sector especially in developing countries through reduced food-supply (animal losses) and international trade restrictions. In addition, these diseases are a threat to disease-free countries. Several studies have attempted to resolve the evolutionary relationships between the members of the '*M. mycoides* cluster' or to infer the evolutionary history of single members within the cluster. However, a comprehensive overview of the evolutionary history of the '*M. mycoides* cluster' and genetic relationship between populations is still lacking. We used a multilocus sequence typing (MLST) approach to gain insights into the demographic history of and phylogenetic relationships among the members of the '*M. mycoides* cluster'. We partially sequenced seven housekeeping genes representing a total of 3,816 base pairs from 118 members of the '*M. mycoides* cluster' as well as five strains isolated from wild Caprinae, spanning their geographic distribution and isolated over the last 100 years. Strikingly, the origin of the '*M. mycoides* cluster' dates to about 10,000 years ago, suggesting that the establishment and spread of the cluster coincided with livestock domestication. In addition, we show that hybridisation and recombination may be important factors in the evolutionary history of the cluster.

Keywords: Capricolum, hybridisation, recombination, mulfilocus sequence typing

Assessing Genetic Diversity of Five Tanzanian Chicken Ecotypes Using Microsatellite Markers and Mitochondrial DNA D-loop Sequencing

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The study aimed to evaluate the genetic diversity of Tanzanian chicken populations through phylogenetic relationship, and to trace the history of Tanzanian indigenous chickens. A total of 196 individuals of five ecotypes of Tanzanian local chicken (*Ching'wekwe, Kuchi, Morogoro Medium, Pemba* and *Unguja*) from eight different regions (Mwanza, Geita, Shinyanga, Tabora, Tanga, Morogoro, Unguja and Pemba) were used. The diversity study was based on morphological measurements, *i.e.* wing length, shank length, shank thickness, keel length and body weight, and 29 microsatellite markers proposed by ISAG/FAO advisory group for animal genetic diversity. Additionally, the degree of shared mtDNA haplotypes from the D-loop region was analysed to disclose likely maternal origin of Tanzanian indigenous chicken. A Principal Component Analysis of morphological measures distinguished individuals most by limb size and body weight. *Morogoro Medium*, *Pemba* and *Unguja* grouped together, while *Ching'wekwe* stood out due to their unproportional short shanks. Kuchi formed an independent group due to their comparably long limbs. Microsatellite analysis revealed three clusters of Tanzanian chicken populations: *Ching'wekwe* clustered together with *Morogoro medium*, *Unguja* and *Pemba* ecotypes made up a common cluster distinct from *Morogoro medium* and *Ching'wekwe* cluster, while *Kuchi* ecotype formed an independent cluster. According to reference mtDNA haplotypes, previously described in the literature by Liu and colleagues, the sampled Tanzanian chickens encompassed two haplogroups of different genealogical origins, *i.e.* the respective haplogroups D and E which originated from Southeast Asia and Indian subcontinent. The majority (95.2 %) of *Kuchi* were found in haplogroup E, and in particular clustering with the E1 haplotype (76.2 %). Latter is identical to haplotype A3 described by Oka and colleagues that contained Shamo game birds sampled from Shikoku Island of Japan in the Kōchi Prefecture. In all three analyses, *Kuchi* formed an outstanding group from the other four Tanzanian chicken ecotypes. The overlap with haplotypes from Shamo in Japan and the name "Kuchi" which is very similar to the Prefecture Kōchi implies that *Kuchi* might be imported to Tanzania from Japan. Haplotype network analysis of mtDNA suggests that Tanzanian chicken originated from the Indian subcontinent and Southeast Asia, respectively.

Keywords: Genetic diversity, indigenous chickens, East Africa

Genetic and Economic Evaluation of Alternative Breeding Objectives for Adoption in the Smallholder Indigenous Chicken Improvement Programme

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The aim of this study was to genetically and economically evaluate the breeding objectives for adoption in the smallholder indigenous chicken (IC) breeding programme in Kenya. A closed three-tier nucleus breeding programme with three breeding objectives targeting within breed selection was simulated. The breeding objectives differed based on the end marketable products. They included IC dual-purpose (ICD) representing the smallholder IC producers' breeding goal for both eggs and meat production, IC layer (ICL), and broiler (ICB) simulating alternative breeding objectives for IC egg and meat pure lines, respectively. A flock size of 48,000 breeding hens with 1 %, 29 % and 70 % in nucleus, multiplier and commercial flock, respectively, was modelled using deterministic approach to assess the genetic and economic merit of each breeding objective. The results indicated that cocks were the main contributors of genetic gains compared to hens reflecting their ability to transmit superior genes faster within the population than hens. The genetic response after one round of selection for individual traits differed between the breeding objectives. The highest genetic gains for egg number (2.71 eggs) and growth traits (average daily gain, 1.74 g, and live weight at 16 weeks, 58.0 g) were realised in ICL and ICB, respectively. The genetic responses for age at first egg were desirable in all the breeding objectives while that for fertility and hatchability were only favourable in ICD and ICL. Faecal egg count had low but desirable response to selection compared to antibody response which had negative genetic gains. The ICD reported the highest increase in feed intake ($0.19\,\mathrm{g\,d^{-1}}$) while ICL had the least ($0.12\,\mathrm{g\,d^{-1}}$). The ICB was the most profitable breeding objective while ICL was the least. The alternative breeding objectives ICL and ICB were found to be superior in genetic improvement for egg production and growth traits, respectively, compared to smallholder farmers breeding objective (ICD). Adoption of the breeding objective targeting improvement of IC for meat production was recommended. However, this must be accompanied by improving the production environment realise high profitability.

Keywords: Breeding programme, three-tier nucleus breeding, dual-purpose, layer, broiler, Kenya

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Effect of Deltamethrin on *Argas persicus* in Selected Clusters Within Machakos and Kitui Counties, Kenya

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A study on prevalence of argasid ticks and their response to deltamethrin treatment was undertaken in 4 purposively selected farmer groups (2 each for Katangi and Munyumbuni cluster) between March to December 2009. The groups were sensitized before the pre-control argasid tick populations were established. Two synthetic pyrethroids, deltamethrin (Ectomin®, UltraVetis, Animal health) and deltamethrin (Decatix®, Coopers Ltd, Kenya), both effective acaricides, were used to spray on chicken houses where birds were separately housed. This was after randomising the insecticide by group. Decatix® was used on the chicken houses belonging to members of the Nzewani women group in Kithito and Wikwatyo group in Munyumbuni, while Ectomin® was used on houses of Ngwate Ngukwate group of Kithito and Mituki ya Iveti group of Munyumbuni. Since both Ectomin and Decatix have concentrations of 5% w/v, a double strength solution of 2 ml (0.1 mg) of acaricide in 10 lites of water was used instead of the recommended dilution of 1ml (0.05 mg) for every 10 litres of water used for spraying animals. The insecticide was then sprayed on the chicken housing units using a knapsack sprayer in the morning before temperature rise during the day. Initial spraying was done weekly for the first month, biweekly regimens were adopted after the soft tick population dropped substantially. Two of the groups were purely women groups while the other two had mixed membership. A total of 39 members participated in the study, each owning between 10 to 40 chickens. The argasid tick population on chicken houses was high and ranged between 0 to 80 with participants in the Katangi cluster having slightly higher tick populations than those in the Munyumbuni cluster. The commencement of spraying Ectomin and Decatix resulted in a significant drop in argasid population in the participating households as was revealed during the monitoring visits. However the ticks were never eradicated owing to their unique biology. The study showed that synthetic pyrethroids are quite effective against argasid ticks and efforts should be made to synchronise soft tick control with that of hard ticks.

Keywords: Argasid ticks, indigenous chickens, tick control

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Analysis of Animal Health Service Delivery in Uganda: An Application of the Social Network Approach

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As a result of continued fiscal challenges from late 1980s to date, most developing countries liberalised the provision of most of the animal health services. Clinical services are provided by the private sector while preventive services like vaccination and disease surveillance are being provided by public and community sector (NGOs) without coordination. As a result, many actors of varying capacities, interests and relevance are involved in providing animal health services. With resurgence of infectious diseases, increased economic and health risks especially to the rural poor, there is need to understand relational patterns of actors to ensure good governance in the animal health sector so as to address emerging and re-emerging animal diseases risks in given political environment. This paper applies social network analytical tools to map out actors involved in delivery of both clinical and preventive veterinary services in both pastoral and intensive livestock productions systems, rank their influence levels, and elicit governance challenges. Preliminary results reveal that the important social relations in animal health service delivery are: cooperation of the private veterinarians and paravets, private veterinarians and government veterinarians in intensive production systems, while in pastoral areas it is the cooperative effort of NGOs, government veterinarians, and community based animal health workers (CAHWs). However, low level of education among CAHWs, absence of government staff, and poor market infrastructure in pastoral areas, and absence of relevant incentives and policies to strengthen the existing workable social relations are limiting factors to service delivery. At local government level, staff absenteeism and corruption are major threats to animal health service delivery. At national level, conflicts between technical staff and administrative staff of the ministry of agriculture, conflict between agricultural ministry and the national agricultural advisory services have greatly affected animal health service delivery. We argue that the government intervention should focus on increasing staff in pastoral areas by recruiting diploma staff other than degree staff, improve on personnel management, invest in infrastructure and pass policy governing the veterinary and para-veterinary relations.

Keywords: Curative services, preventive services, social network analysis, veterinarians, paravets

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Letting Farmers Decide: Supporting Dairy Farming through Delivery of Preferred Breeding Services

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Africa has a deficit in animal products and the situation is projected to worsen because of the increasing gap between supply and demand. There is, therefore, a need for change in the manner in which livestock are reared and for raising the productivity of individual animals on the African continent. Kenya, in its "Vision 2030," aims at reducing poverty and hunger through boosting growth in agriculture and livestock production by 6–8 % per year. Pragmatic efforts and approaches towards this goal, in livestock production, include sustained genetic improvement and appropriate policies, among others. Regarding genetic improvement artificial insemination (AI) is one of the superior technologies for disseminating genes within a population at a reasonable cost. However, after historical changes in dairy policy in Kenya, the use of the breeding service has continued to decline with the cost of the service escalating. Current policy and development efforts directed towards providing solution to the problems facing dairy farmers would benefit from a critical assessment and understanding of farmers' preferences for attributes that could be influencing their choice of these services. This is pertinent in identifying important incentives, barriers and opportunities for policy and strategic interventions. Consequently, the study applied choice experiments, a multi-attribute preference eliciting method, to evaluate farmer preferences for AI service attributes in the milk marketing hubs in Kenya. Three hundred dairy farmers from three dairy hubs in western Kenya were interviewed. The data was analysed using multinomial logit model as well as random parameter logit models. The results reveal that dairy farmers derive the highest welfare gain from AI services offered by dairy hubs, and the highest welfare loss from local semen. The results bring to light the need for proper coordination and organisation of AI service, and the delivery of quality service. These findings are expected to inform the design of dairy service delivery activities that could not only reduce the barriers to farmer access to AI services but also improve the dairy farmers' incomes from dairy enterprises while increasing milk production to meet the increasing consumer demand.

Keywords: Artificial insemination, choice experiment, dairy services, farmer preferences

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Genetic Similarity and Environmental Sensitivity for Milk and Fertility Traits in Holstein-Friesian by Herd Hierarchy

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Population wide progeny test schemes in dairy cattle are being modified towards testing in selected contract herds. This approach is advantageous due to lower cost and ability to record many more traits because the environment is controlled. However, apart from achieving accurate differentiation of superior genotypes in superior environments, genotype by environment interaction between the selection and production environment should be considered. Milk yield and fertility traits records of 5,468 cows, daughters of 251 sires, born between 1990 and 2005 were used to analyse genetic similarity, environmental sensitivity, rank and additive genetic correlation in the Holstein-Friesian population in Kenya for 305-day milk yield, age at first calving and calving interval between the two environments. The genetic link between selection environment and production environment was 0.49. Sire rank and additive genetic correlations ranged from 0.16–0.45 and 0.15–0.46, respectively. Top ten common sires in the two environments from environment specific and joint genetic analysis were 2, 3, 1, and 4, 5, 6, respectively, for age at first calving, calving interval and 305-day milk yield. Genetic change in the production environment as a result of selection in the nucleus was 0.17 days, 0.74 days and 0.21 kg for age at first calving, calving interval and milk yield, respectively. The low genetic and sire rank correlations led to few common top ten bulls due to severe sire re-ranking across the environments. Genetic evaluation based on pooled data resulted in a higher proportion of top ten common sires that ranked highly in the selection and production environments. In developing countries where population wide recording and testing is not possible due to financial and infrastructure constraints, successful implementation of progeny testing in selected contract herds requires the breeding objective of the selection environment to be defined for the farmers in the production environment. The existence of strong genetic links between the selection and production environment can form the basis to evaluate the compatibility of the breeding objective of the selection environment with needs of farmers in the production environment.

Keywords: Compatibility, contract herds, correlated response, selection differential

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Determinants of Access to Breeding Services by Smallholder Dairy Farmers in Kenya

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Smallholder dairy farming is considered one of the most important activities in the agricultural sector in Kenya. It is a source of income and livelihood for up to 800,000 smallholder farmers who supply for more than 50 % of the total milk output. There are several factors that influence farmers' access to various livestock services. It is therefore important to isolate these factors and identify intervention strategies that enhance service accessibility. The objective of this study was therefore to examine the determinants of smallholder dairy farmers' use of breeding services in Kenya, taking the case of Nyandarua and Kiambu counties. Data was collected through semi-structured interviews with 140 randomly selected respondents. The breeding services considered were artificial insemination (AI), natural bull service, and a combination of AI and bull services. A multinomial logit econometric model was used, fitting AI as the base category. There was a negative relationship between higher levels of education, herd size, and location and the use of bull service. However, education, herd size and credit were positively related to the combined option. The results indicate that uptake of AI services after the liberalisation of the sector is influenced by other factors besides costs-related factors. Factors such as accessibility of breeding services and product markets influenced the farmers' decision to choose among the available breeding services. The effectiveness of the breeding services in terms of successful conception also played a big role in the choice. A need for concerted efforts to increase farmers' knowledge on utilisation and effectiveness of available breeding services is imperative.

Keywords: Access, breeding services, Kenya, smallholder farmers

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Phenotypic Characterisation of Sudanese Horse Ecotypes

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In the Sudan, the diversity of agro-ecological zones, climate and cultural conditions has resulted in production systems with well-adapted horse ecotypes or breeds. The horse breeds serve numerous functions in their respective production systems and are bred and selected for sustainable performance. The change in living and production patterns has led to a drastic reduction in the numbers of Sudanese horse ecotypes placing them on the verge of becoming endangered. Phenotypic and genetic characterization to assess the existing biodiversity and differences among the Sudanese horse ecotypes is an essential prerequisite to facilitate the conservation and utilisation programme in an effective and meaningful way. However, very limited research, if any, is being done on equines in the Sudan, and with very limited information available. This is an attempt to contribute to the phenotypic characterization (body measurements and coat color) of the multitude of horse ecotypes in Sudan. Data on phenotypic measurements and descriptions representing the three main horse ecotypes in the country (Dongola horse, Western Sudan horse and the Hybrid horse) were obtained from 1051 horses, selected according to distribution of the horse population and accessibility. The data were classified according to ecotype and age. The body measurements include body weight, body length, neck length, body height, chest girth and ear length. They were measured using a special tape designed for horses, while the coat color was determined by observation. The results indicate clearly the extent of genetic pollution that happened, and that prompt action needs to be taken to conserve local genetic resources.

Keywords: Body measurements, phenotypic characterisation, horse, Sudan

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Technological Options and Approaches to Improve Smallholder Access to Desirable Animal Genetic Material for Dairy Development: Experience with Hormonal Oestrus Synchronisation and Mass Insemination in Ethiopia

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Smallholder farmers and pastoralists dominate cattle production in Ethiopia. Cattle serve various functions such as animal traction for crop production, milk, meat and manure production, provision of services, and fulfiling social obligations. Production is based on indigenous animals, with grazing and low level of inputs. Milk production from the local cows is low and average daily milk yield is around 1.5 litres. Most of the milk produced is used for household consumption and excess milk is processed into butter and marketed in small quantities. Demand for milk and milk products has been increasing in urban and peri-urban areas and farmers take advantage of this by engaging in urban and peri-urban dairy production. These farmers use improved dairy genotypes and better feeding, housing, and management systems. Daily milk yield from crossbred dairy cows ranges from 10 to 15 litres. However, due to lack of properly organised recording and selection system, there is shortage of good quality improved dairy animals. This is again exacerbated by often inefficient and ineffective field artificial insemination service resulting in low pregnancy rates and hence, shortage of good quality improved replacement dairy animals. As a result, in areas where there is good production and marketing opportunity, availability and exorbitant prices of such animals has hindered smallholder farmers from entry into the business. The IPMS project, in collaboration with its partners, designed a hormonal oestrus synchronisation and mass insemination programme to help small farmers get access to crossbred animals. In 2011, a total of 375 local cows were crossbred with Holstein Friesian semen in selected milk sheds in Tigray (200 cows) and Southern Regional States (175 cows). Oestrus response was 90 % and pregnancy rate averaged 62 %. A total of 229 crossbred calves have been born as a result of this intervention. This paper presents the experiences of the IPMS project in developing technological options and organisational and institutional arrangements required for an alternative supply system of dairy genetics to kick start and enhance smallholder dairy production in Ethiopia. The lessons learned for scaling up are also outlined.

Keywords: Dairy, genetics, oestrus synchronisation, smallholder farmers

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Body Measurements and Body Condition Scoring as Parameters for Estimation of Live-Weight in Nilli Ravi Buffalo

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The implementation of management recommendations for Nilli Ravi buffalo in (semi-)commercial dairy production systems in Pakistan is often hampered by difficulties to determine the animals' body weight (BW). Managerial decisions are therefore based on rough and inaccurate BW estimates. A workable and accurate means of predicting BW of this breed by using body measurements and body condition scoring (BCS) was therefore explored.

211 Nilli Ravi buffaloes of the Livestock Experiment Station, Bahadurnagar, Okra, Pakistan, were divided into age groups 1–3 years (G1), 3–8 years (G2) and >8 years (G3). Animals were weighed on a mechanical scale (0–1000 kg, accuracy 1.0 kg), and their heart girth (HG), body length (BL) and shoulder height (SH) was measured. In addition BCS was performed (1–5 point scale with 0.5 point intervals) as suggested by Abeygunawardana and colleagues in 2000. The recorded data was subjected to simple and multiple linear regression analysis.

Buffaloes' BW ranged from 100–750 kg, the overall mean values of BW, HG, BL, SH and BCS were 359 ± 160.9 kg, 170 ± 30.1 cm, 130 ± 19.2 cm, 125 ± 14.5 cm and 3.8 ± 0.77. With correlation coefficients (r) of 0.97 (HG), 0.94 (BL), 0.93 (SH) and 0.43 (BCS), the relationship between the individual independent variables with BW was significant ($p < 0.01$) in all cases. The multiple linear regression between BW and HG, BL and BCS was highly significant ($p < 0.001$) for each of the three groups (G1: $r^2 = 0.95$, G2: $r^2 = 0.86$, G3: $r^2 = 0.83$). The equation for the most productive group G2 was: BW (kg)= -1142.48 + 3.85HG (cm) + 2.56 BL (cm) - 46.87 bcs1 – 27.89 bcs2, whereby bcs1 is a dummy (yes/no, *i.e.* 1/0) for a BCS between >2.5 - <4 and bcs2 is a dummy for a BCS between 4–5. Similar equations were developed for the other two groups.

Buffalo farmers who lack mechanical or electronic scales to regularly determine their animals' BW can thus combine two simple morphometric body measurements (HG, BL) with BCS in order to adjust specific management decisions (feeding, health treatment, breeding) to their individual animals.

Keywords: Body weight, multiple regression analysis, water buffalo

Assessment of Genetic Diversity and Population Structure of Omani Local Chicken Using 29 Microsatellites

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This study attempted to assess genetic variation and population structure of indigenous chickens in Oman. Twenty nine microsatellite markers were investigated in 158 birds from six agroecological zones: Batinah (BT), Dhofar (DF), North Hajar (NH), East Hajar (EH), Musandam (MU), and East Coast (EC). Among all loci, a total of 217 alleles was observed across all populations. The average number of alleles per locus was 6.9 ± 3.3 and ranged from 2 (MCW 98 and MCW 103) to 20 (LEI094). The average number of alleles per population ranged from 5.0 ± 1.9 (DF) to 5.5 ± 2.9 (NH). Across populations the observed heterozygosity was 0.54 ± 0.02, while the expected heterozygosity was 0.62 ± 0.03. For the six populations, observed and expected heterozygosity ranged from 0.51 (EC) to 0.58 (NH) and from 0.57 (BT) to 0.66 (DF), respectively. Mean deficit of heterozygotes within populations (FIS) was 0.130 ± 0.024, and mean fixation index between populations (FST) was 0.034 ± 0.005 indicating low population differentiation. The mean global deficit of heterozygotes across populations (FIT) was 0.159 ± 0.023. The mean polymorphic information content (PIC) was 0.561, ranging from 0.521 to 0.585. Genetic distance calculated based on Nei's standard distance identified DF as distant population from all populations while the smallest distance was between BT and NH populations. Model based clustering using algorithm implemented in STRUCTURE software package was used to detect population substructures and presence of admixture. The results showed that individuals of the six populations were clustered into 3 groups: (NH and BT) and (EC, EH and MU) with a high degree of admixture within the groups. In contrast, individuals of DF population made up a separate cluster. The results suggest considerable diversity and population substructure of the Oman indigenous chickens studied. The Dhofar (DF) population was identified as most distant and most inbred (FIS=0.193) of these populations. Further studies are needed to evaluate these populations as an important reservoir of genetic diversity.

Keywords: Genetic variation, microsatellites, Omani local chickens

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Livestock Genetic Resources in Vietnam: Preservation and Management

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Vietnam is one of the countries, which is rich in biodiversity. Livestock in Vietnam play a pivotal role in agriculture by providing draft power, manure for crop production, and food for human consumption. The main aim of present livestock development in Vietnam is to assist farmers to produce and sustain livestock of high economic potential. Most of the species kept are indigenous types, only 12 % of the cattle and 18 % of the chicken are exotic cross and commercial types. These indigenous types posess many positive qualities, *e.g.* considerable adaptability to harsh climate, poor nutrition, resistance to local diseases and parasites and suitability to subsistence farmers' economy. However, their productivity is low compared to improved breeds of livestock available in the country. Breeding males are nowadays scarce at the village level. Sound national breeding policies have never been formulated and implemented for any species of livestock in the country. On the other hand, neglection of indigenous breeds led to a situation where a number of native breeds of livestock are now under the threat of extension. So, conservation and improvement of indigenous animal genetic resources (AnGR), especially cattle, goat, chicken, sheep and buffalo, as the order of priority, has been recognised. But the mechanism for implementing this agenda remains unclear. Therefore, future efforts should be focused on community-based *in situ* development and conservation of potential AnGR of Vietnam. In this regard, the most successful way could be genetic screening and open nucleus breeding strategies for the improvement of most promising indigenous AnGR. The programmes may operate through both selection and distribution of males to participating village farmers, who agree upon breeding goals. Another way may be operation of sire selection and multiplication for distribution scheme. The said approaches will not only improve the indigenous genetic material but will conserve them *in situ* for the benefit of the livestock keepers. The suspected success of community-based *in situ* animal genetic resource development and conservation strategies will largely be due to the fact that the strategies will be based on the indigenous animal populations in their adaptive environment.

Keywords: Animal genetic resources, conservation, diversity, Vietnam

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Botulism in Livestock in North Darfur State

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Cases suspected to be botulism were known to occur in livestock, especially camels in North Darfur States; signs of the disease are paralysis in the hind quarters. This study was designated to investigate the problem.

A total of 275 samples including 120 carcasses from various animal species, 74 soil samples, 56 water samples, and 25 tissues were collected from six provinces of the state. The tissue samples included small and large intestinal contents, lungs, livers, spleens and lymph nodes, besides ruminal contents and blood samples from cattle, sheep and goats. Water samples were from pools, microdams, bore holes, wells operated by hand pumps, and dams. The soil samples were collected from the same areas. In addition we determined calcium, phosphorous, glucose and protein levels in sera of 600 (100 each) cattle, camels, sheep, goats, horses and donkeys whether infected with the disease or at risk.

The samples were cultured in medium (cooked meat) for isolation of *Clostridium* species and the isolates were identified by conventional biochemical tests. Detection of the botulinum neurotoxin was made by mouse bioassay and typing of the isolates by polymerase chain reaction (PCR), comparing the samples with the known positive *C. botulinum* type C DNA and a negative control. The 22 isolates showed a positive band at 225 bp; the isolates comprised 19 haemolytic and three non-haemolytic *C. botulinum* strains.

The results revealed the presence of *C. botulinum* in all types of the samples investigated. A total of 22 *C. botulinum* type C strains were isolated from the samples: 2 from water samples, 5 from tissues, 7 from carcasses, and 8 from the soil. Other *Clostridium* species which were: 12 *C. tetani*, 8 *C. perfringens*, 7 *C. glycolicum*, 6 *C. bifermentans* and one *C. sordellii* from soil.

The findings indicated that the causative agents of the outbreak were *C. botulinum* strains. Inadequate feeding of animals leads to comsumption of soil (pica) and hence to disease. Vaccination and improvement of animal feeding should prevent botulism and lower the risk for soil ingestion.

Keywords: *Clostridium botulinum*, livestock, pica, undernutrition, Sudan

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Causes of Condemnations of Sheep Carcasses in Abattoirs at Khartoum

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Sheep, either live or slaughtered, are the most important among Sudan's animal exports – a major source of foreign currency. Accordingly, diseases that cause rejection of live sheep at veterinary quarantines and in importing countries, as well as pathological conditions causing condemnation of sheep meat, should receive more attention by veterinarians; not only because of their economic importance, but also because of the potential hazards to human health, especially through meat consumption and handling. The present investigation reviewed the causes of sheep carcass condemnations as well as the condemnation of red offals and some green offals of sheep slaughtered for export. The study analysed records from two major abattoirs in Khartoum State of Sudan covering the period Jan – Dec 2011. Whole carcass condemnation during this period was 0.1 % of the total sheep slaughtered for export. Main causes of carcass condemnations were jaundice, (64.8 %) and hydatid cysts (20 %). Other causes (15.2 %) included abscesses, emaciation, and adhesions. Total condemnation of offals (liver, kidney, heart, lung and spleen) was high (12.8 %), with liver constituting the major condemned part (83 %) followed by the lungs (12.4 %), the heart (4.0 %), kidneys (0.4 %) and the spleen (0.2 %). Major pathological changes in the condemned livers were necrosis, calcification, hydatid cysts, adhesions, fascioliasis, abscesses, jaundice, colour changes and fatty degeneration. Although the described pathological conditions were not further investigated in relation to the diseases they can represent, they point to a high prevalence of parasitic diseases in slaughtered animals. Although the described conditions were not related to areas of animal breeding in the country, they more or less reflect the diseases of sheep in the western part of the country, especially Kurdofan region, where most of export sheep are raised. It is highly recommended that the diseases manifesting as jaundice, in addition to other liver diseases in sheep are investigated.

Keywords: Hydatidosis, jaundice, sheep carcass condemnation, Sudan

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Comparative *in vitro* Efficacy of Selected Medical Plants from Cholistan Against Gastrointestinal Helminthes of Sheep and Goats

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Livestock infestation with gastrointestinal parasites reduces herd productivity in many tropical countries. Synthetic anthelmintics can control this problem but high prices, unavailability, side effects, or development of resistance lead to their very limited use in many pastoral systems. Traditional medicinal plants might therefore be a valuable alternative. Based on interviews with l00 pastoralists and 20 local healers in the Cholistan desert, Pakistan, we tested five medicinal plants that were said to be effectively used against gastrointestinal parasites in small ruminants, namely *Capparis deciduas* (P-I), *Salsola foetida* (P-II), *Suaeda fructicosa* (P-III), *Haloxylon salicornicum* (P-IV) and *Haloxylon recurvum* (P-V). Aqueous-methanol (70 % : 30 %) extracts were prepared of each plant at concentrations of 500, 250, 125, 62.5, 31.2, 15.6, and 7.8 mg dry matter per ml. Their anthelmintic activity was evaluated against adults of *Haemonchus contortus*, *Paramphistomum cervi* and *Trichuris ovis*, which are the prevalent helminthes in the region. Levamisol ($0.55\,\mathrm{mg\,ml^{-1}}$) and Oxyclozanide ($30\,\mathrm{mg/ml}$) served as positive, and pure aqueous-methanol solution served as negative control. Results were expressed as the percentage (%) of worms that died during various intervals of time (0, 2, 4, 6, 8, 10, 12, 24 hours).

All plants showed maximum anthelmintic activity at a concentration of $500\,\mathrm{mg\,ml^{-1}}$, and effectiveness decreased with decreasing concentration. All extracts exhibited minimum and maximum activity at 2 and 12 hours post application, respectively. While P-I was most effective against *H. contortus* (43.2 % ±2.68 dead adults after 12 h), P-IV was least effective against this helminth (36.5 % ±2.74). P-V showed maximum (42.0 % ±2.89) and P-III minimum (26.4 % ±2.67) anthelmintic activity against *T. ovis*. P-V also killed a maximum of *P. cervi* individuals (47.4 % ±2.82), while P-II was least effective against this species (38.0 % ±2.72). The average effectiveness of the positive and the negative control against the three helminthes was 87.4 % (±3.92) and 18.6 % (±3.87).

The results indicate that P-I and P-V are promising candidates for the ethno-botanical treatment of major gastrointestinal helminthes in small ruminants in Cholistan. Since pastoralists may not have easy access to methanol, the anthelmintic activity of purely aqueous extracts of these plants is currently investigated.

Keywords: Anthelmintic activity, ethno-botanical remedies, *Haemonchus contortus*, small ruminants, *Trichuris ovis*

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Livestock Bio-diversity *vis-à-vis* Food and Nutritional Security: Pertinent Issues in Livestock Development in Nepal

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Agriculture is the mainstay of about 65 % people of Nepal. Livestock is the integral part of Nepalese agricultural system which contributes about 28 % share to agricultural gross domestic production (AGDP). Cattle, buffalo, Yak and Chauries are the most important livestock species that contribute more than 73 % share to the livestock sector. There are 3 (Lime, Parkote and Gaddai) and 7 (Lulu, Achhami, Siri, Pahadi, Terai, Khaila and Chauri) different indigenous breeds of buffalo and cattle, respectively in Nepal. The average milk production of local buffalo and cattle is about 850 and 450 liters per animal per lactation, respectively. Though average production is very low, indigenous breeds of buffalo and cattle can survive in harsh environmental conditions, lower profile of nutritional regimes and are very hardy against disease and parasites. Because of the environmental diversity where Nepal enjoys from sub-tropical to the alpine climate, conservation of the indigenous species, which would be very important assets in the future, must get high priority in one side but more importantly, keeping the fact in mind that the food and nutritional security is still prevailing in more than 30, among 75, districts of Nepal, cross breeding, especially upgrading of these indigenous breeds is utmost necessary for the food and nutritional security in Nepal.

Ministry of Agriculture Development has given the high priority for the food and nutritional security and has launched the Food Security Promotion Project (FSPP) jointly supported by the Government of Nepal and United States Agency for International Development (USAID). The results obtained so far are very promising. The average milk production of the dairy cattle in the project sites has been found around 3,000 liters where as that of the highest was 8,263 liters per animal per lactation. The results are also encouraging in the case of buffaloes as well. These results have proved that there is a great scope to increase the production and productivity of cattle and buffaloes which help to increase the income level of the farmers and would be the milestone in food and nutritional security in Nepal.

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Monogastric production systems

Nutritional Value of *Canavalia brasiliensis* CIAT 17009 Herbage Meal in Growing Pigs

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In different tropical regions, forage legumes may offer an alternative feeding option for pigs because of their high protein content, good biomass yield and other ecological and economic advantages. Since 2000, CIAT in collaboration with farmers and national partners has identified a number of promising legume species especially adapted to the soils and the climate of the hillsides in Colombia, Nicaragua, and other countries. *Canavalia brasiliensis* is a legume selected by farmers for its high productivity, good soil cover and outstanding level of drought tolerance based on green forage yield. It is a weak perennial legume and can be grown on a wide range of soil pH (4.3–8.0) on low fertile soils up to a height of 1800 m asl and has a good regrowth up to the second year. In Palmira, Colombia, *Canavalia brasiliensis* yields $6.1 \, t \, ha^{-1}$ dry matter (DM) at 16 weeks, with 19 % crude protein content.

The objective was to study the consumption and total digestibility of canavalia herbage in growing pigs. Twenty-four commercial animals of 39 ± 5.4 kg body weight (BW) were utilised to study 0, 10, 20 and 30 % of canavalia herbage meal (CLM) inclusion in the total diet. Digestibility coefficients were measured by total collection of feces and coefficients of digestibility of CLM alone was estimated by the "difference" method. The inclusion of CLM did not affect DM intake (101; 96; 101 and 96 $g \, kg^{-0,75}$ BW, respectively; ($p > 0.05$). The inclusion of CLM decreased both coefficients, apparent digestibility of the DM (%; 84.5[a]; 81.8[ab]; 76.4[bc] and 74.7[c]) and GE (gross energy; %) (85.7[a]; 81.5[ab]; 70.0[bc] and 66.8[c]) ($p < 0.05$). In contrast, the apparent digestibility of crude protein (CP) was similar in all treatments (83.1; 81.9; 77.0 and 76.5 %) ($p > 0.05$). The average apparent digestibility coefficients of the CLM alone were 51.0 % DM, 61.4 % CP and 14.0 % GE. Thus, CLM was well accepted by growing pigs without affecting the apparent digestibility of CP. However, the digestibility of DM and GE decreased in a curvilinear way. Based on the results, a CLM inclusion of up to 10 % of the diet in growing pig diets offers an alternative protein supplement option.

Keywords: Consumption, digestibility, dry matter, energy, pigs, protein, tropical forage legume

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Feeding Rabbits and Cavies with Improved Forage Legumes in South Kivu, DR Congo

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In South Kivu Province, eastern part of the Democratic Republic of the Congo, farmers currently focus on small livestock, like poultry, cavies (*i.e.*, Guinea pigs) and rabbits, as a consequence of recent violent conflicts. After assessing the agro-ecological adaptability of improved forage legumes, four animal feeding trials were conducted with rabbits and cavies in a shed at Mugwahi farm in Nyangezi, South Kivu. Both species were fed according to traditional practice with available variable local feeds as control. Foliage of different adapted forage legumes complemented the local feeds at 25 %. For rabbits, *Leucaena diversifolia* (trial duration 57 days) and *Desmodium intortum* (85 days) were used, while cavies received *Canavalia brasiliensis* (57 days) and *D. intortum* (85 days). One treatment with cavies complemented 10 % of local feeds with a concentrate consisting of 25 % palm cake, 1 % salt and 74 % rice bran (57 days). Feed acceptability and live weight gains were recorded. A relative palatability index (RPI) was calculated by dividing consumed feeds by the offered in relation to those expected to be consumed if all feeds were of equal palatability. Palatability evaluation showed that some local herbs, like *Ageratum conyzoides* (Asteraceae) and *D. intortum* were most appreciated by both rabbits and cavies. *L. diversifolia* was also well consumed by rabbits, and *C. brasiliensis* and concentrate by cavies. Mean weight gains of cavies fed *C. brasiliensis* or concentrate were 2.1 ± 0.8 g and $2.2\pm0.7\,\mathrm{g\,d^{-1}}$, respectively, thus, substantially higher than that of the control $(0.9\pm0.6$ g$)\,\mathrm{d^{-1}}$. This indicates that forage legumes can be a good alternative compared to concentrate that farmers need to purchase. Cavies fed *D. intortum* gained little weight $(1.0\pm0.2\,\mathrm{g\,d^{-1}})$, comparable to the control $(0.9\pm0.6\,\mathrm{g\,d^{-1}})$. Similarly, rabbits fed *L. diversifolia* did not achieve any difference over local feeds. These preliminary results show that there is scope in feeding rabbits and cavies with improved forage legumes. Further investigation is required to fully appreciate their potential role for use as small livestock species with respect to improving the livelihoods of poor smallholder farmers in DRC.

Keywords: Acceptability, animal nutrition, domestic cavy, tropical forages

Cost Effectiveness of Feeding Fermented Taro Cocoyam Meal to Laying Japanese Quails (*Coturnix coturnix japonica*)

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The decreased predictability of seasons due to climate change has had negative effect on planting time and output of maize, a major energy source in the tropics. This negative effect is further reflected in the decreased availability and high cost of maize. However, the idea of making the most of what is easily available at the least cost, has increased research into root crops as important feed source in bridging the energy gap in poultry feeding. Two hundred and twenty five Japanese quails (*Coturnix coturnix japonica*) were randomly allotted to five dietary treatments (I-V) of 36 hens and 9 cockerels each. Each treatment was replicated thrice with 12 hens and 3 cockerels per replicate. In each of the five diets, 48 hours fermented taro cocoyam meal (*Colocasia esculenta* var. *esculenta*) was used to replace maize at 0 %, 25 %, 50 %, 75 % and 100 % for treatments I, II, III, IV and V respectively. The quails were fed one of the five experimental diets over a period of 70 days. Feed intake was significantly ($p < 0.05$) influenced by diets, with lowest values obtained for quails in treatment V. Cost of feed was significantly ($p < 0.05$) reduced by the inclusion of taro cocoyam. The cost of feed per gram eggs laid was least with treatment II. More savings accrued at 25 % inclusion levels with highest profit and return to Naira invested. Losses were observed at 75 % and 100 % levels of inclusions. The results indicate that it is cost effective to replace maize with 25 % of 48 hours fermented taro cocoyam meal in the diet of laying Japanese quails.

Keywords: Japanese quails, cost effectiveness, fermented taro cocoyam

Nonsteroidal Anti-inflammatory Drugs (NSADS) for Reproduction Control in Nile Tilapia

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Several studies have been conducted to detect the direct effect of inhibiting the aromatase activity, the rate limiting enzyme that converts androgens to estrogens needed for ovarian differentiation in fish to overcome the immediate need for a more environmentally friendly substitute of methyl testosterone. Cyclooxygenase (COX)-inhibitors are potent and irreversible inhibitors of the COX pathway. Since studies on human breast cancer cells showed that COX-inhibitors decreased aromatase messenger ribonucleic acid (mRNA) expression at the transcriptional level we tested the hypothesis of possible aromatase inhibition by the non-selective COX-inhibitors in fry fish tilapia during the crucial period of sexual differentiation. The effects of supplementation of COX1-inhibitors (diclofenac and ibuprofen) and COX2-inhibitors (etodolac and etoricoxib) in the diets of tilapia on growth rate, mortality and sexual differentiation were studied. Furthermore, determination of etoricoxib in fish feces using reversed-phase high performance liquid chromatography (RF-HPLC) with evaporative light scattering and photo diode array detector (ELSD-PDA system) was carried out. Three group experiments were run for 7 months at the Aquaculture Research Laboratory, Al-Quds University, Jerusalem. In experiment 1, 20 genetically females (XX) larvae were stocked in triplicates in a closed system and were given control diet (C group) and a diet supplemented with 10 mg kg^{-1} diclofenac (1 % diclofenac group), 5 mg kg^{-1} ibuprofen (0.5 % ibuprofen group) and 5 mg kg^{-1} diclofenac (0.5 % diclofenac group), respectively, for 4 weeks. After the 4th week all diets were changed to control diet. Results showed that COX-inhibitors could increase growth and alter reproduction in Nile tilapia but subsequent field investigations are needed to confirm these results using different classes of COX-inhibitors at different concentrations. They were well tolerated by fish except for diclofenac that showed high mortality.

Keywords: Aquaculture, nonsteroidal drugs, reproduction control, Tilapia

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Feeding Fish Without Fishmeal: Earthworm Meal as Alternative Animal Protein Source in Rural Areas

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Fishmeal is a limited resource and restricts the development of aquaculture especially in rural areas which have no established markets to supply suitable feed resources. Previous studies have shown that a traditional integrated farmer household in northern Vietnam with in average one cattle and one buffalo can produce 11.1 (min)–33.1 (max) kg of dry earthworms per year. The aim of this study was to evaluate whether earthworm meal can fully replace fishmeal in supplemental feeds and what the feed conversion of such feed is.

In northern Vietnam, a trial was carried out with common carp in net cages (total 32 nets, $1.5 \times 1.5 \times 2\,\mathrm{m}$) lasting for three months. Three iso-nitrogenous (16 % crude plant protein, 11 % crude animal protein) and iso-lipidic (10 % crude lipid) feeds were tested. Carp were fed either $10\,\mathrm{g\,kg^{-0.8}}$ of feed at a stocking rate of 5 fish per cage or $20\,\mathrm{g\,kg^{-0.8}}$ at a stocking of 10 fish per cage. In the feeds A, B and C, fishmeal protein was replaced by 0 %, 50 % and 100 % earthworm protein.

The stepwise replacement of fishmeal by earthworm meal in feeds at lower feeding levels resulted in relatively higher specific growth rates of 0.10±0.15 (A), 0.17±0.19 (B) and 0.22±0.16 (C), while the higher feeding rate accounted for 0.24±0.25 (A), 0.32±0.24 (B) and 0.42±0.27 (C). Lower feeding levels had relatively lower feed conversion rates of 1.4±0.6 (A), 1.2±0.5 (B) and 0.9±0.0 (C) than higher feeding rates which reached 1.5±0.3 (A), 1.5±0.6 (B) and 0.9±0.2 (C).

It was shown that earthworms are suitable as sole animal protein source in plant-based supplemental feeds for common carp under semi-intensive pond management. At an inclusion rate of 20 % of earthworm and financial input of 0.3 € kg^{-1} feed, a household could produce 56(min)–165(max) of feed. As the FCR in this experiment was 0.9, the potential additional fish yield would be 50–149 kg of common carp with a net profit of 83–249 € year^{-1} and household (average income of 156 € per capita and year). Consequently, earthworms as a feed ingredient for common carp may open the possibility for farmers in rural areas to engage in semi-intensive aquaculture.

Keywords: Common carp, earthworm, fishmeal replacement

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Common Use and Collapse of a Natural Resource in West Africa: The Fishery in Benin

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The common use of natural resources is a general practice in developing countries. They include rangelands, forests and water bodies. The livelihood of many fishermen worldwide depends essentially on the availability and accessibility of fish in a lagoon. A clear agreement of usage rules and an efficient regulation are necessary to avoid overusing these resources. Only an efficient regulation assure the sustainability of the resource.

The regulation of commons in sub-Saharan-Africa was the task of traditional authorities, but at present more and more of the modern administration. In this transformation phase, the concurrence between two categories of stakeholders with different rationalities decreases their engagement and causes crisis, which endanger the value of the resource. This problem was analysed using the example of Lake Ahémé in Benin, where the fishery collapsed, due to an increasing erosion of regulation and rising anthropological pressure.

The study is based upon literature and empirical research in 2011. With an ethnological approach as basis, primary data were collected in five villages of the municipalities Kpomassé and Comé (South Benin) on the causes of the decline of fish stocks in Ahémé lake. In addition, secondary data from available literature and official statistics were analysed. The adaptation processes of fishermen from Lake Ahémé were analysed and some scenarios were tested based on the current situation.

The study should provide the Administration of Fishery in Benin with a decision aid for a possible sustainable management of fisheries in Benin, in order to mitigate the problems and to increase the resilience of the lagoon fishery system in Ahémé lake.

Keywords: Benin, commons, lagoon fishery

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Effect of Dietary Levels of Decorticated Cowpea (*Vigna unguiculata*) Supplemented with Molasses on Broiler Chicks Performance

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This study was conducted to determine the effect of different levels of dietary decorticated cowpea (*Vigna unguiculata*) seeds supplemented with molasses on broiler performance. A total of 240 unsexed one-day old broiler chicks (Ross 308) were used. The birds were randomly divided into six equal groups, with 8 replicates each (5 birds per replicate) in a completely randomised design with factorial arrangement. Six experimental diets (each starter and finisher) were formulated to be approximately isocaloric and isonitrogenous to meet the nutrient requirements for broiler chicks. Three levels (0 %, 10 %, and 20 %) of cowpea with two levels of molasses 0 %, 3 % were used. The feed and water were provided *ad libitum*. Feed intake and body weight were recorded weekly. The experiment lasted for 6 weeks.

The results showed that the inclusion of decorticated cowpea seed at 10 % or 20 % without molasses significantly ($p < 0.05$) improved final body weight and total weight gain at finishing period, whereas the addition of molasses at 3 % significantly decreased final body weight and total feed intake. The inclusion of 10 % cowpea in the diets significantly improved feed conversion ratio and protein efficiency ratio, compared with control. Inclusion of 10 % and 20 % decorticated cowpea in the diets without molasses were significantly ($p < 0.05$) better than the other treatments.

Broiler chicks can tolerate inclusion of 20 % cowpea seeds with positive effects on growth performance. Inclusion of high level of molasses in cowpea seed diets has negative effect on broiler chicks' performance. It is recommended to further study the economic value of using cowpea in broiler diets.

Keywords: Broilers, cowpea, molasses

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The Effect of β-glucanase Inclusion in Sorghum Based Diet on Performance of Broiler Chicks

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An experiment was conducted to study the effect of supplementation of commercial enzyme 1,4-β-glucanase (Burgzyme C) on broiler chicks performance, weight gain, feed conversion ratio, internal organs weights, serum total protein, glucose and cholestrol.

One hundred and thirty two birds one day old broiler chicks (Ross)were used in the present study, in a complete randomised design. Birds were distributed into three groups (44 birds per group) with four replicates (11 birds per replicate). Three levels of enzyme 1,4 β-glucanase (Burgzyme C) were used 0.0, 0.125 and 0.25 g kg $^{-1}$ feed with sorghum and groundnut basal diet (A. B and C), respectively. The parameters measured were feed intake, body weight, feed conversion ratio dressing percentage, relative weight of internal organs and some blood parameters cholesterol, glucose and total protein. Feed intake and weight gain recorded weekly for each group. Statistical analysis were based on the pen as replication unit, with four replication per treatment. Data was analysed using computer pograme SPSS and means were seperated by the Duncan method.

The results indicated that inclusion of the β-glucanase enzyme significantly($p < 0.05$) decreased total feed intake and significantly ($p < 0.05$) improved weight gain and feed conversion ratio of broiler chicks. β-gluconase supplementation had no effect on dressing percentage. However, weight of abdominal fat and weight of the internal organs (liver, spleen, gizzard and intestine) were significantly ($p < 0.05$) decreased affected by treatment. Enzyme treatments had no effect on blood glucose and total protein but significantly ($p < 0.05$) decreased serum cholesterol. From the present study result using sorghum basal diet, so its recommended to add 0.25 g β-glucanase per kg feed to starter broiler diet.

Keywords: β-glucanase, broiler, cholesterol

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Effects of Soyabean Oil and Garlic-in-Water Supplementation on Performance, Carcass Traits and Blood Indices of Broiler Chicken

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Influence of soyabean oil and garlic (*Allium sativum*) dissolved in water on the performance, carcass characteristics and haematological variables of broiler chickens was assessed. A total of 160-four-weeks old Harbor strains of broiler chickens were allotted to 4 dietary treatments with 10 birds in each nof 4 replicates. A 2×2 factorial experimental arrangement of a completely randomised design was adopted. There were 2 finisher diets (non-soyabean oil and soyabean oil diets) supplemented with or without garlic in drinking water. The soyabean oil diet contained soyabean oil at $2\,kg$ per $100\,kg$ of feed and garlic supplementation in water was at $1.8\,g$ garlic L^{-1}. The study lasted for 4 weeks during which performance indices, water intake and apparent crude protein digestibility were measured. At the end of the feeding trial, 2 female chickens per replicate were sacrificed to evaluate the carcass characteristics, haematological variables and serum cholesterol. Final live weight (FLW) and total weight gain (TWG) of the birds were significantly ($p < 0.001$) affected by the dietary treatments with birds on the non-garlic supplementation consistently having higher values than those fed on garlic supplemented diets. Also, broilers fed on the soyabean oil-based diet had significantly ($p < 0.001$) higher FLW and TWG than those fed the non-soyabean oil diet. However, the FCR values of birds fed soyabean oil-based diet (2.46 and 2.54) were lower than those fed non-soyabean oil-based diet (2.56 and 3.01) for non-garlic and garlic-in-water supplementation, respectively ($p > 0.05$). Total water intake of birds fed supplementary garlic ($5.6\pm0.02\,L$ bird^{-1}) was significantly ($p < 0.05$) lower than those on non-garlic supplementation ($5.9\pm0.31\,L$ bird^{-1}). The carcass characteristics, relative weight of organs, haematological variables and the serum cholesterol concentration of the chickens were not significantly different between treatments ($p > 0.05$). Garlic-in-water supplementation numerically reduced abdominal fat deposition from 19.5 ± 5.85 to $18.7\pm8.74\,g\,kg^{-1}$ live weight. Similarly, addition of soyabean oil to diets and garlic-in-water supplementation lowered ($p > 0.05$) serum cholesterol level (140.9 *vs* 136.6; 145.8 *vs* 130.4 mg dl^{-1}). It was concluded that the supplementation of soyabean oil in the diet could lead to better broiler performance, and garlic-in-water reduces the abdominal fat deposit with a concomitant serum cholesterol reduction.

Keywords: Broilers, cholesterol, garlic, performance, soyabean oil

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Influence of Bitter Leaf and Ginger Supplementation on Growth and Haematological Indices of Broiler Chickens

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The increasing concern regarding anti-biotic resistance has elicited alternative usage of other substances including essential oils, herbs and spices, such as bitter leaf and ginger. This study was conducted to assess the effect of dietary supplementation of bitter leaf and ginger on growth performance, carcass, haematological and serum biochemistry of broiler chickens. Three hundred and twenty (320) one-week old Anak 2000 broiler chicks were divided into four equal groups and were randomly allocated to four dietary treatments in five replicates each. Four diets were formulated to meet the nutrient requirments for the two brioler phases. Diet 1 served as the control containing no test ingredient, while diets 2, 3 and 4 contained 0.25 % of bitter leaf, ginger and a mixture of bitter leaf and ginger, respectively. Results showed that the final live weight and feed intake did not differ significantly ($p > 0.05$). Birds fed the control diet were better ($p < 0.05$) in terms of daily weight gain (90.0 *vs* 80.1, 85.4 and 81.3 g bird^{-1}) and feed conversion ratio (2.24 vs 2.53, 2.33 and 2.49) when compared to the test diets. Mortality was significantly ($p < 0.05$) reduced among the chickens fed on bitter leaf and ginger diets. The range was 0.48 % in diets 3 and 4 to 1.68 % in the control. Dressed weight, eviscerated weight and abdominal fats were significantly higher ($p < 0.05$) in the control diet than in the test diets. Relative weights of other carcass cuts were statistically similar. Birds fed diets 2 and 3 had superior ($p < 0.05$) haemoglobin content, packed cell volume and red blood cell values. Total cholesterol decreased significantly ($p < 0.05$) in the bitter leaf and ginger diets with values decreasing from 2.50 mg per 100 ml in control diet to 1.60 mg per 100 ml (36 % decrease) in diet 3. Creatinin and serum total protein were significantly higher in the bitter leaf and ginger diets. It could be concluded from the study that bitter leaf and ginger meals supplementation of diets can enhance growth and good health in broiler chicken.

Keywords: Bitter leaf, broiler chickens, ginger, haematology, performance

Modelling Heat Stress Characteristics on Layers' Performance Traits in Southwestern Nigeria

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A hot environment is an important stressor affecting poultry production in tropical and sub-tropical regions. Thus, the effect of high ambient temperature and resultant heat stress on the performance of commercial egg-laying stocks, need to be studied. Data on two strains of layer chickens (Isa Brown and Bovan Nera) were obtained from farm records of Funtuna Farms, Ogere- Remo, in Southwest, Nigeria. Performance traits include age at point of lay, mortality pattern and egg-laying performance. Climatic variables include temperature and relative humidity from which temperature-humidity index (THI) was derived. The THI was grouped into 3 classes: <26, 26–29, and >29 to show the degree of heat stress variation in the chicken houses the birds were exposed to. Effect of threshold of heat stress levels and the associated rate of decline in egg production and mortality were estimated. Egg-laying records of 4,000 pullets on each strain were analysed to quantify the effect of heat stress function in a fixed effect model on performance. Effect of heat stress, genotype, and age of layers on production efficiency, were studied.

Results revealed that egg production was significantly affected by genotype ($p < 0.05$), THI and age of birds ($p < 0.001$). Hen-housed egg production for Isa Brown and Bovan Nera were 4.98 ± 0.21 and 5.20 ± 0.21 per hen per week respectively. There was however, significant effect ($p < 0.001$) of THI on production. The heat stress function developed showed a threshold at THI$= 27.5$ and the associated rate of decline were 0.35 eggs per unit increase in THI (egg production$= -0.35$THI $+ 6.3$). Bovan Nera recorded lower rate (0.32 eggs THI^{-1}) as against Isa Brown (0.37 eggs THI^{-1}). Further, significant effect ($p < 0.001$) of heat stress was recorded on mortality. Isa Brown recorded higher mortality (24.19 ± 1.25) per month of lay than Bovan Nera (14.46 ± 1.25).

In conclusion, the production performance of the two strains (IB and BN) was influenced by heat stress, genotype and age of bird. There exists variability in heat tolerance among the strains and temperature-humidity index (THI) can be used to account for the effects of heat stress on production performance of commercial layers in humid tropics.

Keywords: Heat stress, layers, performance traits

Leaf Composite Mix as Alternative Premix to Commercial Premix in Broiler Finisher Diets

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The main objective of this study was to produce alternative but farmers' friendly premix from a composite leaf mix to replace high input commercial premix in broiler diet. Consequently, fresh leaves of *Moringa oleifera*, *Ocinum gratissimum*, *Manihot esculenta*, *Telfaria occidentalis* and *Vernonia amygdalina* were harvested, air-dried, ground and analysed for their micro-mineral and vitamin contents. Thereafter, they were mixed in equal proportion into a composite mix and used to replace broiler commercial premix in a 4-week feeding trial at 0, 1, 2, 3, 4 and 5 % in place of 0, 20, 40, 60, 80 and 100 % reduction levels of commercial premix, respectively. Three hundred 4-week old Abor Acre broilers were randomly allotted at 50 chicks per treatment of 5 replicates using growth, haematological indices, serum metabolites and cost implication as response criteria. The leaves contained adequate micro-minerals and vitamins in different proportions. Of the growth indices measured only the total feed intake (TFI) was significantly ($p < 0.05$) affected with birds on the control having significantly ($p < 0.05$) higher TFI (137.7 g d^{-1} bird^{-1}) than those fed on 2, 3 and 4 % leaf composite-based diets (128.1–134.6 g d^{-1} bird^{-1}). Though the total weight gain (TWG) was not significantly ($p > 0.05$) different, the TWG of birds fed on 1, 3 and 5 % leaf composite mix diets were numerically higher than those fed the control diet with a concomitant higher feed conversion rate (FCR; 1.3–3.9 %). Birds fed on leaf composite mix diets had significantly ($p < 0.05$) lower cholesterol and creatinine than those fed the control diet while total protein and globulin, though significantly ($p < 0.05$) affected, did not follow a particular trend. All the haematological indices were significantly ($p < 0.05$) affected but did not follow a particular trend. The % cost reduction increased progressively with increased inclusion of leaf composite mix in the diets. Conceivably, within the limit of this study, the replacement of commercial broiler premix with the composite mix made from the leaves under study could help to reduce dependence of broiler farmers on importation of conventional premix in developing countries.

Keywords: Broiler, composite leaf premix, leaves, performance, premix

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Performance, Digestibility and Carcass Characteristics of Broilers Fed Graded Levels of Fermented Cassava Tuber Wastes

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Two cassava tuber wastes (CTW), namely cassava peels (CAP) and cassava starch residues (CSR) were subjected to solid substrate fermentation using a consortium of micro-organisms (*Lactobacillus delbrueckii*, *Lactobacillus coryneformis* and *Aspergillus fumigatus*), in order to improve their nutritive quality and reduce their levels of anti-nutrients. The microbially fermented (MF) products from the two wastes (MF-CAP and MFCSR) were thereafter used at varying levels to formulate seven standard broiler diets designated as Diet 1 (0 % CTW), Diet 2 (20 % MFCAP), Diet 3 (40 % MFCAP), Diet 4 (60 % MFCAP), Diet 5 (20 % MFCSR), Diet 6 (40 % MFCSR) and Diet 7 (60 % MFCSR). Two hundred and ten day-old broiler chicks were randomly allotted to the seven treatment diets. The chicks were fed with these diets for eight weeks. Growth performance, apparent nutrient digestibility and carcass parameters of the broiler birds were used as response criteria.

The results showed that the final body weight and total weight gain were similar ($p > 0.05$) among the treatments. Total feed intake per bird increased with increase in the dietary level of MFCAP while it decreased with increasing level of MFCSR. Crude protein digestibility improved significantly (86.5 %) in the 60 % MFCSR diet. The dressing percentage ranged from 73 % in the 60 % MFCSR diet to 85 % in the 20 % MFCAP diet. Carcass morphometry revealed that the breast, drumstick and thigh were not significantly ($p > 0.05$) affected when the two fermented wastes were used up to 40 % level for MFCAP and 20 % for MFCSR. Since the final live weight, total weight gain and the choice portions of the carcass were not significantly affected, these wastes could be utilised for broiler birds at those levels of inclusion without any adverse effects on their performance and carcass characteristics.

Keywords: Chicken, cassava wastes, digestibility, fermentation, growth performance, dressing percentage

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Effects of Egg Weight on Chick Weight and Post Hatching Growth Performance of Japanese Quail (*Coturnix coturnix japonica*)

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The study determined the effects of egg weight on chick body weight and post hatching growth performance of Japanese quail (*Coturnix coturnix japonica*). A total of 2575 eggs were collected and were categorised into 3 weight groups as light (<10 g), medium (10–12 g) and heavy (>12 g). Egg weight (EW), egg length (EL), egg circumference (EC), shank length (SL) and body weight (BW) were measured on the egg groups. The data was analysed using PROC MIXED of SAS 2003. Percent fertility, hatchability, hatch and rearing mortality were estimated and compared over 3 egg groups using GLM procedure. The result showed that the effect of egg weight on chick weight was significant ($p < 0.001$) for the medium and heavy group. The chick weight at hatch in light, medium and heavy group was 8.75 g, 11.19 g and 13.14 g. High positive correlation was observed between BW and SL, indicating that an improvement in BW would lead to an improvement in SL and vice versa. There was a progressive increase in BW and SL with increase in age in all groups. Positive correlation was obseved between egg size, chick weight and growth performance traits. There were also significant differences ($p < 0.001$) between the egg weight groups with regards to hatching. Hatchability was 58 %, 90 % and 76 % respectively, being highest in the medium weight group. This group also had the highest fertility (94.6 %) and lowest rearing mortality (1.5 %). In conclusion, medium sized eggs (10–12g) lead to better hatchability, fertility and good quality of day-old chicks with better post hatching performance.

Keywords: Chick weight, egg weight, Japanese quail, post hatching

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A Comparative Study of two Fish Culture Systems on the Haematology and Growth of a Tropical Freshwater Fish

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The haematological and growth parameters of the African mud catfish *Clarias gariepinus* (Siluriformes: Clariidae) raised separately in 'in-door concrete' and 'out-door earthen pond' systems for a period of 12 months at the fish farm of the Department of Environmental Biology and Fisheries, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria were assessed in this study. The water quality of the two rearing systems was also studied on a weekly basis. Blood samples were collected from five males and five females each in indoor concrete pond and outdoor earthen pond by puncturing the caudal peduncle with heparinized plastic syringe. The values of haematological parameters were measured using standardised and approved methods. The results from this study revealed that there were no statistical differences ($p > 0.05$) in the blood parameters: packed cell volume (%), red blood cell ($\times 10^9$ g dl^{-1}), lymphocyte (%), haemoglobin (g/dl), thrombocyte (%), white blood cell count ($\times 10^9$ g dl^{-1}), mean corpuscular volume (fl), mean corpuscular haemoglobin (pg) and mean corpuscular haemoglobin concentration (g/dl) of the catfish raised in in-door concrete and earthen pond systems, except in the values obtained for neutrophils which exhibited significant variations ($p < 0.05$). The results obtained in the study also showed that there were significant differences ($p < 0.05$) in the reservoir water parameters: temperature (°C), dissolved oxygen (mg/L), salinity (%), conductivity (S m^{-1}), total dissolved solids (ppm) and nitrate (ppm) of the two rearing systems, except the values of pH, nitrite (ppm) and total hardness (ppm) which showed no statistical difference ($p > 0.05$). The study showed that the fish population in the in-door concrete reservoir showed higher growth rate than in out-door earthen pond. It is recommended that intensive in-door concrete fish culture should be encouraged in order to reduce pressure on land and deforestation usually associated with earthen pond construction.

Keywords: Concrete pond, earthen pond, fish culture, fish growth, haematology, water quality

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Jatropha curcas Kernel Meal as a Protein Source in Aquaculture Diets

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Fish feed price and availability are the main limiting factors in many tropical aquaculture ventures. There is consequently a continuous effort to make fish feed affordable to farmers in these regions. One of the reasons for the high prices of fish feed is the contained fishmeal. For years now, research has been undertaken to lower the fishmeal content of fish feed without lowering its protein content using plant-based feedstuffs. A new option in this respect could be *Jatropha curcas* kernel meal (JKM), which is a by-product of Jatropha production for the biodiesel industry. The meal is high in protein content and has a promising essential amino acid composition that is similar to the one of fishmeal. Also, due to the growing interest in biodiesel and therefore Jatropha, it might soon be readily available in a number of tropical countries. Procedures for detoxification of phorbol esters from *Jatropha curcas* kernel meal have been developed recently; however, a relatively high content of phytate remains. Commercially available phytase products split phytate into sugar and phosphates, however, it is unclear whether these are effective under the pH and temperature conditions of the fish gut, especially in carp (*Cyprinus carpio*), which do not have a stomach and therefore no acidic conditions. A possible solution to the problem is pre-incubating JKM with phytase in conditions suitable for the enzyme (pH 4.5; 45°C).

In this study, carp were fed five different diets: J100: Fishmeal was replaced 100 % by JKM; J50: Fishmeal was replaced 50 % by JKM; J100Inc: Fishmeal was replaced 100 % by phytase-incubated JKM; J50Inc: Fishmeal was replaced 50 % by phytase-incubated JKM; Control: No fishmeal was replaced. Results showed that feed conversion ratios (FCR) of diets containing 100 % JKM were significantly worse than all other diets (J100: 2.4±0.51; J100Inc: 2.6±0.57). Diet J50Inc (1.2±0.12) showed significantly better FCR than diet J50 (1.5±0.15) and was not significantly different from the control diet (1.2±0.16). These results suggest that at least 50 % of fishmeal may be replaced by JKM, if the JKM is phytase-treated before adding it to the diet.

Keywords: Aquaculture, carp, fish feed, *Jatropha curcas*, phytase, phytate

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Effect of Oil Bean Meal Diets on Hematology and Histology of African Catfish (*Clarias gariepinus*)

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A 56-day feeding trial was conducted to evaluate the effect of oil bean seed meal (*Pentaclethra macrophylla*) on the histology of intestinal mucosa and hematology of *Clarias gariepinus*. Oil bean meal (OBM) was included in the diets to substitute fishmeal at various levels (5 %, 10 %, 15 % and 20 %) in diets 2, 3, 4 and 5, respectively. Diet 1 formulated with fishmeal and containing no OBM served as control. All diets were made iso-nitrogenous and iso-energetic at a mean crude protein concentration of 41.1 ± 0.12 % and gross energy content of 16.9 ± 0.04 /kJ g^{-1}. The experiment was carried out in triplicate tanks containing 15 fish each (mean initial weight: 77.4 ± 1.02 g). Fish were fed 3 % of body weight per day in two portions. At the end of experiment, highest mean weight gain of 155.7 ± 2.04 g per fish, relative growth rate of 187 % and specific growth rate of 1.88%/day were recorded in fish fed the control diet. The feed conversion ratio (FCR) for control (1.5 ± 0.12), diet 2 (1.6 ± 0.28) and diet 3 (1.9 ± 0.31) were not significantly different. Diets 4 and 5 however performed badly. In comparison with the control, growth response became lower as higher levels of heat-treated OBM were included in the diets. The histological examination of *C. gariepinus* intestinal mucosa indicated that fish fed the control diet remained normal. However, progressive damage to epithelial mucosa of *C. gariepinus* was observed with increasing dietary levels of OBM. While fish fed diet 2 showed minor degeneration of the intestinal mucosa, those fed diet 5 showed severe damage. Results of the hematology showed that the haematocrit (PCV), red blood cell count, white blood cell count and haemoglobin concentration were not significantly ($p > 0.05$) different among the fish receiving different treatments. They were however poor relative to the control. The poor haematological values and damages to the intestinal mucosa of fish fed diets with OBM might be due to the presence of higher levels of heat stable anti-nutrients coupled with non-starch polysaccharides. Results of this study indicate that including OBM in diets of *C. gariepinus* beyond a 5 % level may undermine fish growth and bring about histological deformation of intestine mucosa.

Keywords: Alternative protein sources, fish meal, *Pentaclethra macrophylla*

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Small-Scale Cooperative Based Aquaculture in Katahr, Nepal

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In spring of 2000, the project "Women in Aquaculture in Nepal" began in Kathar village in Chitwan, Nepal, initiated by the Asian Institute of Technology (AIT), Thailand, and the Aquaculture Development of Tribhuvan University, Institute of Agriculture and Animal Science (IAAS), Nepal. The project was created in consideration of the following goals: to increase the limited availability of consumable protein in rural families, to create additional income for households through sales of raised fish and to empower women. In its early stages, the project was accompanied by multiple workshops that trained local women in successful aquaculture methods. Additionally, 26 fish ponds of varying sizes were constructed and stocked with Nile tilapia (*Oreocromis niloticus*) and carp species (*Cyprinidae* spp.). External assistance was given to the farmers until May 2002 at which point the community was largely left to manage the fish ponds on their own as a cooperative. In 2011, 106 households with 121 fish ponds were involved in aquaculture production. The upward trend in growth and participation in aquaculture in this region suggests that more households are likely to participate. For the study, a *status quo* analysis and its impact on ethnic women in resource-poor communities was conducted through quantitative and qualitative interviews carried out in Kathar over a four month period. The presence of household fish ponds has been recognised to be beneficial to human health, because it enriches the diet by providing fish protein to the local population, and on family income, when the fish is sold on the local market, generating extra revenue which can be used to purchase additional food items.

As the project has been very successful in achieving the intended goals, the Nepalese government along with varying NGOs started to heavily promote and support the project. Currently, more research is taking place to find out if the implementation of similar projects in different areas might be as successful as the project in Kathar. Thus, rural small-scale aquaculture in Nepal is likely to expand and contribute to women empowerment, food security, income generation, employment and the country's overall economic development.

Keywords: Carp species, ethnic groups, food security, fish ponds, Nile tilapia

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Management Strategies Employed by Small Scale Shrimp Farmers in the Philippines in Coping with Economic Crises due to Shrimp Diseases

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The Philippines is an archipelago of more than 7000 islands. Aquaculture is a source of income for Filipinos. Before the 1970's, aquaculture in the Philippines was synonymous with milkfish culture. The success of a trial shipment of tiger shrimp, *Penaeus monodon*, an incidental species in brackishwater milkfish pond, to Japan lured businessmen to go into *P. monodon* monoculture. More ponds were dug, sugarlands and ricelands were converted to *P. monodon* ponds. Stocking densities increased through the years. More aquaculture products were introduced resulting to the deterioration of the pond environment and consequently to shrimp diseases and to bankruptcy of most shrimp farmers especially those with low capital. This paper describes how smallholders cope with economic crisis due to shrimp diseases.

A structured questionnaire type of survey was employed to gather data. The interview was done from March-June 2011. Corporate operated shrimp farms that practiced intensive or semi-intensive shrimp monoculture were not included in the survey. Respondents were owners of a total of 252 family-owned shrimp farms in the top six *P. monodon* producing provinces of the Philippines. Only 16 shrimp pond owners were into *P. monodon* monoculture, of which 13 were into semi-intensive (stocking density (SD) = 20–25 m^{-2}) while 3 were into extensive farming (SD>10). The majority of the farms (236) had reverted to milkfish monoculture or polyculture of shrimp with either milkfish, tilapia or crab. To increase shrimp survival, shrimp were usually stocked in net enclosures for 2–3 weeks before release into the rearing pond instead of direct stocking practised in semi-intensive or intensive *P. monodon* culture. Some farmers fed the shrimp with commercial pellets in the first month only compared to pellet feeding during the whole production cycle in intensive holdings. Most farmers relied on naturally grown food such as lumut and lablab (*Lablab purpureus*) as shrimp feed. Percentage return on investment of the different shrimp farming systems: polyculture, milkfish monoculture, semi-intensive shrimp monoculture, and extensive shrimp monoculture will be compared and advantages and disadvantages of the different farming systems will be discussed.

Keywords: Farming system, shrimp

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Growth Performance of Rabbits Fed *Telfaria occidentalis* and *Centrocema pubescens* as Protein Supplement

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Eighteen mixed bred weaner rabbits (average initial weight $950 - 1366$ g) were used to investigate the nutrient potential of and growth responses of weaner rabbits to *Centrosema pubescens* and *Telfaria occidentalis* (Ugu). The forages were cut, air dried and milled. Three experimental diets (protein concentrate) were formulated based on maize, soybeans, bone meal, vitamin premix, lysine, methionine, salt and wheat bran. Diet T1 contained no forage and 20 % protein concentrate; diet T2 contained 5 % *Telfaria occidentalis* and 15 % protein concentrate, and T3 contained 10 % *Centrosema pubescens* and 10 % protein concentrate. The animals were randomly distributed to the three diets. The feed was weighed each day before it was administered and it was fed *ad libitum*. Weight gained was recorded once every week in all treatments. Feed-gain ratio was also evaluated every week. The experiment lasted for six weeks. Data obtained were subjected to analysis of variance. The highest final weight (1916 g) was observed in T1 though similar to T3 (1850 g) and T2 (1500 g). Average daily weight gain was 21 g, 13 and $12\,\mathrm{g\,d^{-1}}$ in T1, T2 and T3, while the feed/gain ratio was 1.75, 2.79 and 4.60 for the 3 treatments, respectively. The difference between the treatments was significant ($p < 0.05$). The feed intake averaged 42.8, 36.3 and $53.0\,\mathrm{g\,d^{-1}}$ for treatment T1 , T2 and T3. The result revealed that *Telfaria occidentalis* could better serve as a protein supplement to rabbits than *Centrocema pubescens* and should be recommended.

Keywords: *Centrocema pubescens*, protien supplementation, rabbits, *Telfaria occidentalis*

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Evaluation of Growth Indices, Dry Matter Digestibility and Economic Implications of Feeding Rabbits with Millet Offal

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A 56-day feeding trial was carried out to evaluate the potential of replacing maize in the diets of rabbits with millet offal, an agricultural waste, on the performance indices and cost benefit of growing rabbits. Fifty growing rabbits of cross breeds and mixed sexes were allotted to five dietary treatments of 10 rabbits per treatment in a completely randomised design. A rabbit was taken as a replicate. Millet offal was used to replace maize grain at 0, 25, 50, 75 and 100 % in diets 1, 2, 3, 4 and 5, respectively. The response criteria included growth indices, carcass cuts, haematology, serum metabolites, apparent digestibility and economic benefit. The final body weight of 1.72–1.81 kg and total weight gain of 0.99–1.04 kg of rabbits on the control diet was not significantly ($p > 0.05$) different from those fed the millet offal diets. The total feed consumption was significantly ($p < 0.05$) affected by the dietary treatment with rabbits fed the control diet having the highest value (4.02 kg) and rabbit fed the 75 % millet offal diet having the lowest value (3.31 kg). Compared with the control group, rabbits fed on 25–100 % millet offal diets had an improved feed converion ratio of 10.5, 12.5, 17.5 and 18.3 % over those fed the control. The apparent digestibility values suggested that millet offal could be tolerated by rabbits even up to 100 % (*i.e.* 47.46 g per 100 g in the gross feed composition) inclusion level, as this level considerably decreased cost of feed per kilogram weight gain and improved relative cost benefit by up to 52.3 %. The slaughter weight, fasting loss and carcass 'fast cuts' were not significantly different b etween groups ($p > 0.05$). Of the entire haematological variables measured, only the WBC, MCH and MCV were significantly ($p < 0.05$) influenced by the test diets; increased serum protein and blood glucose and decreased total cholesterol were observed in the animals fed on 50–100 % millet offal diets. Thus, replacing maize with millet offal could lead to better affordability of rabbit meat by resource poor people, better animal protein production/consumption and ultimately improved savings of rabbit farmers.

Keywords: Digestibility, economic implications, maize, millet-offal, rabbit

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Vitamin E Ameliorates the Effect of Dietary Fumonisin B1 on Growth Performance of Female Rabbits

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The economic consequences of mycotoxin contamination are profound, and exposure of humans and livestock to mycotoxin-contaminated food is particularly a serious problem in the tropics. Various nutritional strategies have been proposed to alleviate the adverse effects of mycotoxins on livestock. In this study, 49 young female adult rabbits were used to evaluate the ameliorative potentials of an antioxidant, vitamin E, against the growth-depressing effect of fumonisin B1 (FB1) – an environmental mycotoxin produced by *Fusarium* moulds, on animals. The animals were randomly assigned to the control diet without FB1 and six diets containing different concentrations of dietary FB1 and/or Vit E (*i.e.* 0.25 mg FB1, 0.5 mg FB1, 0.75 mg FB1, 0.25 mg FB1 + 100 mg Vit E, 0.5 mg FB1 + 100 mg Vit E, and 0.75 mg FB1 + 100 mg Vit E) for 28 days. The weight changes of the rabbits generally decreased significantly ($p > 0.05$) with increase in the dietary FB1 concentration, and the potential of the antioxidant to balance the effect of the toxin on the animals also decreased with increase in the dietary FB1 concentrations. The weight gains by the animals fed diets containing FB1 were about 26–33 % of those of the control, while those fed diets containing FB1 and Vit E had 43–87 % of those on the control. The antioxidant also improved the feed efficiency of the animals over those fed diets containing varied concentrations of FB1. Therefore Vit E at 100 mg kg^{-1} of feed is recommended as a nutritional supplement to alleviate the growth-depressing effect of FB1 in rabbits.

Keywords: Mycotoxin, performance, rabbit, vitamin E, *Fusarium* toxin

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The Welfare of Working Horses in Northwest Nigeria and Their Impact on the Local Economy

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Working horses are used for ridden work, draught and pack worldwide. A few horses-power mills for crushing sugar are still operating in small scale in Kaduna, Kano and Katsina, Northwest Nigeria. Therefore, it has become imperative to assess the welfare and economic benefits of these animals, especially in a situation where high animal welfare tends to have direct economic benefits. This study generated data via an on-the-spot assessment form and a pre-tested questionnaire administered to respondents in Kaduna, Katsina and Kano States in 2012. A number of factors where assessed namely legal responsibilities, grazing, housing, feeding, husbandry practices, estimated work intensity, income generation, labor requirement, quantity and cost of natural forage and concentrate. A total of 30 facilities where purposely selected across the 3 states. Majority (80 %) of the working horses were the Nigerian breed of horses, a member of the group also known collectively as West African barb or West African Dongola. About 90 % of the facilities fell short of the minimum standard requirement for the welfare of horses. 60–75 % of their income was derived from selling the brown sugar powered by the horses and hiring out of horses for various traditional festivities. Under these circumstances decisions about horse welfare may be strongly influenced by a lot of factors among which could be, the economic benefit of the horse to the owner. In this regard assessing the welfare and economic value of these working horses will help us to re-focus our attention on the welfare of the horse rather than on performance criteria. These working horses are contributing to the sustanance of the local economy of these communities but are to some extent subjected to conditions beyond their physiological limits. Considering the components of the values of sales derived, it is not surprising that horses and the brown sugar consistently remain one of the significant agricultural commodities and represent a small but significant portion of the total economy of the three nortwestern states studied. In conclusion, there is a need to educate owners on ways to identify animal welfare issues especially using basic health and behavior parameters.

Keywords: Economic benefit, animal welfare, working horses

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Evaluation of the Chemical and Phytochemical Constituents of *Alchornea cordifolia* Leaf Meal as Potential Feed for Monogastric Livestock

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Phytochemical constituents, proximate and mineral composition of *Alchornea cordifolia* (Schum and Thonn) Muell. Arg. (Euphorbiaceae)), Christmas bush leaf meal obtained from the campus of Niger Delta University were investigated in order to evaluate its nutritional value for non ruminant livestock since it is well known that the presence of antinutrients and toxic substances severely limits the nutritional benefits of leaf meals. The results of proximate analyses showed that the leaf meal contained moisture (9.96 %), crude protein (17.94 %), carbohydrate (39.53 %), crude fat (4.34 %), gross energy (3.37 MJ), ash (11.38 %) as well as crude fibre (16.85 %). Elemental analysis revealed the following minerals in the leaf meal: calcium (2.88 %), magnesium (0.22 %), potassium (7.25 mg kg^{-1}), copper (32.5 mg kg^{-1}), iron (192.5 mg kg^{-1}), manganese (58.35 mg kg^{-1}) and cobalt (40 mg kg^{-1}). Aluminium, zinc, posphorus, selenium and sodium were not detected. Detected phytochemicals in the leaf meal were phytate (1.21 %), oxalate (0.86 %), saponin (2.04 %), phenols (1.16 %), cardiac glycosides (0.11 %) and hdrocyanic acid (22.30 mg kg^{-1}) while alkaloids, anthraquinones, tannins, flavonoids and steroids were not detected. Overall concentrations of all phytochemicals were low, often the nutritional quality of plants severely limited by the presence of antinutrients (oxalate, phytate) and toxic substances (cyanide, nitrate, and phenols). The low values of these substances in *Alchornea cordifolia* indicates that the leaf meal may be recommended for non ruminant and human consumption. It contains nutrients and mineral elements that make it comparable to other leaf meals such as *Gmelina* leaf meal, *Leceunea leucocephala* leaf meal, *Ipomea batatas* leaf meal and cassava leaf meal

Keywords: Anti-nutrients, *Alchornea cordifolia*, Christmas bush, leafmeal, minerals, phytochemical screening, proximate analysis, proximate analysis

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Ruminant husbandry systems

Reproductive Performance of West African Dwarf Goat Fed with *Moringa oleifera*

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The study evaluated the reproductive performance of West African Dwarf (WAD) does fed with *Moringa oleifera* and *Gliricidia sepium* as inadequate nutrition undermines ruminants in representing their full genetic potential. A total of thirty WAD goats, consisting of twenty-five matured does and five bucks were used for this study. Using a balanced randomised design, the does were divided into five experimental treatments based on the feed combination ratio (*i.e.* 100:0 (T1), 75:25 (T2), 50:50 (T3), 25:75 (T4), 0:100 (T5) of *G. sepium* and *M. oleifera* respectively). Each treatment had five does as replicates with an average weight of 12 kg. We observed that crude protein intake (CPI) by does' was greatly influenced by levels of *M. oleifera* in their diets. This invariably enhanced the conception rate of does and Average weaning weight of kids (offspring) in treatments with higher level of *M. oleifera*. Does fed with the highest level of *M. oleifera* had 100 % conception, with conception rate decreasing as *M. oleifera* level decreases. Highest weaning weight of 4.98 kg was recorded for kids from the does fed 100 % *M. oleifera* after three months. Gestation length in does, litter size at parturition, birth weight of kids and milk uptake, among other reproductive traits assessed, were not significantly different between the treatment groups. However, the average birth weight of kids from does fed high level of *M. oleifera* was 300 g higher than their counterparts with $\leq$25 % *M. oleifera* inclusion. This indicates that improved conception rate, birth weight and weaning weight of kids can be achieved by including high levels of *M. oleifera* in the diets of WAD does.

Keywords: Browse plant, estrus synchronisation, nutrition, productivity, prolificacy

Adaptive Strategies by Pastoralists to Cope with Drought Episodes in North Kordofan, Sudan

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The northern part of North Kordofan State of Sudan is considered as a real pastoral area, dominated by camels and dessert sheep herders. As a result of the recurrent drought spells that hit this arid Sahelian area, pastoralists face multitude of challenges that trigger development of some adaptive strategies to cope with such environmental crisis. The present paper scrutinizes the adaptive strategies tailored by pastoralists in Hamrat Elsheikh Administrative Unit in North Kordofan State. It intends to develop a model for proper management of the pastoral system in the drought-stricken areas in this tate. This model is expected to resolve problems within the system as shortage of biomass and range/and species resulting from drought episodes jeopardise the natural pastures. Historical, descriptive and analytical approaches were followed via direct interviewing with questionnaires, addressing key informants randomly selected from pastoralist villages in the study area. The majority of the interviewees (61 %) quoted the main adaptive strategies that prevail in the area. These include herd mobility in search of water and pastures, keeping drought resistant animals by having a higher proportion of desert sheep, goats and camels than cattle, diversifying livestock species in favour of resilience to drought, synchronising livestock breeding time with rainy season, and herd splitting with assistance from relatives. These strategies mitigate the impact of drought on pastoralists' life in the area. Furthermore, they have also contributed very much in boosting-up livestock populations, pave the way for pastoralists to survive in the area and sustain their animal resources. However, some shortcomings were observed by pastoralists like the lack of some extension and veterinary services and lack of dispersion of seeds of range and species. In conclusion, strengthening these adaptive strategies could reduce vulnerability of pastoral resources which is key to reducing drought risks.

Keywords: Adaptive strategies, livestock, pastoralists, resilience to drought

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Fodder Production and Utilisation Patterns in Disadvantaged Areas: A Study of Eastern India

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The Indian dairy sector is characterised by an inadequate supply of fodder and lack of knowledge on feeding. The fodder scarcity affects most farmers, especially small and landless livestock keepers. It is documented that crop residues, especially rice and wheat are the main feedstuffs that supply about 44 % of the feed requirements of cattle in India. It is therefore neccessary to understand the problems in fodder production, traditional utilisation patterns and knowledge about quality of fodder, which could help farmers to utilise the local feeds in a better way for meeting the future challenges. The present study was carried out in Bihar state of India to understand production and feeding strategies of different classes of farmers, distinguishing surplus and deficit. The primary data was collected from four surplus and four deficit zones districts of Bihar. Results show that rice-wheat crop residues are common feeds and these two crops constituted more than 90 % of dry fodder production in the fodder surplus zone, whereas in the fodder deficit zone these crops constituted 78 %. Paddy straw was the most important dry fodder accounting for 67 % of sale volume; its share was higher in the surplus zone: about 72 %. Wheat straw was the second important dry fodder with respect to production and marketing. The type of fodder used also depended on the intensity of production: with increasing intensification of dairy production, the share of wheat straw being fed to dairy animals increased. However, the recent decline in the area under rice and the use of combine harvesters in rice and wheat crops, particularly in the fodder surplus zone, presents a threat to fodder availability in Bihar.

According to farmers' perception on fodder quality, short chopped straw was the most desired quality of paddy and wheat straw. Bright colour was the second important quality attributed for wheat straw, and fourth for paddy straw. Purity of fodder emerged as third important attribute for wheat and paddy straw.

Keywords: Rice straw, wheat straw. livestock productivity, quality, smallholders

The Effect of Supplementation Strategies on Productive Performance of Cows Kept under Different Husbandry Systems

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The three extensive sedentary, transhumance and migratory cattle husbandry systems were closely monitored during 365 days in the semi-arid rain fed area of Western Sudan.

In the sedentary system seven groups of cattle herders were selected, in the transhumance system three groups and, in the migratory system five groups. Supplementation groups were offered either poultry manure and molasses, or only molasses, and were compared to groups using farmers' own concentrate feed. In each group the recently calved cows were monitored for post-partum ovarian activity using milk progesterone radioimmunoassay. Days to conception were taken as non-return to estrus. Regression analyses were done for fertility parameters against body weight (BW) and body condition score (BCS) at calving, 30, 60, and 90 days after calving, as well as milk yield (MY) at 30, 60, and 90 days after calving.

The results revealed that there was a wide variation in both, days to first ovulation and days to conception in all systems. Cows in the sedentary and migratory system showed gradual increase in BW and MY from calving up to 90 days. BCS was found to decrease from calving to 60 days in all systems. Poultry manure/molasses diet as supplementation showed the best increase in MY in the sedentary system. Diets substituted with molasses alone increased MY in the sedentary and transhumance system.

It was concluded that poor reproductive performance in cows kept under extensive traditional management was due to poor management practices, which ignored high-energy supplementation during late pregnancy and early lactation, especially during the dry season when pastures deteriorate drastically. Controlled mating and suckling together with good feeding strategies may greatly enhance reproductive performance of cows kept under extensive systems of management. Fertility of cows kept under traditional extensive systems was low as indicated by long post-partum anoestrus periods and long days to conception in the majority of cows investigated. The sedentary system showed the shortest days to ovulation and conception as these farms used controlled suckling. The migratory system cows showed better fertility parameters and were in a better nutritional status than cows in the transhumant and sedentary system.

Keywords: Dairy cows, feed supplementation strategies, husbandry systems

Milk Production on Small-Scale Farms in the South of Rio Grande do Sul, Brazil

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Market liberalisation and fierce competition within the dairy sector provoked a continued decline of small-scale dairy farms in Brazil since the 1990s. However, small-scale family enterprises still prevail in southern Brazil. Therefore we studied factors influencing choice of milk marketing channel, milk production, and contribution of milk production to farm income in 200 small-scale dairy farms in the south of Rio Grande do Sul state. A structured questionnaire was administered to the randomly selected farms in summer 2010.

Factors determining choice of marketing channel were identified using logistic regression analysis. While area (ha) devoted to subsistence crops ($p < 0.001$), total pasture area (ha/cow; $p < 0.01$) and investments (Reais) in dairy production during the past 10 years ($p < 0.05$) where decisive variables on farms delivering milk to producer cooperatives, area of subsistence crops ($p < 0.001$) and cumulative years of schooling of family members ($p < 0.05$) were influential on farms selling milk to private companies. Multiple linear regression analysis showed that only the cow numbers influenced daily milk output on cooperative farms ($p < 0.001$; r^2=0.68), while cow numbers ($p < 0.001$), daily amount of concentrates offered (kg/cow; $p = 0.01$) and summer pasture area (ha/cow; $p < 0.05$) determined daily milk output (r^2=0.83) on farms selling milk to companies. Daily milk production of the individual cow depended on fodder maize area (ha/cow; $p = 0.001$, r^2=0.28) on cooperative farms, and on summer pasture area (ha/cow; $p = 0.001$) and daily amount of concentrates offered (kg/cow; $p < 0.01$) on farms selling milk to companies (r^2=0.55). The contribution of the dairy unit to overall farm income (%) was positively related to winter pasture area (ha/cow; $p < 0.01$) and negatively related to hiring of labor ($p < 0.05$) on cooperative farms (r^2=0.66), while on farms selling milk to companies only the summer pasture area (ha/cow) had an influence ($p < 0.05$, r^2=0.55) on this variable.

We conclude that irrespective of the milk marketing channel the area available for fodder cultivation is key for milk production on small-scale dairy farms in southern Brazil, while concentrate feeding plays only a secondary role even for 'business-oriented' farms. This must be accounted for when exploring options for increasing milk production on such farms.

Keywords: Companies, cooperatives, dairy cows, farm income, pasture area

Peri-Urban Cattle Production System and Herders' Feeding Strategies in the Coastal Area of Southern Benin

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Despite the increased urbanisation and the obvious shrinking of the forages resources around the major coastal cities in southern Benin, cattle farming still represents an important activity for many urban dwellers. The objective of the current study was to examine this production system with emphasis on the feeding practices and herders' adaptation strategies to cope with the changing urban/peri-urban environment. Forty-five (45) cattle farms located in the coastal belt of the cities of Abomey-Calavi and Ouidah were rapidly surveyed in October 2011 with a questionnaire designed to address the ownership of the herd, its size and breed composition, and management practices. Based on their willingness to cooperate, fifteen (15) herdsmen were then selected for more detailed interviews on their feeding strategies. Almost half (48 %) of the herds had multiple owners who were wealthy public servants or rich merchants living in the city. The animals served as wealth accumulation and were entrusted to hired herdsmen who were mainly Fulani people from Niger Republic (49 %), northern Benin (47 %) or Burkina Faso (4 %). The average herd size was 55 ± 30. Out of a total number of 2477 animals counted, 55.6 % were identified as Borgou cattle (humpless $\times$ humped), 22.2 % as crossbred between Borgou and the native dwarf shorthorn cattle (Lagune), 15.6 % as Lagune, 4.4 % as N'Dama and 2.2 % as Zebu Gudali. Sixty percent of the herds were fed exclusively on natural pasture. The remaining 40 % additionallly received crop residues. Most respondents mentioned wet seasons (61 %) and the short dry season of July to September (27 %) as the periods when forage is most available. Forage availability was also perceived as being highly affected by the expansion of peri-urban commercial vegetable gardens (98 %), climate variability (98 %), and urbanisation (71 %). While all respondents were aware of the decrease of and difficulty to access grazing areas, most of them (87 %) mentioned the disappearance of palatable forage species due to overgrazing. Splitting and moving herds in the long dry season (November-February) farther away from their permanent settlements towards wetlands and rural areas were the main adaptive feeding strategies reported by the herders.

Keywords: Cattle husbandry, coastal area, feeding strategies, urban fringe, West Africa

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Effects of Climate Variability on some Main Compounds of Milk in Iran

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Climate change is attributed directly or indirectly to human activity. It will affect animal welfare, food production and human health through its short-term and long-term impacts on all components of global and local food systems (FAO framework, 2008). In general, the projected climate change is foreseen to have a negative impact on food security, especially in developing countries.

In Iran the change and variability of climate elements in every agro-ecological regions are different. Temperature variations are commonly used to detect and quantify possible changes in climate. To assess the influence of temperature variability upon main compounds of milk the paper addresses the following points:

1) Statistical investigation of variability in milk compounds in different areas of Iran based on the observed variability of local temperatures. 2) Construction of a statistical downscaling model to relate large-scale temperature from reanalysis projects to milk compounds variability.

The aim of this research is zoning of potentially positive and negative effects of climate change on the milk components in different regions of Iran. This would allow finding an optimum scenario for minimizing negative effects of climate change on the milk components, such as changing the feed rationing of cows or changes in milk processing.

To treat the research question milk yield, fat and protein content data from individual cows (>250 cows per station) on a daily basis were gathered for whole Iran for the period 2002–2010. The data is adjusted for the period of times that cow use the natural pasture for feeding (springs & summers). Climatic data of near surface temperature was taken from stations as well as from the NASA MERRA reanalysis for the same area and period. The first result on the preliminary milk data analysis in Northwest of Iran reveals a monomodal probability density of the milk compounds. Then the simple monthly average of the individual daily data was performed. The results of a correlation analysis between the monthly mean values of milk compounds and the regression modelling between milk data set and temperature will be presented based on the NASA reanalysis MERRA to construct a downscaling model for future use.

Keywords: Climate change, Iran, milk compounds, NASA MERRA reanalysis

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The Weight of Kids and the Lactation Performance in the Mountain Goats with and without Milking during the Suckling Period

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This study was conducted in the Syrian Swida governorate (Oura Research Station) with mountain goats to investigate the weight gain of kids and the lactation performance with and without milking during the suckling period. 36 goats in their first to third lactation were used. Experimental animals were selected at the end of pregnancy and they were randomly divided into two equal groups based on their lactation numbers and body weight. The daily milk production was measured in the first group by lamb-suckling method during the suckling period (60 days) and by twice daily hand-milking from weaning to the end of lactation. In addition, the weight gain of the kids was estimated during the suckling period. For the second group, the same treatment has been applied as in the first group, only during the suckling period the milk production was determined by a combined lamb-suckling and hand-milking of the residual part of milk. Data were analysed by analysis of variance (ANOVA) for repeated measurement using the SAS programme package. The weight of the weaning kids was higher in group 2 than group 1 ($p < 0.05$; 12.1 ± 0.36 and 11.0 ± 0.34 kg kid^{-1}), respectively. The statistical analysis showed also a higher significant difference of milk production between the first and second group regarding the daily-, lactation yield and the value reached up to 0.89 ± 0.05 *vs.* 1.11 ± 0.05 kg milk day^{-1} ($p < 0.01$) and 186.8 ± 5.16 *vs.* 237.9 ± 5.92 kg milk lactation^{-1} ($p < 0.001$), respectively, while there was no significant difference of lactation length between groups 1 and 2 (209.9 ± 5.8 and 219.3 ± 5.5 days, respectively). From the above results we can conclude that the milking process in parallel to suckling can improve the daily milk yield-and the production over the whole lactation period. Consequently production of milk for sale is increased, and the increment reached in the milk yield was 27.35 % higher in the second group compared to the first group. Thus emphasise the need to use this method of rearing at the mountain goats.

Keywords: Milk production, mountain goats, suckling milk, weaning weight

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Micro-livestock Development for Sustainable Livelihoods in Cross River State - Nigeria

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In Nigeria, micro-livestock make valuable contributions to farming systems and to people's livelihoods. Because of their special value to poor households, their integration in poverty reduction activities and food security becomes imperative. Cross River State is mainly an agricultural state with about 75 % of its people engaged in subsistence agriculture. The state is also rated second highest in terms of poverty ranking within the south-south zone of Nigeria. The study therefore analysed the implications of micro-livestock husbandry as sustainable livelihood options for the poor, surveying of micro-livestock farmers in Cross River State, Nigeria. The multi-stage sampling technique was used to select a total of 170 micro-livestock farmers from the Ikom agricultural zone. The results of the study show that male and female respondents were almost equal in percentage (51 % and 49 %, respectively). The majority of the livestock farmers was less than 35 years old (69 %), and 76 % had more than 10 years farming experience. Most of the respondents (71 %) had formal education. Poultry and goats ranked high among the respondents (65 %) with flock sizes bellow 100. Only 16 % earned more than Naira 31,000 per annum. A Tobit regression model was used to analyse the effects of micro-livestock keeping on poverty reduction. Sex and household size were significant at 1 % (0.439 and 0.240). The results revealed that flock size had a negative but significant relationship with poverty (-0.038) while the type of livestock kept (0.073) and access to improved breeds (0.489) showed positive and significant relationship to poverty reduction. Education also had a significant positive coefficient of 0.670. From the foregoing, it can be concluded that micro-livestock development can help facilitate poverty alleviation in rural communities of Nigeria by increasing the income and the protein consumption of the rural people.

Keywords: Farming system, poverty alleviation, rural communities

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Production Characteristics of Tagger Goats in Southern Kordofan State, Sudan

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A survey was carried out using a questionnaire on randomly selected farmers in the eastern mountains of southern Kordofan, Sudan. The study attempted to define the phenotypic characteristics of the Tagger goats, their management practices and production potential with particular emphasis on their meat producing abilities. The mean flock size was 29 goats. Total females were 66.7 %, breeding males 7.5 % and castrates 8.0 %, with a buck to doe ratio of 1:6. Breeding was uncontrolled and kidding occurred all year round, but a peak was noticed in the wet season. Age at first kidding was 13.5 months which is older than in many African goat breeds . Average kidding interval was 7.7 months which was similar to many other African breeds. Twining rate was 57 %. The average birth weight was 1.4 kg and average mature weight was 20 kg for males and 18.5 kg for females. Mortality rate was 16.1 % in young kids and 7.9 % in adults.

The slaughter data involved twelve males and an equal number of females slaughtered at different age (young and adult). No significant differences were observed between both sexes in slaughter weight. The hot dressing percentage was not significantly different but it tended to be higher in young male kids and adult females than in young females and adult males. The total carcass muscle was greater in young females but the total carcass bone was greater in young male kids and adult female goats, while the fat content was greater in young male kids than in adult female goats. The yield of commercial cuts was generally higher in adult males than in females but the leg, the chump and best end of neck were heavier in female goats.

Keywords: Production characteristics, southern Kordofan, Sudan, tagger goats

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Effects of Increasing Levels of Quebracho Tannin Supplementation on Nutrient Digestibilities in Heifers

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Condensed tannins are known to bind to polymers such as cellulose, hamper the adhesion of rumen microbes to feed particles, and reduce the activity of microbial enzymes. This may strongly decrease fibre digestibility and hence, feed and energy intakes of animals offered diets rich in cell wall constituents. The objective was therefore to investigate to which extent different levels of Quebracho tannin extract (QTE) reduce apparent total tract digestibilities of dry matter (DM), organic matter (OM), neutral (NDF), and acid detergent fibre (ADF) in heifers.

The study comprised five experimental periods (9d adaption + 6d feces collection). Six ruminally cannulated heifers (491 ± 35 kg bodyweight) were offered a basal diet consisting of 2.6 kg d^{-1} of grass hay, 2.6 kg d^{-1} of concentrate feed, and 60 g d^{-1} of a mineral premix in two equal meals. While in the first period, no QTE was administered (control), all animals simultaneously received 1, 2, 4, or 6 % QTE of their daily DM intake during the following four periods. For this, half of the daily QTE dosage was diluted in 1 l of warm water and infused intra-ruminally during each feeding. Fecal excretions were quantified and feed and feces samples analysed for DM, OM, NDF, and ADF contents.

DM and OM digestibilities linearly decreased from 0.750 (SD 0.018) and 0.776 (SD 0.015) without QTE supplementation to 0.714 (SD 0.012; R^2=0.49) and 0.749 (SD 0.012; R^2=0.46) at a dietary concentration of 6 % QTE, respectively. The decrease in nutrient digestibilities was most pronounced for NDF and ADF with -0.023 (SE 0.004) per 1 % of QTE for both parameters (R^2=0.52; R^2=0.54). Thus, compared to the control (0.718, SD 0.024; 0.623, SD 0.039), NDF and ADF digestibilities were only 0.590 (SD 0.075) and 0.493 (SD 0.058) at 6 % QTE, respectively.

Moderate to high concentrations of condensed tannins strongly reduce total tract digestibilities of the fibrous fractions in ruminant diets which may negatively impact their feed and energy intakes. Together with the direct inhibition of rumen microbes, the lower availability of rumen fermentable substrate may furthermore reduce microbial protein synthesis and therefore amino acid supply to the animals.

Keywords: Fibre digestibility, quebracho, ruminant, tannins

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Silage of Sweet Sorghum Residues for Animal Production

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A special sweet sorghum (*Sorghum bicolor*) cultivar has a high potential as primary material for paper production, due to its agronomic and compositional characteristics. The remaining forage parts such as leaves and panicle are by-products in Colombia, useful for animal nutrition. However, what first seemed to be the principal new business opportunity for farmers with the paper industry has meanwhile changed to a secondary income, the main benefit resulting from the animal feed. The objective of this study was to evaluate ensiling as a conservation option for sorghum residues, both under controlled and simulated field conditions. *Sorghum bicolor* ICRISAT 615 was harvested at milk-ripe stage (90 d), leaves and panicles were mixed. Two treatments (molasses alone at $33\,g\,kg^{-1}$ fresh matter (FM), T1; molasses+homofermentative *Lactobacillus* inoculum, T2) × two types of packaging (vacuum sealed bags "Rostock Model Silages", Co; standard plastic bag wrapped in black garbage bag, Fi) were applied. Silages were stored for 30 d at 25°C and evaluated for their fermentation quality and aerobic stability afterwards. Silage dry matter (DM) ranged between 320 and $350\,g\,kg^{-1}$ FM. The pH was significantly lower in the Co silages independent of the treatment (pH 3.7 *vs.* 4.2), the same applied for acetic acid contents (6.9 *vs.* $11.8\,g\,kg^{-1}$ DM on average), explained by oxygen availability in Fi. Proteolysis expressed as ammonia-N from total N ranged from 89 to $106\,g\,kg^{-1}$ without statistical differences, with an original crude protein content of $103\,g\,kg^{-1}$ DM. Butyric acid content was slightly higher in FiT1 ($47\,g\,kg^{-1}$ DM) while lactic acid was lowest in this treatment ($31\,g\,kg^{-1}$ DM). Highest lactic acid content was achieved in CoT2 ($57\,g\,kg^{-1}$ DM), which is low compared to other forages and is explained by the low buffering capacity of sorghum (2.2 g lactic acid per 100 g DM). All silages were of good quality according to DLG (German Society for Agriculture) criteria, but showed to be prone to aerobic deterioration indicated by pH increase after 7 d and yeast infestation, except for FiT2, which was least affected. Thus, ensiling offers a good option to preserve sorghum residues provided an adequate silo size.

Keywords: Additives, leave, panicle, silage quality, *Sorghum bicolor*

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Accelerating CBPP Research Towards a Better Vaccine through the Application of Genome Transplantation

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Contagious bovine pleuropneumonia (CBPP) caused by *Mycoplasma mycoides* subsp. *mycoides* (Mmm) is one of the most important livestock diseases in sub-Saharan Africa. CBPP impacts health and poverty of livestock-dependent people through decreased animal productivity, reduced food supply, and the cost of control measures. Additionally, CBPP is a barrier to trade in many African countries and this reduces the value of livestock and the income of many value chain stakeholders.

Presently control of CBPP relies mainly on a live vaccine of limited efficacy and duration of immunity. Vaccines with better efficacy are necessary for control and eradication programmes within all African regions.

The identification of Mycoplasma target molecules for vaccines has been hampered by the non-existence of genetic tools to manipulate the pathogen's genome in a systematic way. Recently, techniques for the targeted mutagenesis of the closely related Mycoplasma species *Mycoplasma mycoides* subsp. *capri* (Mmc) have been developed as part of synthetic biology efforts. Yeast is used as a host cell for the whole Mycoplasma genome, opening up to the fast and efficient genome manipulation toolbox for yeast. Back-transplantation of the genome to Mycoplasma cells will enable the subsequent testing of targeted genes for their role in host pathogen interactions using *in vitro* and *in vivo* systems.

Targeted mutagenesis will accelerate the knowledge gain with respect to pathogenicity and host specificity and therefore vaccine development.

We are in the process of transferring the genome transplantation technology to ILRI in Africa and adapting the method to field strains of Mycoplasma mycoides subsp. mycoides. We have also started the procedure of targeted mutagenesis of putative virulence genes in the already established *Mycoplasma mycoides* subsp. *capri* model.

Keywords: Animal health

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The Impact of Management System on Sudanese Camel Calves Growth Rate

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This study aimed to investigate the effect of management system on the growth rate of Sudanese camel calves. Twenty (20) camel calves (10 males and 10 females) at the first day of birth were selected, from the Sudanese Arabi (Kababish) bred. The camel-calves with their dams were maintained under semi-intensive and traditional management systems for 18 successive months. Calves in the semi-intensive system, in addition of suckling their respective dams, received supplementation diets (one kg of concentrate/head/day), *ad libtium* watering, health care and spraying weekly against ticks and external parasites. The body weight of calves was obtained through direct weighing at birth, 6 months, 12 months and 18 months of age. The results indicated that there was no significant difference ($p > 0.05$) in birth weight of calves raised under semi-intensive and traditional system. In both systems the males (39 ± 0.31 kg) were significantly ($p < 0.05$) heavier than the females (36 ± 0.34 kg). The body weight of the calves under semi-intensive system at six, 12 and 18 months of age was 123 ± 2.2, 221 ± 2.2 and 326 ± 2.4 kg respectively, the respective body weight of camel calves under traditional system was 96 ± 1.6, 159 ± 2.4 and 208 ± 2.5 kg. With significant differences ($p < 0.01$) between systems. The overall mean daily gain of camel calves under semi-intensive and traditional system were 535 ± 9.8 g and 317 ± 5.4 g, respectively. The average daily body gain from birth to 6 months, 6 – 12 month and 12–18 months of age in semi-intensive system was 477 ± 10.9, 542 ± 8.3 and 585 ± 8.4 g d^{-1}, while corresponding values for calves managed under the traditional system were 352 ± 10.6, 272 ± 16.0 and 317 ± 5.5 g d^{-1}.

Keywords: Daily gain, management system, Sudan, supplementary feeding

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Plants and Soils

Cropping systems and environment

Domestication of Shea Tree (*Vitellaria paradoxa* C.F. Gaertn) via *ex-vitro* Propagation

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Horticultural propagation of the Shea tree (*Vitellaria paradoxa* C.F. Gaertn) is constrained by its long gestation period and long tap root of seedlings which makes transplanting very difficult. We therefore investigated the effect of heat (high temperature), Gibberillic Acid (GA3) and mechanical scarification on reduction of gestation period and seedling production in Shea. Seeds were kept in the oven at temperatures ranging from 30–60°C for 3, 6, 9 or 12 hours before sown in soil and monitored for germination. The incubation of seeds at 30°C for either 3 or 6 hours prior to sowing improved germination over the control treatment. To further improve germination, seeds were soaked in different concentrations of GA3 (0, 5, 10, 15 or 20 %) for 24, 48, 72 or 96 hours. Germination of seeds was influenced by the presence and concentration of GA3 in the soaking medium. Seeds soaked in 20 % GA3 for 48 hours resulted in the highest percentage germination, mean number of leaves and seedling height 12 weeks after sowing. However, soaking of seeds in GA3 beyond 48 hours decreased percentage germination irrespective of the concentration. Also, seeds soaked in higher GA3 concentrations developed thin, fibrous root structures compared to controls which had a long and thick tap root. Mechanical scarification of seeds involved the complete or partial removal of seed testa prior to sowing in soil. The presence or absence of the seed testa influenced radicle emergence and growth affecting days to germination. This study has shown that both heat and GA3 can enhance seedling production of Shea promoting propagation and large scale cultivation.

Keywords: Emergence, germination, gibberellic acid (GA3), seedling height, testa

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Historic and Future Winter Chill for Temperate Fruit Trees and Knowledge Constraints to Orchard Planning

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Temperate fruit and nut trees require particular climatic conditions during all seasons to produce yields that allow commercial orchard operations. The most critical requirement in warm temperate and subtropical regions is winter chill, of which a certain quantity must be accumulated for trees to break dormancy and resume regular growth in spring. Different models exist for quantifying winter chill, but they differ greatly in accuracy and sensitivity to temperature change. All models are empirical proxies, which are not founded on thorough understanding of tree physiology. This casts doubts on their suitability for climate change projections. The problems associated with this range of models are illustrated using a global dataset of winter chill, based on temperature records from more than 5000 weather stations around the world, and supported by more detailed studies in California's Central Valley and in high-altitude oases in Oman. Results show that winter chill models are not equivalent, and the relationships between the various chill metrics are strongly dependent on temperature. Accordingly, projected winter chill for climate change scenarios depends primarily on the choice of model, casting doubts on the usefulness of many projections done in the past. The most robust model across temperature gradients appears to be the Dynamic Model, developed in Israel, one of the world's warmest growing regions. Based on a dataset of more than 4000 weather stations worldwide and on 20 climate scenarios, historic and likely future decline in winter chill was identified for warm growing regions. Orchards in North and South Africa, Southern Europe, Southern Australia and other subtropical regions, as well as in the Tropical highlands, appear particularly at risk. Temperate regions are projected to experience relatively stable conditions, while cold regions could even see increasing chill. The accuracy of such projections, and thus the ability of orchard managers to plan cultivar succession, is constrained by substantial knowledge gaps about tree dormancy. Long-term phenology records and innovative statistical tools, most notably projection-to-latent-structures regression, can help close some of these gaps, but extensive experimentation is also needed to ensure that high-value orchards remain viable in a gradually warming future.

Keywords: Chill portions, chilling hours, climate change, dynamic model, phenology, winter chill

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Mixed-Farming in South Asian an Era of Resilient Agricultural Systems

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Two-thirds of the rural poor in South Asia still depend on mixed crop-livestock systems for their livelihoods despite a trend towards more specialised farming. In this region the main links between cropping and livestock are crop residues as feed and dung as farm yard manure. At the same time crop residues can be incorporated into the soil directly to improve fertility, vital to improving the sustainability of intensifying cropping systems. While mechanisation has reduced the number of draft animals, the growing demand for milk and meat and reduced grazing opportunities have increased the demand for cereal residues as feed.

In this regard, the present study seeks to improve the understanding of current crop-livestock interactions, mainly in regard to the use of crop residues, in mixed systems with different levels of agricultural intensification and agro-ecological conditions. Surveys were conducted among 480 households in three study sites: two from India (Karnal and Udaipur) and one from Bangladesh (Dinajpur) across the Indo-Gangetic plains from January to April, 2011. The results indicate that the use of crop-residues varies across crops, regions, market integration and also harvesting method (*i.e.* manual or combined). The main residue used for stall feeding in Dinajpur is rice straw while in Karnalit is wheat straw and in Udaipur farmers mainly feed maize stover. Where crops are harvested by combine harvester (in high intensity areas such as Karnal) more than 50% residue is left in the field while more than 70% of residues are used as feed when crops are harvested manually. Regression analysis of crop residue use shows that landholding size does not determine the share of residues used for mulching or feeding. However, herd size has positive impact on the relative extent of feeding of crop-residues. The findings on dung use indicate that a higher proportion of dung is used as manure in less intensified areas (Udaipur) compared to highly intensified systems with good access to inputs as in Karnal. Nevertheless, the threat to system sustainability appears to be highest in Udaipur overall demand for off-field residue use is greatest within the three study sites.

Keywords: Crop residue, feeding, manure, mixed-farming, soil fertility

Effect of Marker-Assisted Backcrossing to Introgress Resistance to *Striga hermonthica* into African Sorghum Varieties

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The parasitic weed *Striga hermonthica* causes substantial yield losses in the production of sorghum and other cereals in large parts of sub-Saharan Africa. The additional loss of water to the root parasite compounds the effect of drought on the parasitized crop, aggravating the susceptibility of rural household food security to climate variability. Improved cereal cultivars with quantitative *striga* resistance are expected to stabilise yields in infested areas, and seeds of such improved cultivars can be easily regrown by farmers and distributed along traditional seed exchange channels. However, conventional resistance breeding is hampered by the labor intensity and difficulties of field trials to reliably identify stable host-plant resistance. Marker-assisted backcrossing (MAB) to transfer previously identified resistance quantitative trait loci (QTL) from an exotic, resistant sorghum variety into locally well-adapted sorghum cultivars is expected to speed up the development of farmer-accepted, high-yielding and striga-resistant varieties. To validate the MAB-approach, breeding lines of five farmer-preferred sorghum cultivars from Eritrea, Kenya, Mali and Sudan were introgressed with up to five striga-resistance QTL from the exotic sorghum line N13 using MAB techniques. Selected backcross-2 lines carrying zero to five introgressed QTL, along with their parental lines, were field-tested under *striga* infestation in multiple locations in Mali and Sudan from 2009 to 2011. *Striga* count data showed resistance levels of the best performing introgression lines similar to that of the donor parent N13, and lines combining high resistance and grain yield levels were identified. Elevated *striga* resistance levels were weakly correlated to the total number of introgressed QTL, while considerable variation also occurred between lines carrying the same QTL-combinations as well as between test environments. Under mild *striga* pressure, grain yield of the introgression lines was on average superior over that of the donor line N13, but still below that of the original African sorghum variety. Nevertheless, farmer-participatory evaluation of the introgression lines revealed high preference scores for high-yielding and *striga* resistant breeding lines. In general, the marker-assisted introgression of *striga* resistance into adapted, farmer-preferred sorghum varieties was considered a very useful breeding strategy.

Keywords: Marker-assisted selection, resistance breeding

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Effects of Induced Drought and Different Shade Levels on Leaf Gas Exchange of *Musa* spp.

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Several climate scenarios predict that extreme weather events like droughts are likely to become more frequent and severe. Moreover, average precipitation may decrease or at least rainfall patterns could change and become less predictable. To face the impact of such weather events it may be necessary for the rural population to adapt land use practices concerning production techniques and adequate varieties. Agroforests tend to offer better resilience to reduced precipitation compared to monocultures and annual crops. Hence, agroforestry may play a decisive role in reducing the vulnerability of the rural poor to extreme weather events. In general agroforestry systems present a more balanced humidity regime. Additionally, advantages result from the existence of different shade levels and the reduction of soil and air temperature peaks. Thus the evaluation of water budgets and changes in plant water use under prolonged drought conditions is essential to predict responses of ecosystems to climate change. In a banana (*Musa* spp.) agroforest with coffee (*Coffea arabica*) plants associated with *Erythrina* spp. shade trees, we studied the effect of soil moisture depletion and different shade levels on leaf gas exchange and chlorophyll fluorescence of two *Musa* varieties: 'Gros Michel' (*Musa* AAA) and 'Bluggoe' (*Musa* AAB). The study was conducted at two experimental sites: one at CATIE, Turrialba, Costa Rica consisting of an agroforest with different shade levels and the other one near Matagalpa, Nicaragua where the induced drought conditions were established. In order to achieve a reduced soil moisture content in a fraction of the experimental field in Nicaragua, roofs were constructed over individual plants. In addition to the measurements of soil moisture content, leaf gas exchange and chlorophyll fluorescence, we collected meteorological data such as diurnal precipitation, temperature and relative humidity. The preliminary results show clear trends regarding the responses of the two varieties. 'Bluggoe' shows a higher drought tolerance than 'Gros Michel'. Both varieties performed best at a shade level of 50 %, although 'Gros Michel' is better adapted to high irradiance. An in depth analysis is currently being conducted.

Keywords: Agroforestry, Central America, chlorophyll fluorescence, drought, leaf gas exchange, *Musa* spp., shading

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Impact of Irrigation System on Microclimatic Parameters and Gas Exchange in Lowland Rice

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Interest in water-saving irrigation techniques in Senegal is rising from the aim to increase the domestic rice production. Rice-rice double-cropping and expansion of the rice growing area are the strategies for becoming self-sufficient on rice in the near future. Furthermore, high irrigation costs account for a relatively large share of production expenses due to increasing fuel and electricity prices. Nevertheless, yield stability under water-saving irrigation is not assured and the reasons remain widely unclear. In the absence of a ponded water layer, plants are exposed to higher temperature extremes at the growing point. In addition, reduced evaporation can lead to lower relative humidity in the canopy. Therefore, microclimate is considered to influence gas-exchange parameters.

Experiments were conducted between November 2008 and October 2010 in Ndiaye, located in the Senegal River delta, with typical Sahelian climatic conditions and thus three distinct seasons: a hot-dry-season from March to July, a short wet-season from August to October and a cold-dry-season from November to February. In bi-monthly staggered sowing dates, soil temperature, temperature at the growing point and inside the canopy as well as relative humidity inside the canopy was observed for five irrigated lowland rice varieties grown under flooded and non-flooded conditions year-around. Gas-exchange measurements for transpiration, assimilation and stomatal conductance were conducted on a regular basis.

The effect of higher temperature amplitude in the absence of a ponded water layer was more pronounced in the two dry-seasons than in the wet season. A negative effect of water-saving irrigation on soil temperature, temperature at the growing point and relative humidity and thus an increased vapour pressure deficit inside the canopy was observed under hot and dry conditions. Low soil temperature and high vapour pressure deficits were associated with a decrease in stomatal conductance and thus assimilation rate. Reduction of assimilation rate without standing water under high vapour pressure deficits was more distinct in varieties adapted to the wet tropics than in local varieties, whereas neither an impact of irrigation technique nor variety could be detected in the wet-season.

Keywords: Assimilation, Sahel, transpiration, water-saving irrigation

Comparison of Climate Change Effects on Bread Wheat and Durum Wheat

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Drought, ultraviolet radiation and atmospheric CO_2 enrichment are three environmental factors, which affect food security in the future. The objective of present research was to study the effect of two levels of carbon dioxide (400 and 900 ppm), ultraviolet radiation (UV A, B and C with intensity of 18, 25 and 40 microW cm^{-2} respectively) and water deficit (100 % and 40 % percent of field capacity) on yield and some metabolic leaf compound of bread wheat (cv. Pishtaz) and durum wheat (cv. Arya). The experiment was conducted in the Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran during 2011 growing season and designed as factorial base plan RCDB. The result showed that interaction of UV-C and elevated CO_2 increased carbohydrates in both cultivars. Interaction between elevated CO_2 and water deficit significantly decreased specific leaf area and increased spike per square metre in durum, but decreased spike per square metre in bread wheat. UV enhancement did not significantly reduce spike per square metre in durum wheat, but it was decreased in bread wheat. Leaf proline, falavenoid, antocyanin content and grain protein significantly decreased by water deficit in both cultivars. Elevated CO_2 significantly increased height of plants, protein, SLA and chlorophyll of flag leaf in bread wheat but decreased RWC, Fv/Fm ratio, fertile tillers, spike, grain yield, anthocyanin and flavonoids. The elevated CO_2 could not affect significantly on the spike per square meter, grain weight, proline content of flag leaf. In conclusion, we found that durum wheat in comparison to bread wheat had better respond in simultaneous stress.

Keywords: CO_2, food security, UV, water deficit, wheat

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Medicinal Herbs Cultivation, Trade and Consumption in Colonia del Sacramento, Uruguay

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In the global era, few value single-site ethno-geographic research. It is everybody's dream, however, to travel to far distant places, usually green sites, for pleasure and tranquility. There we all hope to forget everyday troubles, the exigencies of urgency and action, which characterises the 21st Century interconnected working places worldwide. This contribution focus is on a unique living in-between two countries city – Colonia del Sacramento, Uruguay – one hour distant by ship from the capital city of Argentina, Buenos Aires. Over one million tourists travel year-round to this small oasis of peace, enjoying nature as much as architecture. Colonia del Sacramento is located on the northern bank of the River Plate. The town has an aura of mysticism due to the fact of having been dedicated to the Holy Sacrament. Founded in the late January 1680 by the Portuguese Governor of Rio de Janeiro, the port soon became a strategic base, aimed at conquering sites further inland. In the midst of the year 2011 I've interviewed fifty urban gardeners and herb traders as to their preferences in terms of medicinal plants, teas and cataplasms. Results show that the first preference is constituted by herbs of European origin, followed by Native Americans. It was the first time that the European influence was singled out in this research. So far I have interviewed over 1,000 people from other eight Latin American cities and metropolis (Santiago, Belem, St. Louis, Lima, Habana, Central Mexican Region, Rio Cuarto, San Jose), and the local medicinal species were always the top ranking use. Hope is to contribute to value single-site ethnography in the field of traditional medicinal knowledge.

Keywords: Single-site ethnography, traditional medicinal knowledge

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Allelopathic Effects of the Babassu Palm on Crops, Pasture-Grasses and Key Soil Fungi

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The babassu palm (*Attalea speciosa* Mart.) is prominent throughout large parts of Amazonia, both socioeconomically (palm-oil extractivism provides low-income subsistence to the rural poor) and ecologically (dominant in frequently-burned degraded lands). The association of babassu with annual crops has been hailed as traditional agroforestry and in extensive pastures as traditional silvopastoril systems, and minimum palm density is even regulated by law (120 adult palms per ha). However, very little is known about the ecological properties and effects of this remarkable palm.

We investigate the possibility of allelopathic effects of babassu leaf and root aqueous extracts on (i) germination and initial (5–7 day) growth of five indicator crop species (maize, rice, cowpea, *Brachiaria* and lettuce; microcosm experiments), (ii) *Brachiaria* development, mycorhizal root-infection and number of mycorhizal spores in the soil (4-month pot-experiment), and (iii) growth of two further key soil fungi (*Trichoderma* and *Fusarium* in petri-dishes with aqueous and alcoholic extracts).

Effects of babassu extracts were negligible on seed germination, initial shoot and root growth was strongly affected by babassu leaf and root extracts. Contrary to our expectations, both negative (inhibition) and positive (stimulation) reactions occurred in similar frequency and strength. Relationships differed between indicator-species and effects of root extracts tended to be stronger than those of leaf extracts. *Brachiaria* shoot and root growth was significantly reduced by babassu root (but not leaf) extracts, even at its weakest concentration. Root and leaf extracts significantly affected both *Brachiaria* mycorhizal root-infection and spores in the soil. Relationships tended to be similar with stimulation at mid-concentrations, and depression at highest concentration. Both root and shoot extracts significantly affected *Fusarium* and *Trichoderma mycelia* growth, relationships differed between species and between aqueous and alcoholic extracts. We conclude that babassu leaves and roots exert strong allelopathic effects on a wide range of indicator plants and soil fungi. Relationships are, however, extremely complex, with differences between indicator-species, growth-stages, concentration and type (aqueous/alcoholic) of extractant. Both positive and negative allelopathic impacts of babassu are to be expected. We are at the beginning of an understanding of babassu above- and belowground interactions.

Keywords: Arbuscular mycorhiza, *Brachiaria*, cowpea, *Fusarium*, maize

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Characterisation of Insecticide Resistance in Clonal Cultures of *Myzus persicae* (Homoptera: Aphididae) Obtained from an Italian Field Population in 2010

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Green peach aphid, *Myzus persicae* (Sulzer) is globally known as a polyphagous sucking pest insect on a wide variety of host plants and provides damage by direct feeding, transmission of plant viruses and honeydew excretion. To keep the pest under economic thresholds it is usually controlled by chemical insecticides belonging to different mode of action classes. Due to the frequent use of insecticides such as pyrethroids, carbamates, organophosphates and neonicotinoids, *M. perscae* developed resistance and is no longer affected by recommended rates of many compounds. This study was conducted to characterise the resistance mechanisms in clonal cultures derived from an Italian aphid population collected in 2010. Eight clones were investigated for their susceptibility towards three different insecticide modes of action by discriminating dose bioassays. The results revealed high resistance levels to pirimicarb (carbamate) and deltamethrin (pyrethroid), but moderate levels of resistance to imidacloprid (neonicotinoid). All clones were also biochemically investigated for the presence of metabolic resistance mechanisms such as esterase over-expression as well as target-site resistance, *i.e.* the presence of SNP´s (single nucleotide polymorphisms) in genes of target proteins which convert into amino acid substitutions leading to target-site insensitivity. A high level of esterase E4/FE4 was present in all clones. Acetylcholinesterase inhibition studies revealed insensitivity to pirimicarb which is linked to a heterozygously present S431F mutation as shown by pyrosequencing. Furthermore the well-known kdr mutation (L1014F) was identified in the voltage-gated sodium channel. Interestingly we did not detect the commonly known M918T super-kdr mutation, but identified for the first time in Italian *M. persicae* a M918L mutation, another super-kdr-like mutation. All these mutations result in pyrethroid resistance. The implications of the presence of multiple mechanisms of resistance in resistance management strategies are discussed.

Keywords: Insecticide resistance, *Myzus persicae*, pyrosequencing

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Developing New Fair Trade Markets Based on Local Wild Perennials: *Boscia senegalensis* (*hanza*) at the Base of a New Emerging Food Chain in Niger Republic

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Niger Republic is battling food insecurity and malnutrition for decades. The battle at farming system level however is still mainly done from traditional agricultural perspectives like improving crops, applying (chemical) fertiliser, mechanising and irrigation. Unfortunately, dependence of the annual crops on yearly rainfall is high with harvest failures occurring regularly.

A resilient farming system in Niger takes into account its extreme dry and variable climate. It should be a low input system with crops well adapted to the climate and being able to produce in years with poor rainfall. Local wild perennials are well adapted to the dry climate and are able to survive the long dry season.

Hanza (*Boscia senegalensis*) is a little-valued perennial in Niger and its seed generally considered a famine food. Yet it is highly productive, nutritious and could be a key element in making Niger self-sufficient in staple foods. Currently the seeds are consumed on a large scale in many of Niger's rural areas, but they have served as staple food for numerous people in the rural area during prolonged periods.

The *hanza* bush is able to thrive in extensive parts of Niger. Being drought resistant, it yields well even in years of insufficient rainfall ($<100\,\mathrm{mm}$), when no other crop is successful. Untreated seeds are rarely attacked by insects or diseases and neither cattle is interested in them due to their bitter taste. To make *hanza* seeds edible they need to be soaked in water. Debittering efficiency is researched to find optimal debittering methods whilst keeping water consumption to a minimum. Processing *hanza* seeds on a larger scale will open the possibility to sell it off on the urban markets of Niger providing rural population with a new source of income. An efficient logistical chain has to give the finished product competitive prices, whilst offering a worthwhile compensation to the rural population. Access to an outlet for the products will encourage the rural population to protect these plants. The economical value of the *hanza* bush improves with a growing demand for products made from it.

Hanza fits in a natural farming system with a biodiversity of local wild perennials producing food during different harvest seasons even in years with poor rainfall and without the need of irrigation or fertiliser.

Keywords: Africa, food security, new markets, poverty reduction, rural development

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The Patterns of Pomological Variation of Wild Plum (*Prunus divaricata* Ledeb.) in Kazdagi (Mt. Ida), Area of Turkey

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Consisting of more than 9 000 plant species, 30 % of them being endemics, the flora of Turkey is very rich in diversity. A wide range of different geological and climatic conditions and the location of the country has greatly contributed to the richness of this biodiversity. Turkey is located within the borders of several floristics regions namely: Euro-Siberian, Mediterranean, and Irano-Turanian. A broad spectrum of germplasm is required in breeding programs for crop improvement. This genetic variation in plant populations may be considerable especially in centres of diversity, or gene centres, of particular plants. Eight centres of variation, previously termed "centres of origin" were originally proposed by Vavilov. Two of these ("Near East"and "the Mediterranean") extend within borders of Turkey where five areas were designed as "gene microcentres" by Harlan. In order to identify gene management zones of plum (*Prunus divaricata* Ledeb.) for *in-situ* conservation in Kazdagi, four plum sites were chosen as possible candidates zones. Pomological characteristics of plum fruits collected from labelled trees were observed. Average fruit weight, fruit size, fruit colour, fruit taste, aroma, solible solids, ratio of stone were recorded. The most fruit samples examined were found as rough-fibred or fleshy, little juicy, sour and much aromatic. Nevertheless, a few sample were found sweet to be eaten. The observation of pomological characteristics of plum populations is one of the ways to determine existing variability among them. From the findings of pomological characteristics it can be concluded that significant differences were observed in plum trees for fruit colours and fruit weight within and between sites.

Keywords: *In-situ* conservation, plum, pomological characteristics, *Prunus divaricata*

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ASsessing ThE Risk of Water Saving Ground Cover RICe Production Systems on Regional Soil Carbon and Nitrogen Stocks (ASTERICS)

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In China rice production is increasingly challenged by the growing demand of its rising population and the increasing demand for water by the industry/ private sector. The latter is resulting in shortages in irrigation water for lowland rice ($>90\,\%$ of total area) as well as to a decline in water quality. Therefore, China enforced its search for expanding and to intensify rice cultivation in regions which were formerly of only marginal importance. One of the most promising techniques to overcome problems in water shortage as well as in temperature limitations of rice production is the so-called Ground Cover Rice Production System (GCRPS). Here, lowland rice varieties are used and the soil is kept moist between irrigation periods by covering materials, thus reducing water demand by 50 up to $90\,\%$. Keeping a soil constantly moist but not waterlogged is likely to accelerate mineralisation of soil carbon (C) stocks – with negative impacts for soil fertility and nutrient retention- and potentially decrease crop nitrogen (N) use efficiency due to increased losses of fertiliser N to the atmosphere or hydrosphere. In our study we determined the effects of GCRPS on soil carbon stocks, $d^{13}C$ and $\delta^{15}N$ signals and mineralisation activity of the soil by sampling chronosequences of land use as well as a large number of adjacent pairs (50+) of traditional lowland and GCRPS rice production in Hubei province. Results on changes of soil $\delta^{15}N$ signals but also SOC concentrations shows, that introduction of GCRPS has already resulted in detectable and significant changes in soil C and N cycling with so far largely unexplored consequences for biosphere-atmosphere exchange. But against expectation rice production via the GCPRS technique resulted in increased soil C and N stocks, increased N use efficiencies and increased yields. Possibly mechanisms how GCRPS is positively affecting C and N cycling in rice systems will be discussed.

Keywords: Environmental sustainability, ground cover technique, soil C/N stocks, rice

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Enhancing Germination of *Aframomum melegueta* K. Schum. through *ex-vitro* and *in-vitro* Propagation Techniques

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In spite of the huge economic importance of *Aframomum melegueta* K. Schum. in the herbal and pharmaceutical industries, its production is limited by the lack of planting materials and long juvenile phase. Thus, production has not kept pace with demand; hence, an *ex-vitro* study of breaking of seed dormancy was undertaken to improve germination. Seeds were immersed in 25 % H_2SO_4 for 1 hour and the percentage germination compared with cold stratification in a fridge for 7 or 14 days at $4\pm1°C$, and a control. 25 % H_2SO_4 treated seeds had the highest germination percentage (60.7 %) compared to cold stratification or control treatments. To further improve germination, an in-vitro study was conducted. Seeds scarified with 25 %, 50 % or 75 % H_2SO_4 for 1hour, together with controls were soaked in 0 - 25 mg l^{-1} GA3 for 1day prior to inoculation on Lloyds and McCown medium. 25 % H_2SO_4 scarified seeds alone significantly enhanced percentage germination (100 %). But, plantlets of GA3 treated seeds were taller than the 25 % H_2SO_4 scarified seeds without GA3. Subsequently, the seeds were scarified with 25 % H_2SO_4 and cultured on Lloyds and McCown medium fortified with 0 - 100 mg l^{-1} GA3 in an attempt to optimise germination and growth. Although, at 60 mg l^{-1} GA3 percentage germination equalled germination in the control, the plantlets grew less vigorously. Thus, GA3 was found to have no influence on growth. Additionally, dormancy was identified to be caused by the hydrophobic waxy seed coat, but not dormancy stimulating hormone. Scarification with 25 % H_2SO_4 for one hour can be used to improve germination.

Keywords: *Aframomum melegueta*, Lloyds and McCown medium

Traditional Rainfall Prediction Skills and Response Strategies in Selected Frontline States of Nigeria

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Although northern Nigeria has a long history of recurrent drought, the public preparedness to prevent or curtail its devastating impact is non-existent. This paper is based on the results of a pilot project conducted to strengthen Nigerian Meteorological Agency's (NIMET) capacity to provide reliable planting date forecast in Nigeria. This aspect of the project aimed at understanding traditional knowledge base and farmers' prediction methods, community perceptions of impacts of rainfall variability, coping strategies and opportunities in four states of Nigeria. Semi-structured interview and focus group discussion were used to sources for information. The survey indicates that the farmers have developed a variety of traditional indicators for predicting weather situation to make farm management decisions and those relating to other means of livelihoods. The traditional forecast knowledge has been adapted to local conditions and its requirement is dependent on physical observations like behaviour of birds, flowering or flushing times of some trees species, prevailing wind directions and cloud patterns. The survey also indicates that the farmers have evolved series of adaptive contingency strategies over to time to ameliorate the problem of drought. These mitigation measures usually integrated within the socio-economic framework of the rural farmers and are predominantly temporal stop-gap measures until rains return. Impacts of rainfall variability in the communities were asserted to include; poor yield, low prices of crop/livestock, low dowry for their daughters, high cost of labor as a result of migration to urban centres, inadequate water for dry season farming, low income, low standard of living, and high level of poverty. An integration of traditional proven methods of rainfall prediction with scientific methods will evolve reliable forecast that will reduce risks in rain fed farming systems.

Keywords: Crop production, northern Nigeria, rainfall prediction, traditional knowledge base

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Evaluation of Hydrus-2D for Soil Water Infiltration by Using Laboratory Measurements in the Weighing Lysimeter

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From a hydrological perspective, water uptake by root systems and their spatial distribution can largely control water fluxes to the atmosphere and the groundwater. For an improved understanding of the magnitude of these fluxes, accurate estimates of the temporal and spatial root water uptake patterns are needed. Although solutions of transient water flow can be obtained by numerical modelling, their application may be limited in part as root water uptake is generally considered to be one-dimensional only. The objective of this study was to evaluation accuracy of two-dimensional root water uptake model by Hydrus2-D in the lysimeter. The root water uptake model was incorporated into a two-dimensional flow model, and parameters of governing equation were optimised, minimising the residuals between measured and simulated water content data. Water content was measured at different points and layers. To calibrate the flow, a genetic algorithm was used. With the optimised parameters of model, simulated and measured water contents during the 30 days period were in excellent agreement. Based on results, R^2 values generally ranging between 0.92 and 0.94 and a root mean squared error (RMSE) of 0.0236 m^3m^{-3}. Finally, results illustrated that Hydrus2-D is extremely flexible in simulation of soil water content pattern. The 2D root water uptake model has considered the spatial variability of soil water and roots distribution to some extent, which almost reached the reality of field, so the simulated and measured results were almost similar. This study highlights the importance of root distribution and pattern in regulating soil water use and thereby improving endurance of plants to seasonal droughts for sustainable agricultural productivity.

Keywords: Hydrus-2D software, soil water content, soil water infiltration, weighing lysimeter

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Euphorbia tirucalli L. – Physiological and Genetical Characterisation of a Drought Tolerant Plant and its Potential as a Source for Bioenergy Production

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The decrease of mineral oil supplies has induced research on biomass as an alternative source of energy. A number of plant species have been examined; however, climate change has brought problems to agriculture such as drought. To deal with those consequences, it is important to find plants for growing in non arable land. The plant should have high drought tolerance as well as be beneficial for other purposes such as phytochemical and pharmaceutical applications. *Euphorbia tirucalli* L. grows well in arid areas, has a high tolerance to drought stress and could be therefore a source of biomass. This plant contains also valuable compounds of pharmaceutical benefit and might serve as a source of rubber.

To analyse a broad variety of plants with different genetic backgrounds *E. tirucalli* genotypes collected in different countries (Burundi, India, Indonesia, Italy, Kenya, Morocco, ornamental from our greenhouse Hannover, Rwanda, Senegal, Togo, USA) have been investigated for their genetic relationship using AFLP analysis with UPGMA clustering. The different physiological responses to drought stress are determined in the genotypes from Morocco and Senegal by different parameters. The rubber content is measured using Nuclear Magnetic Resonance (NMR).

The cluster analysis shows that the genotypes are divided into two main groups, African genotypes with bootstrap value 60 % and non African genotypes (except Rwanda and Kenya) with bootstrap value 68 %. The plants respond significantly different to various levels of volumetric water content (vwc). Both genotypes from Morocco and Senegal show the same response to drought stress by different parameters. The NMR measurement shows that the rubber content per fresh weight is different between genotypes, the highest has genotype Senegal (17.33 mg g^{-1}) and the lowest genotype Burundi (1.48 mg g^{-1}).

The results show that the genotypes might be ecotypes and adapted to the respective conditions, although more samples from different regions need to be investigated. The drought tolerance in low level vwc shows that this species can grow in arid area. Different rubber content provides information to select the most beneficial genotypes; however, more research is needed to make sure whether the difference is due to genetic or environmental factors.

Keywords: Drought tolerance, milk sap

Pollination Services in Irrigated Rice Based Production Landscapes

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Pollination is an important ecosystem service and essential for seed and fruit set of major crops. Thus, it is of outstanding ecological and economic importance and crucial for farmers' well being. There is increasing evidence that pollinator diversity is declining due to land use intensification and losses of suitable habitats in agricultural landscapes. Extensively managed woody areas represent important nesting and foraging habitats for bees in the tropics. Within the framework of the LEGATO Project (http://www.legato-project.net/) this study focuses on the effects of woody areas on bee species richness and abundance and pollination services in landscapes dominated by rice production systems. We ask the following questions:

1. Does the presence of woody habitats positively affect pollinator richness and abundance in landscapes with rice based production systems?
2. Are pollination services higher in and around rice fields that are located in the vicinity of woody habitats?
3. How do woody habitats in the surroundings influence seed set and fruit quality of cucumber, *Cucumis sativus* L., on the bunds of rice fields?

The study takes place near Los Banos, Laguna Province, Philippines. Eight study areas were chosen within a region of 15 km^2. Each study area contains three different study sites: 1. woody habitat adjacent to rice cropping area, 2. paddy rice field adjacent to woody habitat, and 3. rice paddy without any woody habitats in the surroundings. Pollination services are determined with a phytometer experiment using potted cucumber plants (three insect-pollinated plants and one self-pollinated plant per site). Pollinator richness and abundance are recorded with direct observations of the potted plants and yellow pan traps (four traps per site).

We expect that pollination services, bee abundance and richness are increased in and around rice fields adjacent to woody habitats. Thus, ecosystem services, such as pollination, may benefit from ecological engineering measures that enhance the availability of suitable habitats for bees and other beneficial insects, such as biocontrol agents, in rice production landscapes.

Keywords: Bee, cucumber, ecosystem services, habitat, pan traps, sustainability

Turiaçu Pineapple: A New Cultivar Native from the Eastern Periphery of Amazonia, Maranhão State, Brazil

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The centre of diversity of the genus Ananas is currently concentrated in an area located between 10°N to 10°S and 55° to 75°W. Brazil is the greatest centre of genetic diversity of pinneaple in the world, and next to *Ananas comosus*, several other *Ananas* species as well as related genera such as *Pseudananas* and *Bromelia*, all of which with endemic occurence in Amazonia. The present study physical and chemically characterises pineapple fuits as well biometric plant characters of the 'Turiaçu' cultivar. This cultivar is of great importance to Maranhão State, is native to eastern Amazonia and derived from selection process of smallholder farmers that developed an agroecossystem known as 'Tacuruba'. Rural poverty in the region is great and is associated with slash and burn shifting cultivation. Our field experiment was conducted from 2007 to 2009 and investigated the effects of different spacings in simple rows. Our data are compiled from samples of 12 fruits per plot, and four plot replications. The slips used for planting got 35 to 40 cm. We analysed our data with descriptive statistics such as general averages of each character and linear correlation coefficients between nine main characters. The average fruit weight of the 'Turiaçu' cultivar (1 620 grams), the medium crown, the content of total soluble solids (16,1°Brix) and the yellow pulp colour confirm its outstanding quality and acceptance in local and regional markets and constitute a product suitable to markets of increasing exigency. The hight production of slips per plant (11,3 slips) assure cultivation in new areas. Fruit form is unstable, with a predominance to conic structure. Acidity is lower than that of other cultivars, requiring adjustments in harvest period when destined for industrial uses. Here we propose a process of agroecological transition in Turiaçu pineapple cultivation, in order to guarantee the sustainability of this agroecossystem.

Keywords: *Ananas comosus* var. *comosus* (L.) Merril, fruit quality, native fruit, plant biometry

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Potential of *Crotalaria* spp. in the Agroecological Restoration of Fruit Orchards in the Soconusco, Chiapas, Mexico

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Rambutan (*Nephelium lappaceum*) is a fruit tree from the Malaysian and Indonesian regions. It was introduced in the Soconusco, Chiapas, in the 1950's. The present cultivated area amounts to more than 1500 hectare. With increasing importance of this crop, the cultivation system is now facing increasing plant sanitary problems, substantial soil erosion and productivity issues, which are due to worsen in future by a lack of agro-ecological responsibility. From August 2006 until March 2007, the effects of different intercropping systems with rambutan and leguminous crops were compared. More particularly, the effects of *Crotalaria longirostrata* (Chipilin), *Crotalaria spectabilis* and *Vigna unguiculata* were evaluated in so far related to soil fertility, insects dynamics, leguminous biomass and rambutan fruit production within a typical rambutan orchard of the Soconusco, located at 15° 21´ North latitude, 92° 33´ West longitude and at 335 m asl. The results demonstrate that the legume enriched intercrops have a positive effect on the soil fertility and biomass production. By the same token, the *Crotalaria* spp. flowering time concurs with that of *Nephelium*, offering an additional attractive effect for insect pollinators and predators. The agro-ecological change in the fruit system was reflected by a superior rambutan fruit production of 5 719 kg ha^{-1} in the intercropped *Crotalaria spectabilis* as compared to only 2 840 kg ha^{-1} in the traditional rambutan cultivation (without legume). Finally, rambutan monoculture offers an extraordinary economic income of € 2 266 per hectare whereas € 5 840 per hectare were recorded for the different leguminous variants.

Keywords: Agro-ecology, intercrops, legumes, productivity, rambutan

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Comparative Studies of Root Anatomy in Some Date Palm (*Phoenix dactylifera* L.) Cultivars from Diverse Origin

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Worldwide Pakistan is the 5th largest producer of date palm (*Phoenix dactylifera* L.) and the species ranks third among the country's fruit crops after citrus and mango. The > 325 date cultivars growing in Pakistan comprise native and exotic ones which differ widely in morphological and anatomical characteristics. Adventitious roots of thirty four cultivars from the collection at Jhang Date Palm Research Station were used to characterise these differences. To this end a 2 cm piece form each root-shoot junction was placed in FAA (formalin acetic alcohol) solution and root parameters were measured by a ocular micrometer under a compound microscope, which was calibrated with the help of a stage micrometer. The collected data on dermal, ground, and vascular tissues subjected to ANOVA and means separated by DMR0.05.

Epidermis thickness was largest in Berehmi (59.9μm) cultivar followed by Dakki (52.8μm) and Kozanabad (46.3μm) while Halawi-2, Jansohaar and Karbalaen had similar minima (21.8μm). The largest Sclerenchyma cell thickness was observed in Shado (209.7μm), followed by Aseel (196.1μm) and Shamran-2 (187.1μm) while values were lowest for Deglut Noor (100.8μm). Makran had the highest cortical thickness (798.7μm) pursued by Zaidi ($768\ \mu$m) and Aseel ($738.0\ \mu$m), whereas thickness was lowest in Jaman ($503.8\ \mu$m).

Saib had the thickest endodermis ($49.0\ \mu$m) followed by Khudrawi-1 ($44.5\ \mu$m), Makran (43.6) and Angoor ($44.5\ \mu$m) while Zaidi and Deglut Noor had similar minima ($24.5\ \mu$m). Vascular region thickness was highest in Chohara ($471.96\ \mu$m) followed by Zardu ($460.24\ \mu$m), Shamran and Khudrawi-2 were similar ($452.1\ \mu$m), whereas Daanda ($317.4\ \mu$m) had the lowest value. The results indicate different evolutionary routes for the date palm cultivars studied which merit further molecular genetic study.

Keywords: Date palm, diversity, root anatomy, sclerenchyma thickness

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Differential Expression of *alp* Gene and Sporulation Pattern of *Glomus* with Ri T-DNA Transformed Hairy Roots

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After nitrogen, phosphorous (P) is second most limiting element for plants growth. It is a major component of fundamental macromolecules, plays an important role in energy transfer, regulation of enzymatic reactions and different metabolic pathways. P is taken up by plant roots as phosphate (Pi), which is one of the least available nutrients in the soil even after application of P-fertilisers. Plants have evolved a variety of adaptive strategies for Pi-acquisition which involves altered root morphology, exudation of organic acids, phosphatases and nucleases for solubilising Pi from organic resources and the establishment of a symbiosis with arbuscular mycorrhizal fungi (AMF).

Alkaline Phosphatase gene (*alp*) is an AMF specific, considered to reflect fungal activity within the symbiotic system and not reported in uncolonised roots as it is expressed only under symbiotic conditions.

In this study the Ri T-DNA transformed roots were grown *in vitro* with *Glomus intraradices* as root organ cultures and analysed for the variations in patters for sporulation, alp gene expression and nutrient growth profiling. It was demonstrated that *alp* gene regulating the production of alkaline phosphatases was host dependent. For the nutrient analysis, the phosphorus concentrations obtained were similar to those obtained in the real time expression study with a maximum for *Daucus carota* var pusa kesar (carrot), followed by *Trifolium subterraneum* (egyptian clover), followed by *Daucus carota* var Berlicummer (carrot) with 0.9993 correlation factor.

This study helps in the selection of appropriate inoculum as a biofertiliser, based on its enzymatic ability to solubilise the phosphates and aiding better nutrient uptake in agricultural crops.

Keywords: Alp gene, biofertilisers, inocula, nutrient growth profiling, phosphorus, real time expression, sporulation

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Forage Production with Limited Water and Nutrient Resources in Pakistan

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The Agriculture sector has key importance in Pakistan's economy. It is one of the largest sectors, accounting for more than 20 % of national GDP. Livestock, the most important contributor, shares more or less 55 % of the agriculture value added. Green forage is the most valued and economical source of feed for livestock. Sustainable availability of sufficient feed for livestock is critical to smallholders who rely on animals for their livelihood. In Pakistan forage production is facing the problems of water and fertiliser shortage. An experiment was conducted to evaluate different forage types for water and nutrient efficiency at University of Agriculture Faisalabad in 2010–11. Three factorial completely randomised design was used for the experiment. Three fertiliser levels (control, farm yard manure and chemical fertiliser), two irrigation levels (recommended irrigation and half than recommended irrigation) and two forage species (*Trifolium alexandrinum* and *Avena sativa*) were used in the experiment. Data obtained was analysed by using statistical software package R. In both crops fresh matter and dry matter yield showed highly significant differences for all the treatments while interaction of fertiliser treatment with irrigation and forage type was significant, also interaction of irrigation with forage types was highly significant. Regarding quality traits (acid detergent fiber, crude protein and metabolisable energy) all treatments showed non-significant differences except forage type where highly significant differences were observed. Differences for neutral detergent fiber were significant for both fertiliser and forage type. For fresh matter yield, dry matter yield, acid detergent fiber, neutral detergent fiber and metabolisable energy *Avena sativa* showed higher mean values than *Trifolium alexandrinum* while regarding crude protein contents *Trifolium alexandrinum* showed higher mean values than *Avena sativa* in all treatments. It is concluded from the results that by using *Avena sativa* as forage crop we can get higher yields even in limited resources of water and fertiliser to fulfil the needs of the livestock.

Keywords: Forage production, quality traits, water and nutrient efficiency, yield

Development of Insect Resistant Transgenic Pea (*Pisum sativum*): Molecular and Functional Characterisation of Putative Transgenic Pea Plants

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Pea (*Pisum sativum* L.) is one of the economically important legume crop cultivated worldwide. However, its production and storage is constrained by different species of insect pests. Thus, development of insect resistant variety is one of the main goals of breeding and improvement efforts in many producing countries. In line with this, gene transformation can complement the conventional breeding strategy through widening access to resistance genes beyond the species gene pool.

In this study, putative transgenic pea plants developed *via Agrobacterium*-mediated transformation using a construct harboring *cry1Ac* gene for insect resistance and *bar* gene for herbicide resistance were characterised using molecular and functional analysis. The *in vitro* putative transgenic shoots were micro-grafted on a 5–7 days old seedling rootstock germinated under laboratory condition and leaf samples were collected for DNA isolation from successfully grafted and well grown plants. Then, molecular analysis of the isolated DNA samples was done for *cry1Ac* and *bar* genes using their respective primers. Functional analysis based on leaf paint was done to detect *bar* gene activity in the segregating progenies of transgenic plants. Filial generation of confirmed transgenic plants were raised and analysed for the inheritance of the transgene.

The molecular analysis of successfully grafted *in vitro* putative transgenic plants showed the stable integration of the transgene construct in the analysed clones. Further molecular analysis of the filial generations from confirmed transgenic clones showed the inherence of the introduced transgenes to the next generations (T1, T2 and T3). So far, T4 generation was obtained and further analysis to select homozygous transgenic plants is ongoing. Leaf paint test as functional analysis using herbicide solution, showed a clear difference between transgenic and control non-transgenic plants. The herbicide treated leaves of non-transgenic control plants showed necrosis after 5–7 days of herbicide application while the herbicide treated leaves of transgenic plants showed no sign of necrosis. In general, the molecular and functional analysis from this study confirmed the integration and heritance of the introduced GOIs. Any confirmed homozygous *cry1Ac* transgenic lines from this study would be very valuable in the effort of gene stacking in pea improvement.

Keywords: *cry1Ac* gene, *Pisum sativum*, functional analysis, insect resistant, molecular analysis, transgenic pea

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Seed Germination and Early Growth of *Chrysophyllum albidum* Seedlings under Different Light Intensities

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The need for domestication of important and endangered forest food tree species has been pointed out. This study investigated the effects different light intensities on the germination of *Chrysophyllum albidum* seeds and early growth of its seedlings, which is a necessary step towards it domestication. Seeds were collected from *C. albidum* elite trees identified in previous study. The light intensities (LI) investigated were 100 %, 60 %, and 40 % while the controls were under forest canopy and open nursery condition. The growth characteristics investigated were total height, collar diameter, number of leaves and biomass accumulation. The experiment was conducted at the nursery of the Department of Forestry and Wood Technology, Federal University of Technology Akure, Nigeria and monitored for 18 weeks. Results showed a significant effect of light intensity on seed germination and seedlings early growth. Cumulative germination ranged from 19.0 % to 58.7 % and was highest under forest canopy and lowest under 100 % light intensity. Seedlings under high light environment (100 % light intensity and open nursery condition) died soon after germination, indicating that full exposure to light has adverse effect on *C. albidum* seedling growth. Seedlings development was best under low light environment like 40 % and 60 % light intensities. Mean total height was 15.2cm; 14.3 cm and 8.8 cm under 40 % light intensity, 60 % light intensity and forest canopy, respectively while collar diameter was 0.44 cm, 0.31 cm and 0.25 cm under 40 % light intensity, 60 % light intensity and forest canopy, respectively. Except collar diameter, both 40 % and 60 % light intensities had similar effect on all growth parameters. Seedlings under 40 % light intensity had a significantly higher collar diameter than those under 60 % light intensity. Total biomass accumulation after three months of growth was 0.82g (60 % light intensity), 0.66g (40 % light intensity) and 0.62g (under forest canopy). Seedlings under forest canopy had very poor growth rate, suggesting the *C. albidum* seedlings may not perform optimally under high shade environment. Thus, *C. albidum* seedlings should not be raised under full light or high shade environment. For optimum growth, the seedlings should be raised under reduced light environment (*e.g.* 40–60 % light intensities).

Keywords: Domestication, early growth, germination, light intensity, Nigeria

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Management of Fungi Associated with Grain Discolouration in Rice, an Emerging Threat to Rice Crop in Pakistan

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Grain discolouration in rice is an emerging threat to rice yield and market value in Pakistan. Fungi associated with grain discolouration of rice were isolated and tested for their pathogenecity on healthy rice grains. Isolation and purification of many fungi such as *Fusarium* spp, *Tricoderma*, *Aspergillus* spp, *Helmithosporium*, *Cercospora* and *Pseudomonas* were done. For management of disease, *in vitro* experiments were conducted to evaluate the efficacy of various fungicides and bio-products against two prominent fungi causing grain discolouration of rice *i.e Aspergillus flavus* and *Fusarium oxysporum*. The most effective treatments in fungicides were Kumulus-DF (44.04) proved to be best fallowed by Cabrio-top (43.38) and Trimiltox-forte (41.80) and in bio-products Neem extract (49.13) was proved to be best fallowed by *Brassica* extract (44.67) in growth inhibition of *Aspergillus flavus*. While in case of *Fusarium oxysporum* growth inhibition, Defeater (29.16) was proved to be best fallowed by Alli-ete (26.16). In bio products and antagonists evaluation Diver (24.23) and *Aspergillus niger* (42.41) were proved to be best respectively. Germination percentage studies of infected rice seeds were carried out after treatment with fungicides/bioproducts. Kumulus-DF, Cabrio-top and Trimiltox-forte gave significant result at 80 ppm while in bio-products *Brassica* extract, Neem extract and Diver (Minral oil) also gave significant result at 8 % as compare to control. The suitable conditions of fungicides and bio-products were found for their application under field conditions. The experiments were laid down in completely randomised design (CRD). Data was analysed statistically and means were compared by using least significant difference (LSD) test.

Keywords: *Brassica* extract, discolouration, *Fusarium* spp., kumulus-DF, neem extract

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Genetic Evaluation of Quality Protein Maize Genotypes under *Striga lutea* and Mycorrhiza Interaction in Nigeria

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Striga parasitic weeds, which cause 20 to 80 % yield loss, are major constraints to maize production in savannah ecosystems of Nigeria. A single approach to several adopted control measures has proved inadequate. Therefore, this study evaluates thirty-four genetic traits in four QPM genotypes under artificial striga infestation and mycorrhiza inoculation in order to provide information for the selection of the best yield components in maize improvement. The pot and field experiments were sited in three locations representing different agro-ecological zones of southwestern Nigeria in 2008 and 2009 seasons using $6 \times 4 \times 4 \times 3$ split-plot design with three replications. AMF were inoculated at the rate of 25 g per plant while 10.4 g of striga seeds was artificially infested in each designated pot. Uninoculated and uninfested pots and plots served as control. The growth, striga and yield related traits were evaluated for phenotypic and genotypic coefficient of variability (PCV and GCV), while heritability estimates (H2b) and genetic advance (GA) were obtained from phenotypic variance components. The GENSTAT and MSTAT programs were used in these calculations. Data were analysed using ANOVA, correlation and principal component analyses (PCA).

Combined ANOVA from the three locations showed significant differences ($p < 0.05$) among QPM for all traits evaluated with first three PCA accounting for 38 %, 25 % and 23 %, respectively. The influence of AMF was highly significant ($p < 0.01$) for eight traits consisting of growth, yield and striga related traits in ART − 98 − SW5 − OB. High H2b (53–98.1 %) estimates were observed for 15 traits, medium H2b (48–50 %) for two traits, while striga emergence count had low H2b (10 %). The genotype × environment interaction was highly significant ($p < 0.01$) for 10 traits. Highest GA (58) was recorded for two traits, while PH at 10WAP (0.51) was the least. Tolerant genotypes had higher potentials for developing cultivars with broad-based resistance to *Striga lutea*. High heritability suggests quality genetic traits as indices for selection of the best yield components in maize improvement. The yield increase indicated positive interaction between the genotypes and AMF.

Keywords: Genetic component, maize, mycorrhiza, striga

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Effectiveness of Resistant Germplasm and Biological Control Agents as a Sustainable Means for Managment of *Fusarium* Wilt Disease of Chickpea

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Wilt caused by *Fusarium oxysporum* f.sp. *ciceri* is a devastating disease of chickpea in word wherever chickpea is grown. Management of this disease is very important for word food security because Chickpea is considered as an alternative to animal protein due to it highly portentous nature. Chickpea (*Cicer arietinum* L.) is an annual legume and the only cultivated specie within genus Cicer. In my investigation natural sources (*i.e.* looking for resistance in germplasm and biological control agents, isolated from natural environment of chickpea) were used for successful management of disease. To identify genetic sources of resistance against wilt disease under sick plot condition, three hundred and eighteen genotype obtained from various sources were evaluated. The experiment was repeated twice during the years of 2010–11 and 2011–12, planted in augmented design with single replication. Among those only three lines/varieties (5006, k021–10 and k035–10) were found to be highly resistant during the year of 2010–11 while only two lines (5006 and k035–10) showed highly resistant response during the year 2011–12. Most of the lines/varieties fell between the moderately resistance to susceptible range (21–50 % Disease incidence). For the effective management of disease six biological control agents were tested against *Fusarium oxysporum* f.sp. *ciceri*. *In vitro* experiments *Pseudomonas fluorescens* was proved to be most effective with 5.71mm inhibition zone fallowed by *Rhizobium* spp. (isolated from chickpea roots) with 5.31mm. These were compared in green house, which showed that seed and soil inoculation with *Pseudomonas fluorescens* proved to be the most effective with 66.66 % mortality reduction of chickpea plants fallowed by *Rhizobium* spp. with 55.57 % disease reduction over untreated control.

Keywords: Chickpea, *Fusarium oxysporum* f.sp. *ciceri*, *Pseudomonas fluorescens*, *Rhizobium* spp

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Characterisation of Sudanese Pearl Millet Germplasm as Source in Breeding for Adaptation to Climate Change

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Pearl millet (*Pennisetum glaucum* [L.] R. Br.) is one of the most important crops for millions of poor rural households in the whole Sahelian region from Senegal to Sudan. The objective of this study was to morphologically characterise and identify superiorly adapted pearl millet genotypes which can be used as sources of resistance to climate-change-related stresses and for other consequent breeding activities. A set of 225 pearl millet accessions collected from different geographical zones of Sudan, including 10 accessions provided from ICRISAT, Niger were planted in three different locations in Sudan, in lattice design with three replications during 2010 rainy season. Twenty morphological and agronomical traits were collected from each accession under study. The results showed wide range of variability among the accessions for all of the morphological traits investigated such as, days to 50 % flowering, plant height, panicle length, 1000 seeds weight and grain yield. Different accessions possess high potential for selection of desirable traits. B9 Tabi is the earliest genotype in term of days to flowering (62 days), while HSD 7197 was the shortest genotype with a height of 118 cm. The early maturing genotypes recorded by PE 08030, HSD 2166 and B9 Tabi while HSD 2168 and HSD 2281 were the highest yielding genotypes. There were 19 genotypes had 5 to 6 tillers while 35 % of the genotypes had 4 tillers. 30 % of genotypes had panicle length range from 25 to 34 cm while 6 % had medium to long bristle length. 11 % of the genotypes with white seeds colour while 26 % had gray seed colour. However, high grain yield was associated with early flowering genotypes. High heritability was estimated for most of the traits under study such as days to flowering ($h2 = 0.80$), panicle length ($h2 = 0.85$), seeds colour ($h2 = 0.73$) and spike density ($h2 = 0.83$). This study provided useful information about the investigated genotypes in terms of morphological characterisation and phenotypic plasticity and therefore, the most valuable and promising accessions can be recommended for commercial cultivation and/or used as source of desirable traits for further breeding programs.

Keywords: Climate change, germplasm, morphological characterisation

Establishment and Parasitism Efficiency of *Trichogramma principium* (Sugonyaev and Sorokina) on Cotton-infesting *Helicoverpa armigera* (Hb.) in Sudan

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This study was conducted at the Gezira Research Station Farm during the 2010–11 season to verify the establishment and parasitism efficiency of *Trichogramma principium* (Sugonyaev et Sorokina) (Hymenoptera: Trichogrammatidae) in eggs of *Helicoverpa armigera* (Hb.) (Lepidoptera: Noctuidae), a major pest of cotton in Sudan that causes considerable losses in yield and quality and usually checked with insectiides at around 30 % of the total cost of producion. The cultivars experimented were "Barac 67B", "Hamid", "Burhan" and "Abdin". *Trichogramma* was acquired from the Rearing Unit, Agricultural Research Corporation, at preimaginal stage, in eggs of *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae). One release was done on each of Barac and Hamid and two on each of Abdin and Burhan. The release rate was 24,000 parasitoids per feddan, at 7×7 m distance between release points and 14-day intervals. At the first release, the cultivars' average of the percentage of emerged parasitoids ranged between 60.5 % and 94.8 %, the overall average was 79.2 % and the percentage of parasitized *H. armigera* eggs ranged between 60 % and 22.2 %. At the second release, the corresponding figures were 46.6%-96.7 %, 77.7 %, and 77.7%-22.2 %, respectively. The high level of parasitoid emergence recorded is an indication of good viability of the released insects, tolerance of the parasitoid to the local weather conditions and the crop environment and acceptance of both, the host eggs and the crop. The levels of parasitism were quite acceptable for this introductory release. In summary, as evidenced by the successful establishment and high parasitism efficiency against *H. armigera* in this study, *T. principium* is strongly recommended for use on Sudanese cotton cultivars.

Keywords: Cotton, *Helicoverpa armigera*, *Trichogramma principium*

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Evaluation of Strigolactones Types in Cowpea Genotypes under Phosphate Starvation

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Farm productivity remains low in sub-Saharan Africa because of a variety of factors such as drought, impoverished soils, pests and diseases. For instance *Striga spp.* are mainly found in Africa, particularly in West Africa where $>60\%$ of crops growing areas are infested. Yield losses in legume crops, especially cowpea, caused by the parasitic *Striga* weed amount to 40% annually. In dry areas of Nigeria, for example, *Striga* has reduced cowpea productivity from potential 2–3 t ha^{-1} to 0.37 t ha^{-1}. *Striga* germination is induced by strigolactones secreted by the host plant root into the soil. It was reported that phosphorous deficiency in the soil increases production of strigolactones. A range of phosphate starvation was used to evaluate the amount and types of strigolactones in different cowpea genotypes using liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS). All 13 cowpea genotypes produced two types of strigolactones (orobanchol and orobanchyl acetate) and a third unidentified strigolactzone. There was significant variation in strigolactones amount among the thirteen genotypes investigated. The genotype IT97K-461–4 was shown to have the highest and IT81D994 the lowest orobanchol and orobanchyl acetate production compared with the other genotypes. Germination bioassays revealed that the cowpea root exudates stimulated the germination of *Striga gesnerioides* seeds even at high dilutions of exudate. Selection of plant with low secretion of strigolactones could be an interesting trait to breed for *Striga* resistance.

Keywords: Liquid chromatography coupled to tandem mass spectrometry, orobanchol, orobanchyl acetate, strigolactones

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Foliar Application of Methanol on Some Quality Traits of Soybean under Deficit Irrigation

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To determine effects of methanol foliar application on soybean grain yield under, a factorial split-plot experiment based on a randomised complete block design with four replications was done at Research Field of Faculty of Agriculture and Natural Resources, Islamic Azad University-Karaj Branch, Karaj, Iran, during 2011. The first factor was drought stress in two levels (based on depletion of a1=40 % and a2=70 % of available soil moisture). The second factor was spraying times of methanol in two levels (in the morning at b1= 8–10 AM and in the evening at b2=19–21 PM). Third factor was foliar application number of methanol with three levels (each c1=7, c2=14 and c3= 21 days, Methanol spray was applied 5, 3 and 2 times during growth season of soybean, respectively). All treatments were sprayed with 21 % (v/v) methanol concentration. Grain yield, biomass, protein and oil percentage and yields were measured in this study. The results showed that there was significant ($p > 0.05$) differences between effects of drought stress level on measured parameters. Under normal irrigation, the highest (3187 kg ha^{-1}) and lowest (1526 kg ha^{-1}) soybean grain yield was obtained in a1 and a2, respectively. results of oil yield indicated that a1 and a2 were produced the most (731 kg ha^{-1}) and least (484 kg ha^{-1}), respectively. Besides, results showed that significant differences exists ($p > 0.05$) between interaction effects a*b, a*c, b*c and a*b*c in some traits, as under normal and deficit irrigation maximum grain yield were observed by methanol spraying every other week in the evening and every 7 days in the morning, respectively. Conclusion: It seems applying aqueous solutions 21 % (v/v) methanol on water deficit condition on different periods on soybean plants and time application can reduce harmful effects of drought and improve plant potential to cope with stress.

Keywords: Biomass, harvest index , methanol, soybean, yield

Genetic Variation in Salt Tolerance in Oilseed Rape

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Salinity is one of the harshest environmental stresses that drastically affect crop produciton in many parts of the world. About 20 % of the irrigated land throughout the world is salt effected. The objectives of this project are (i) to test the genetic variation in salt tolerance in a genetically very broad material, (ii) to analyse the variation in salt tolerance in a population of doubled haploid (DH) lines, and (ii) to identify genes for salt tolerance by QTL analyses.

The genetic material investigated consisted of (i) 13 genetically very different genotypes, and (ii) 138 DH lines from a cross between two very different parents. Seeds were germinated in ptri dishes without salt stress (control) and under salt stress (5 ml 200 mM NaCl added to each petri dish). Salt tolerance was estimated by two approaches: (i) germination percentage, and (ii) germination pace, which measures how fast the germination process starts.

For both germination percentage and germination pace a large genetic variation was observed. Under stress conditions, the heritability estimates were in similar range (0.75 for germination percentage and 0.86 for germination pace), but germination percentage and germination pace were not closely correlated.

As nest step a QTL mapping in this material is under progress. A limitation of the present date is, that only seedlngs up to eight days after germination were analysed. Therefore experiments to analyse salt tolerance of young plants (about four weeks after germination) and adult plants are planned. For such experiments a suitable experimental testing system is under development.

In conclusion, these preliminary results show a large genetic variation for salt tolerance in oilseed rape and are the basis of a specific breeding programm for salt tolerant oilseed rape for regions where this type of stess frequently occurs.

Keywords: Oilseed rape, salt tolerance

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Effects of Late Season Drought Stress on Yield and Physiological Traits of Spring Wheat Cultivars

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Undesired effects of drought on plant growth and development are higher than other environmental stress. Different crops with considering the environmental and economical conditions may counter to drought stress in a specific part of growth stage. Before introducing new cultivars for drought prone regions, it is necessary to determine the crop susceptibility to drought stress in different growth stage. In order to evaluate the effects of late season drought stress on yield and some physiological traits in five cultivar of spring wheat an experiment was conducted using strip-plots based on randomised complete block design, in Agricultural Research Station of Khorasan, Iran. Three levels of irrigation, *i.e.* complete irrigation (IR1), cutting of last irrigation (IR2), and cutting off two last irrigations (IR3) were in the main plots and the sub-plots were assigned to 5 cultivars of spring wheat. Based on the results, effect of irrigation treatments on grain yield, grain protein percentage and 1000 seed weight was significant and by increasing the intensity of drought stress grain yield, 1000 seed weight and weight of hectoliter decrease whereas protein percentage increased. Effects of irrigation treatments on canopy temperature and leaf relative water content (RWC), also was significant ($p < 0.05$), and with increasing drought stress canopy temperature increased but RWC decreased. Results showed that cutting last irrigation didn't have significant effects on yield and quality of wheat cultivars but cutting of tow last irrigations have significant effects on these traits. Based on current results measuring canopy temperature and RWC for determination of drought intensity is recommendable.

Keywords: Canopy temperature, chlorophyll, drought stress, relative water content

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Genetic Variation of Stem Characters in Wheat (*Triticum aestivum* L.) and their Relation to Yield Components under Drought and Heat Stress

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Drought and heat stresses, singly or in combination, are major constraints to wheat during grain filling in Mediterranean environments. After anthesis, the stored carbohydrates in stems play an important role in grain filling in wheat. The aim of this study was to find out the relationship between stem characters such as diameter, weight, and density and yield components including 1000-kernel weight (1000-KW) and grain yield per spike (GYPS). In addition, the genetic control of these characters was investigated. In season 2006/2007, a 7-parents F_1 diallel cross was grown under favourable, drought and combined drought and heat stresses environments. Polygenes with mainly additive effects were involved in the control of stem characters. Results showed that only stem diameter showed highly positive correlation with 1000-KW and GYPS under the three different environments. Stem density was positively correlated with 1000-KW under favourable environment and with GYPS under drought environment. On the other hand, stem weight did not show any correlation with the respective characters. The narrow-sense heritability (h^2) of stem diameter was of comparable magnitude under favourable (0.73), drought (0.62) and combined drought and heat stress (0.76). Stem diameter was negatively and significantly correlated with heat susceptibility index of 1000-KW (-0.37) but it was not significantly correlated with GPYS. The relationship between significant stem characters and 1000-KW and GYPS in 12 F_2 populations forming a 3×4 North Carolina Design was also investigated under heat stress in season 2007/2008. Stem diameter ($h^2 = 0.62$) displayed positive correlation with 1000-KW under heat stress which was uniformly significant in the 12 F_2 populations analysed and with GYPS in only 9 of the 12 populations. However, under heat stress stem density ($h^2 = 0.52$) was positively correlated with 1000-KW in only 5 F_2 populations and with GYPS in only 6 of the 12 F_2 populations. Based on strong correlation among stem diameter and yield components characters under stresses, we concluded that this character plays an important role in grain filling under such circumstances. This is possibly due to a greater stem capacity to store assimilates. Subsequently, after anthesis, these assimilates are being remobilised to grains.

Keywords: Heat susceptibility index, stem diameter, yield attributes

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The Effect of Environmental Conditions on Seed Germination of Some Saudi Arabian Rangeland Species

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Saudi Arabia experiences unpredictable and low rainfall and high temperatures. Growth of plants occurs mainly in winter. Rangelands occupy about 70 % of the land area. Factors which may relieve seed dormancy include: afterripening; chemical treatments such as potassium nitrite and nitrate; temperature and light.

Experiments were carried out to investigate the effects of light, different alternating and constant temperature regimes and several chemical treatments on seed germination and dormancy of six Saudi Arabian rangeland species. The ultimate aim is to anticipate potential impacts of global climate change.

Seeds of *Atriplex leucoclada*, *A. halimus*, *Calligonum comosum*, *Salsola villosa*, *Teucrium polium* and *Nitraria retusa* were collected in Saudi Arabia in 2007 and 2008. Seeds of *S. villosa* were tested with and without covering structures (wings). Germination of seeds collected in 2007 was tested at two alternating temperatures (15°/25°C, 10°/30°C, 12h/12h), three constant temperatures (10°, 20° and 30°C), two light treatments (light and darkness) and moistened with either water or 0.01 M potassium nitrite. Seeds collected in 2008 were germinated in a range of concentrations of (KNO_2) and (KNO_3) in alternating temperatures (15/25°C, 12h/12h) and light.

Optimum constant temperature for germination of *S. villosa* with and without wings and *T. polium* was 20°C with no promotion of germination at alternating temperatures implying that seeds were non-dormant. In *A. leucoclada*, (KNO_2) promoted germination in the light but not in darkness at all temperatures. In *A. halimus* there was no effect of light and slight promotion by alternating temperatures and potassium nitrite. In *C. comosum* potassium nitrite promoted germination in light but not in darkness at 20°C, 15/25°C and light generally promoted germination. In *S. villosa* with and without wings and *T. polium*, (KNO_2) generally inhibited germination. In *T. polium* light promoted germination in water at 10°, 30° and 10/30°C (data not shown) but not at 20°C , 15/25°C. The germination of *C. comosum* was promoted by exposure to low concentrations of (KNO_2) (10^{-3} M) and (KNO_2) (10^{-4} M).

Results are discussed with reference to the impact of the characteristics of seed dormancy and germination on the resilience of their regeneration in rangelands.

Keywords: Climate change, dormancy, germination, rangeland species

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Status Quo of Farmers Knowledge about Fruit Flies and Their Control in Mango and Guava Orchards in Some States in Sudan

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The expansion of urban areas resulted in increase in awareness of nutritional value of fruits. The latter lead to substantial increase of fruits area in Sudan where about 326,000 feddan were grown by different types of fruits in 2010. Mango (*Mangifera indica*) and guava (*Psidium guajava*) are the main fruits produced for local consumption and export. However, in the last years, fruit production was hampered significantly by fruit flies with infestation damage approaching 100 % in some areas. Accordingly, in 2008, fruit flies were added to the list of the national pests of Sudan by the first National Workshop on Fruit Flies. The workshop also recommended some control measures as a first procedure against fruit flies in Sudan. Following this a set of extension activities were conducted by the Federal Ministry of Agriculture among farmers to elevate their awareness about fruit flies and their control using pheromones and baited traps. A survey of about 50 fruit orchards was conducted in 2011, in central states of Sudan (Sennar, Gezira and Khartoum), using a semi-structured questionnaire. Descriptive analysis was used for data analysis. Results indicated that 76 % of sampled fruit farmers were well educated. Also, most of the sampled farmers (75 %) owned the land and grew less than 100 fruit trees in the orchard. Only 12 % of the farmers mentioned that they experienced high fruit fly infestation in their farms; 58 % sold the infested fruits, especially those in Khartoum. About 26 % of the sampled farmers received information about how to use pheromones, whereas 43 % use it. Moreover, 17 % of respondent farmers used the recommended application rate of Methyl Eugenol. No synthetic insecticides were used against fruit fly in orchards up to survey time. In conclusion, fruit producers are still lacking extension information on how and when to apply effective control measures against fruit flies.

Keywords: Fruit fly, guava, mango, Sudan, trap system

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Crop biotic stresses (DPG session)

Dermal and Inhalation Exposure Assessment of Pesticide Management in Greenhouse Flower Crops in Colombia

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Pesticides are chemicals of public health concern because epidemiological studies have evidenced the association between agricultural occupation activities and related health problems. Floriculture is an agricultural activity in developing countries in which the greenhouse environment conditions are designed to optimise the plant growing rather than to protect the worker's health. Colombia is the second world flower exporter with a cultivated area of 6800 hectares with an average of 15 workers per hectare. Numerous studies worldwide have assessed the exposure to pesticides in greenhouses; however, there are no available studies in the floriculture system in Colombia in which large number of workers might be at risk of exposure. In our research, we assess the dermal and inhalation exposure applying the Material Flow Analysis methodology to study the dispersion of the pesticides in the human body during pesticide management. The study area was a flower farm located in Sabaná de Bogotá, Colombia. The Whole Body Dosimetry was applied to obtain the pesticide distribution on the human body parts using the tracer uranine as pesticide surrogate and tyvek garments as sampling media. The Button Personal Inhalable Aerosol Sampler was used to measure inhalation exposure. The results show high levels of potential dermal exposure in upper body parts like abdomen, chest and back; however, the level of protection given by the personal protective equipment was higher than 98.6 %. Actual dermal exposure represented 0,48 % of the total amount of tracer applied. From the total human exposure (*i.e.* actual dermal exposure and inhalation), actual dermal exposure represented 95 % and inhalation exposure 5 %. Even though exposure values were very low, there is still a high health risk depending on pesticide toxicity, type of pesticide mixtures and total time of exposure. Therefore, further research is required to determine the level of human exposure and how the exposure dynamics change with the time when there is a cumulative exposure to pesticide mixtures affected by a determined degradation rate. This research was funded by the Swiss National Science Foundation and performed by a cooperation between LMU München, ETH Zürich, UniZürich, UniBoyacá and Universidad Nacional de Colombia.

Keywords: Colombia, dermal exposure assessment, developing countries, flowers, greenhouses, inhalation exposure assessment, material flow analysis, pesticides

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Effects of Sanitation and using Insect-Proof Screens on Population Density of *Chaetosiphon fragaefolii* (Cockerell) on Strawberry under Greenhouse Conditions

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The strawberry (*Fragaria ananassa* Duchesne) hosts a wide variety of aphid species. *Chaetosiphon fragaefolli* (Cockerell) (Homoptera: Aphididae) produces honeydew where sooty molds grow, leading to downgrading of the fruit. Although aphids are not the main pests in strawberry fields, strawberry aphid can be a serious problem because it can transmit viruses such as cytorhabdovirus, one of the most dangerous viruses affecting strawberry. In this study, strawberry plants cultivar Selva, were grown to determine the effect of crop sanitation and the use of insect-proof screens on the population density of *C. fragaefolii*, under greenhouse conditions (L:D 14:10, $26 \pm 2°C$ Temp., and $60 \pm 10\%$ R.H.). A field experiment was conducted during the 2010/2011 season, in two experimental greenhouses of the Iranian Research Organisation Science and Technology (IROST) in Tehran, Iran. Experiments were performed as factorial experiments in a completely randomised design with two factors, which were sampling time (at eight different times), and the type of greenhouse (organic and untreated (control) greenhouse) with ten replications. In the organic greenhouse, the crop sanitation and the insect-proof screens were used in order to protect the strawberry greenhouses for excluding aphid. Prior to planting, 13×23 screens (13×23 threads cm^{-2}, 13×23 screens have 13 threads by 23 threads in a centimeter square) were installed in all windows and doors of the greenhouse. The results indicate that under the conditions of the experiment aphid populations were significantly different in the greenhouses (F = 208.2688, $p < 0.0001$, df = 1). *C. fragaefolii* populations in the control greenhouse were significantly greater than populations in the organic greenhouse at all times of sampling. However, there was no significant difference between sampling times. There was also not a significant difference in time of sampling $\times$ type of greenhouse interaction, which suggested that difference in aphid population across a type of greenhouse was not relative to sampling times. Moreover, results showed that no aphid was found in the organic greenhouse in all the sampling times. It is concluded that sanitation and using insect-proof screens for *C. fragaefolii* populations control will benefit by decreasing insecticide application and have advantages in strawberry aphid integrated pest management programs.

Keywords: *Chaetosiphon fragaefolli*, organic greenhouse, sanitation, strawberry

Factors Influencing Performance of Seedplot Technique in Seed Potato Quality Improvement among Small Scale Farmers

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Potato seedborne diseases majorly causes continuous low yields in potato production in East and Central Africa. A small seedplot technology (SSPT) has been developed as a step towards effective management of the seedborne diseases. This was successfully promoted and adapted to varying farming conditions, as a self-sustaining technology for on-farm seed potato production, where disease-free seed is planted at high-density in plots that are apparently free from bacterial wilt. The objectives of the study were to establish the influence of spacing and fertiliser nutrient composition on the performance of small seedplot, and to determine the influence of fertiliser levels on the performance of small seedplot. Trials with 5 potato varieties were conducted in seven locations for three seasons. Different fertiliser types (DAP and NPK) and rates (0, 45, 90 kg N ha^{-1}) were used at a spacing of 20×20 cm and 30×30 cm, to optimise management for SSPT. In most locations, tuber numbers were higher with NPK application compared with DAP. When planting in common spacing of 75×30 cm the varieties used in the trials produce about 25 tubers m^{-1}, whereas the SSPT spacings of 20×20 cm and 30×30 cm produced 67 and 54 tubers m^{-2}, respectively. Data was collected on tuber number, size and weight. The results indicated that the spacing of 20×20 cm produced higher tuber number per m^{2} (51, 71 and 80 at 0, 45 and 90 kg N ha^{-1}, respectively) than with a spacing of 30×30 cm (45, 55 and 61 at 0, 45 and 90 kg N ha^{-1}, respectively). However, double starter seed is required and handling in planting is more difficult. Moreover, the multiplication rate per tuber was about 20 % higher at a spacing of 30×30 cm compared with the spacing of 20×20 cm. Hence, in general if clean land is extremely limited the spacing of 20×20 cm should be chosen to make best use of this part, whereas if clean land is relatively sufficient a spacing of 30×30 cm seems to be more practicable and economically viable.

Keywords: Fertiliser, seedplot, quality seed potato

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Entomopathogens as Endophytes, an Innovative Biological Control Strategy

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Entomopathogenic fungi are reported as effective biological control agents against many insect pests of crop plants, some of these entomopathogens have already been commercialised as biological insecticides, thereafter many examples were reported using these myco-insecticides under greenhouse and laboratory conditions, while the drawbacks of aerial applications under field conditions, showed limited control success. Because of these prevailing problems the idea of testing these Entomopathogenic fungi as endophytes came up. Bing and Lewis (1991) were the first to demonstrate the endophytism of *Beauveria bassiana* in maize plants and its effect on the European corn borer. Since then many other studies have been published testing the endophytic capacity of *Beauveria bassiana*. In contrast, only one paper has demonstrated that *Metarhyzium anisopliae* has an endophytic activity in tomato plants, at the same time promoting plant growth. It is likely that these entomopathogens have more than one mode of action operative in controlling plant pests and pathogens. One of these hypothesised modes of action relates to the production of secondary metabolites, acting as mycotoxins, such as Beauvericin from *Beauveria bassiana*, and Destruxin A, B, E and D known from *Metarhyzium anisopliae*.

In our research we present data on the effects of endophytic colonisation of two tomato cultivars (*Solanum lycopersicum*) by three strains of *Beauveria bassiana* and two strains of *Metarhyzium anisopliae* on greenhouse whitefly development (*Trialeurodes vaporariorum*). Culturing on fungal selective medium and Real-Time PCR proved successful endophytic colonisation of the selected fungi in both tomato cultivars, while HPLC analysis proved that the mycotoxins Beauvericin and Destruxin A were at the non-detectable levels. Moreover, we present in our results that endophytic colonisation of tomato plants with some of these entomopathogenic fungi strains can significantly enhance the growth of the plants. More evaluation for the field application of this biological control strategy is required; therefore, the detection of other possibly produced mycotoxins by *Beauveria bassiana* and *Metarhyzium anisopliae* and their possible synergic effect, the endophytism mechanism and the interaction mode with the host plant and its metabolites, as well as the interaction between the endophytic entomopathogen and the plants pathogens will be the aim of our coming research.

Keywords: Biological control, endophyte, entomopathogen, mycotoxin

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Integrating Varietal Resistance and Phosphonate Fungicide in Management of Foliar Late Blight in Potato

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Conventional potato production is not possible without fungicide and the commonly used fungicides are expensive and are considered as environmental and human hazards. The aim of the experiment was to evaluate the efficacy of Phosphonate fungicides, the potential of combination with potato cultivars and economic impact as late blight control alternative. Two Phosphonates formulations; Agrifos 400 and Fosphite were compared Ridomil alternated with Mancozeb on different potato varieties in Kabete and Koibatek. Agrifos 400 alone was compared with Ridomil alternated with Mancozeb on different varieties in Kisima, Njambini and Limuru. Planting was done in $3\,\text{m} \times 3\,\text{m}$ plots with four row and 10 tubers per row. Experimental units were replicated three times in a split-plot design. The results showed an effect of Phosphonates, which represent lower risks to human health and environment than conventional fungicides, on control of foliar late blight. In all the five sites Agrifos 400 was not significantly different with Ridomil alternated with Mancozeb in control of foliar late blight in most the varieties used and they were also comparable in yields with no significant differences in most of the sites. Preliminary economic analyses were also done and the result showed that there is more economic benefit in the use of Phosphonate formulation Agrifos 400 compared to conventional fungicides Ridomil and Mancozeb. The study suggests that the relatively inexpensive Phosphonate fungicides have significant potential to become an effective management tool for control of foliar late blight, and can be used as alternative to the hazardous conventional fungicides.

Keywords: Developing countries, economic benefit, phosphonate, *Phytopthora infestans*

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Agricultural Practices and Possibilities for IPM and Sustainable Resource Management in the Mojanda Watershed, Ecuador

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Agriculture in the Mojanda Watershed is facing rainfall reductions caused by climate change. Reductions of water availability in the Watershed are also due to constant extension of the agricultural activities into the páramo ecosystem above 3000 m asl, with this ecosystem having immanently important functions in the local water balance. The application of pesticides threatens the quality of water and with less precipitation contaminations will further concentrate in the outflow. To analyse problems associated with agricultural practices in the area a questionnaire about agricultural practices (28) was conducted and fields (20) were surveyed for pests and diseases with a focus on potatoes (*Solanum tuberosum* L.), tree tomatoes (*Solanum betaceum* Cav.) and peas (*Pisum sativum* L.). Potatoes were infected to a low degree with *Phytophthora infestans* and according to the farmers the Andean potato weevil (*Premnotrypes* spec.) caused biggest losses. To combat the weevil the soils are disinfected with toxic Carbofuran (WHO Class 1B). Tree tomatoes showed symptoms of various fungal diseases. Most important was *Fusarium solani* causing the branches to rot and Anthracnosis (*Colletotrichum gloeosporioides*) causing the fruits to rot. Fungicide applications were correspondingly high. Peas were only minorly affected by Ascochyta blight (*Mycosphaerella pinodes*) and a root rot. Overall 19 active ingredients were applied of which fungicide Mancozeb (WHO class table 5) and insecticide Carbofuran (WHO Class 1B) were applied the most. Common IPM methods are advised to reduce pesticide use. For tree tomatoes regular cutting of branches infected with *F. solani* and regular collection and disposal of infected fruits with Anthracnosis are advised. For potatoes plastic barriers around the fields prevent the Andean potato weevil from laying eggs thus reducing infestation with the larvae in the tubers. Local bioinsecticide "Biol" seems effective and without harm to the environment, although not used by many farmers. Organic fertilisation promises to restore decreasing soil fertility and reduce erosion. The newly established extension service programs of the Ecuadorian Government, "Schools of the Agrarian Revolution" (ERA) are aimed at reaching smallholders and reducing poverty, and should consider IPM methods for improving agricultural practices to solve local environmental problems.

Keywords: Ecuador, IPM, maize, Mojanda watershed, pea, pesticide use, potato

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Pesticide Contamination in Land Reform Settlements in Brazil: The Case of 'Cachoeira Bonita' in Caiaponia, Goias State

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Brazil is the largest consumer of pesticides in the world, especially products that are no longer used in developed countries. Public health studies in Brazil show that inadequate use of pesticides increases the incidence of accidents and contamination of poor rural communities in Brazil. The objective of this study was to identify factors that determine the occurrence of problems with pesticides in a typical Brazilian land reform settlement. The study was carried out in the land reform settlement of 'Cachoeira Bonita' in Caiaponia, Goias state, Brazil. In the empirical analysis the econometric model probit was used. The dependent dichotomous variable was the existence of health problems in the family setting that are caused by the use of pesticides. The independent variables were the family size (p value = 0.0098); the attendance to any church, whether Catholic or Protestant (p value = 0.4828); if farmers received any technical assistance (p value = 0.8251); the current health condition of the family (p value = 0.0223), and if there are exacerbated erosion problems on the farm (p value = 0.0298). Data from 28 farmers were collected through a structured questionnaire. The probit model showed good fit of 0.5694 by the McFadden R-squared statistic and of 20.02 by LR statistic. Among the main findings, larger families have a higher probability of accidents involving pesticides. The current health conditions of family and the problems of soil degradation in the farm imply a reduction in the likelihood of contamination with pesticides. These two results indicate that rural households that have good health condition and have experienced environmental degradation on their farm have higher environmental awareness. The variable technical assistance also reduces the likelihood of accidents with pesticides, but was not statistically significant. Finally, the church attendance variable was statistically non-significant and had an opposite sign to what we expected. Therefore, the study shows that decision makers must plan and programme policies (technical assistance, adequate handling of pesticide packing, waste control and management and environmental education) with focus on sustainable development, especially in these poor rural communities that are marginalised in the process of economic development.

Keywords: Environmental awareness, pesticide use

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Microclimatic Requirements for Wheat Blast (*Magnaporthe grisea*) and Characterisation of Resistance in Wheat

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Magnaporthe grisea is the causal pathogen of wheat blast, which can cause high yield losses in subtropical wheat production. Wheat blast has been a critical problem for wheat production areas in South America. The temperature and wetting period are important factors in the development of wheat blast. The effect of temperature (20, 23, 26, 29 and 32°C) and spike wetness time (24, 48, 72 and 96 h) on the flowering stage of ears were studied in the susceptible wheat cultivar BR18. The results showed that higher temperatures (>26°C) are conducive to the growth and infection of this pathogen, which is capable to induce high disease severity even at 29°C and 32°C. A minimum spike wetness time of 24 h was required for infection; wetting periods above 24 h had little effect on infection and the development of disease symptoms. Twenty-seven wheat lines were assessed for their resistance to wheat blast in a standardised screening assay in the climate room. Inoculations were performed on the leaves and on the ears in separate experiments in order to test the organ-specific responses. The set of tested cultivars represented a wide range of susceptibility/resistance responses to wheat blast. Leaf infection was not correlated with ear symptoms. Upon ear inoculation at flowering stages, cultivar MILAN showed the highest resistance to *M. grisea*, but this was associated with a relatively high susceptibility to *Fusarium* head blight (FHB, *Fusarium graminearum*). SUMAI 3 and GONDO-CBRD were susceptible for *M. grisea*, but relatively more resistant to *F. graminearum*. The study indicates the existence of resistance sources in wheat lines to blast. However, it also demonstrates different resistance factors being involved in the infection of wheat ears with head blight and blast.

Keywords: *Fusarium* head blight, *Magnaporthe grisea*, resistance, temperature, wetting periods, wheat blast

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Developing an IPM Strategy at the Vallée Du Kou Irrigated Rice Scheme in Burkina Faso

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Rice is one of the major food and cash crops in Burkina Faso. National production (270,000 tons of paddy) accounts only for 60 % of the population needs. Insect pests and diseases are major biotic constraints to rice productivity and production. At the irrigated rice scheme of Vallée du Kou (1200 ha) stem borers can cause as much as 40 % of yield loss during the dry cropping season. Therefore, there was a need to develop an IPM strategy. A study has been carried out from 2010 to 2011 during 4 consecutive cropping seasons (wet and dry) to investigate the effects of periods of transplanting on the occurrence of insect pests damages and their natural enemies. For this purpose, the irrigated rice scheme was divided into two zones within which 48 farmers' fields were randomly selected according to three periods of rice transplanting (16 fields per period). A network of 48 light traps was installed into the 48 sites. Entomological and agronomic observations were done every two weeks from the 21st day up to 80th day transplanting while records of trap catches done on a daily basis. Results revealed that insects of the *Chilo* genus (*C. zaconnius* and *C. diffusileneus*) were the major rice pests. Picks of adult populations were reached in dry season (April) each year. Damages and parasitism (up to 38,5 %) associated with stem borers as well as yields were higher during the third period of rice transplanting as compared to the two first ones. This is an important step in setting up an IPM strategy to control insect pests and diseases of rice, in order to contribute to the sustainable production and food security and to increase small farmers' income.

Keywords: Chilo, damages, insect pests, light traps, parasitism, rice, stem borers, transplanting

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A Model of the Potential Distribution of *Striga hermonthica* in the African Continent and its Prospection under Climate Change

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The genus *Striga* (Orobanchaceae) comprises parasitic weeds recognised as a major problem for crop production in sub-Saharan Africa. *Striga hermonthica* is an obligate parasite of pearl millet, sorghum and other important crops in semi-arid and arid regions of the tropics, producing millions of hectares of yield loses and a great impact on human welfare in the rural areas where it occurs. Under the present situation and the possible scenarios within the framework of climate change *Striga hermonthica*'s current and future distribution needs to be estimated urgently, in order to efficiently target available prevention and management strategies. Using the maximum entropy (Maxent) approach for modelling species' distributions, our research focuses on better describe the present distribution of *Striga hermonthica* and to predict potential future areas where this dangerous parasite could spread in the African continent.

Historical "presence-only" data gathered from museums together with field studies and climatic datasets from the IPCC 4th Assessment Report where used as inputs for our distribution models. Acknowledging the uncertainties of the future, the distribution of *Striga hermonthica* was projected for the year 2020, using the IPCC scenarios and their climatic models. Our intention is to provide managers and decision-makers a useful tool to take preventive and palliative actions against the menage of infestation. This is of great relevance especially for vulnerable areas where the parasite has not yet appeared.

The results of this research, based on the environmental preferences of *Striga hermonthica*, show the existence of two different sub-population in Africa where their current distributions and their different future trends can be identified.

Keywords: Africa, climate change, maxent, potential distribution, Striga

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Collective Action and On-farm Benefits of Pesticide Substitution: Case Study on Potato Pest Management Practices in the Peruvian Highlands

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Worldwide resource-poor farmers and their agricultural systems are affected by biotic stress from insect pests. Economic losses can be significant even with cost intensive standard control measures by pesticide use. Additionally there are serious threats to human health and the environment. Resilience of ecosystems is affected by pesticides' effect on natural enemies of invasive pest species. Hence there is a need for farmers having at hand sufficient options to adapt to those problems. International agricultural research for example of the International Potato Center's Global Program on IPM (Integrated Pest Management) has contributed to develop the availability of ecological options for pest control management. Field trials and results from participatory research on certain pest management practices (*e.g.* plastic barriers to control the Andean Potato Weevil, APW) with some communities in former CIP projects revealed clear benefits for adopting farmers. But for scaling out of the new technology problems like input market access and coordination within farming communities for collective action have to be considered. Ways to provide ecological pest management methods to farmers, on how to "educate" their adoption-decision making process and how to make their demand effective have to be found.

The poster will present first insights of an ongoing BMZ-CIP project in 6 communities of the Peruvian Highlands. Dissemination of plastic barriers as an option for APW control is linked to the economic analysis of the farmer's adoption-decision-making problem. The concept of possible cost savings from pesticide substitution and of higher production values (lower damages, higher producer prices) is introduced to farmers during training events, whereby an emphasis is put on the farmers doing their own calculus exercises. The respective material (manual for farmers and field extensionists) is being developed and tested. Farmers' coordination for collective action is being promoted by showing the individual benefits. The problem of input market access is tackled by facilitating a link to the respective sales agents. Positive lessons for scaling out and complementarity of intervention objectives can be learned from cooperation with a NGO partner. Empirical information on farmers' ex ante adoption situation and attitudes will be provided from a recent diagnostic survey.

Keywords: Adoption, collective action, pest management, potato

Euphorbia hirta Extract for Manipulation of Seed Germination and Haustorium Initiation in *Phelipanche ramosa*

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Phelipanche ramosa L. (Pomel), a devastating root parasitic weed, is a copious seed producer. The seeds are characterised by prolonged viability and special germination requirements. The seeds, following pre-treatment, conditioning, in a moist moderately cool environment for several days, germinate in response to exogenous stimulants. Subsequent to germination the radical elongates and in response to a second host-derived stimulant a haustorium is initiated and attachment to the host root is achieved. The parasite inflicts most of its damage to the host prior to emergence. Manipulations of seed germination and pre-attachment stages are therefore mandatory to avoid and/or reduce the damage and subsequent yield losses. A series of laboratory experiments was undertaken to investigate the effects of aqueous extracts from *Euphorbia hirta* on germination, radical elongation and haustorium initiation in *P. ramosa*. *P. ramosa* seeds conditioned in water and subsequently treated with diluted *E. hirta* extract (10–25 % v/v) displayed considerable germination (47–62 %). Increasing extract concentration to 50 % or more, inhibited germination significantly. Undiluted extract resulted in lower germination (27 %). Conditioning of *P. ramosa* seeds in *Euphorbia* extract inhibited germination in response to the synthetic germination stimulants GR24 and Nijmegen-1 in a concentration dependent manner. *P. ramosa* germlings treated with diluted *Euphorbia* extract (10–75 % v/v) displayed haustorium initiation comparable to DMBQ at 20 μM. *Euphorbia* extract applied during conditioning reduced haustorium initiation in a concentration dependent manner. The results indicate the potentials of *E. hirta* as a source of compounds that can be used as templates for synthesis of more active compounds to manipulate pre-attachment stages in *P. ramosa*.

Keywords: Euphorbiaceae, parasitic weeds, strigolactones, suicidal germination

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The Dark Side of Fungal Melanin: *Alternaria alternata* as Example

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Melanins are dark, brown to black, high molecular weight pigments produced by organisms ranging from animals and plants to micro-organisms. These pigments are formed by the oxidative polymerisation of phenolic or indolic compounds. Melanins appear to have an indirect as well as a direct function in virulence of microorganisms. Melanins accumulate in fungal cell walls and act as body armour protecting fungi against environmental stress or unfavourable conditions like extreme temperatures, drought, UV, ionizing and gamma radiations, compounds secreted by microbial antagonists, and defense responses of host plants and animals against fungal infection. The potential protection role of melanins produced in fungal cell walls against radiations was investigated in this study through the assessment of the inhibitory effect of UV-radiation on the growth rate of *Alternaria alternata* as a melanized fungus and *Fusarium oxysporum* and *Penicillium digitatum* as non-melanized fungi. Spore suspensions of these fungi were exposed to different wavelengths of UV-radiation (300 nm & 600 nm). The growth rates of these fungi were measured after 3, 6 and 9 days of incubation. The results showed that the inhibitory effect of UV-radiation against the nonmelanized fungi; *F. oxysporum* and *P. digitatum* was significant when compared to the melanized fungus *A. alternata* which tolerated the radiation with growth rates of $0.07\,\mathrm{mm\,h^{-1}}$, $0.06\,\mathrm{mm\,h^{-1}}$ and $0.23\,\mathrm{mm\,h^{-1}}$, respectively when exposed to the wavelength 600 nm of UV-radiation. When putting in consideration the wide application of the classical methods for sterilisation as well as by UV-radiation, the gloomy picture of protection becomes clear as melanin is produced by some wide spread fungi.

Keywords: *Alternaria alternata*, melanin, UV-radiation, wavelength

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Effects of Triclopyr and Nitrogen on Striga Incidence and Sorghum Growth and Yield

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Striga hermonthica, an important root parasitic plant on cereals, is a difficult weed to control. Several control measures were reported, but their performance was often inconsistent. The present investigation was undertaken to study the effects of nitrogen, the herbicide tricolpyr and their combinations on Striga incidence and sorghum growth and grain yield. Striga count, in the untreated control, was 10 and 34 plants m^{-2} early and late in the season, respectively. Nitrogen at 43.8 and 87.6 kg ha^{-1} displayed excellent (>80%) suppression of the parasite early in the season, however, only, poor (22-38 %) control was achieved late in the season. Tricolpyr at 0.68 kg a.e. ha^{-1}, alone, resulted in moderate to poor control of the parasite. The herbicide at 1.0 and 1.4 kg a.e. ha^{-1}, irrespective of nitrogen, resulted in good to excellent (72-100 %) suppression of the weed throughout the season. Unrestricted Striga parasitism increased sorghum peduncle length, significantly. Nitrogen at 43.8 and 87.6 kg ha^{-1} reduced peduncle length by 10 and 44%, respectively. Triclopyr, alone and in combinations with nitrogen reduced peduncle length by 44-61 %. Striga parasitism resulted in a low head weight (32.5 g). Nitrogen had inconsistent effects. Triclopyr alone at 0.68 kg a.e. ha^{-1} had no effect. However, the herbicide at 1.0 and 1.4 kg a.e. ha^{-1} increased head weight by 49 and 36 %, respectively. Triclopyr, at all rates, when supplemented with nitrogen increased head weight by 37-54 %. Unrestricted Striga parasitism reduced sorghum grain yield significantly. Nitrogen at 43.8 and 87.6 kg ha^{-1} increased grain yield by 32 and 24 %, respectively. Tricolpyr, at 0.68, 1.0 and 1.4 kg a.e ha^{-1}, alone, increased grain yield by 10.4, 54.8 and 30.5%, respectively. Tricolpyr, at all rates, when supplemented with nitrogen, at the lower rate, increased grain yield by 41-52%. Increasing nitrogen to 87.6 kg ha-1 increased grain yield by 56-57%. The data indicate that triclopyr at 1.0 and 1.4 kg a.e. ha^{-1}, when supplemented with nitrogen, had the most consistent performance and resulted in the highest suppression of the parasite and the highest sorghum grain yield.

Keywords: Nitrogen, sorghum, striga, triclopyr

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Modelling Pesticide Fate in the Lower Mekong Delta

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Vietnam is the second largest rice exporter in the world and the Lower Mekong Delta is the main rice growing area in the country. Besides rice, fruit and shrimp farming are important industries. Due to its significance in agriculture and aquaculture, water quality is of essential importance. However, previous research has shown that water pollution by pesticides is a considerable risk for agricultural production as well as for human health. Despite these facts, pesticide monitoring for recently used active ingredients has not yet been established on a regular basis. Similarly, no efforts have been made to predict pesticide pollution and build up different scenarios using mathematical models.

To address these gaps, pesticide use was investigated through surveys and participatory rural appraisals with farmers; pesticide residue concentrations were monitored in field outflows, connected irrigation canals and in drinking water and finally pesticide fate was modelled using different tools such as Steps1–2, RICEWQ and a coupled MIKE 11/ MIKE SHE model. This abstract focuses on a pesticide use survey and pesticide modelling in an agricultural area with two intensive paddy rice crops per year (An Long Commune, Dong Thap province). The fate of ten pesticide compounds (buprofezin, butachlor, cypermethrin, difenozonazol, fenobucarb, fipronil, hexaconazol, isoprothiolane, pretilachlor, and propiconazol) was modelled from April to July 2009.

Steps1–2 builds up the potential "worst case scenario" of pesticide concentrations in water and sediment phases via run-off and spray drift. RICEWQ predicts mainly the concentrations of pesticides and their metabolites as a result of agrochemical run-off. Finally, the fully distributed, physically-based model MIKE SHE and MIKE 11 enables to track pesticide movement in different water zones under various conditions and to evaluate the likely impacts of alternative mitigation strategies. These three approaches together allow providing a risk assessment to humans and/or aquatic organisms with regard to pesticides pollution.

Keywords: MIKESHE, pesticide, RICEWQ, STEPS12, water surface

Measuring Resistance in Potato to *Phytophthora infestans* with Field, Laboratory and Greenhouse Assays

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Host plant resistance against *Phytophthora infestans* was evaluated for twenty-five potato genotypes in 2010 and 2011 at Khumaltar, Lalitpur, Nepal. A locally isolated strain of *P. infestans* 'LPR-1' was used for inoculation in all the assays. Host resistance was measured with four assays, three for foliage resistance (field, whole-plant and detached leaf) and one for tuber resistance (tuber slice). The inoculum concentration was 6×10^3 sporangia ml^{-1} in all the assays. Inoculum was equally distributed over the entire foliage using plastic atomizer in field and whole-plant assays. Detached leaves and tuber slices were inoculated with $50\,\mu$l suspension of inoculum and incubated at $16.5 \pm 0.5°$C for 7 days. Infected foliage area in the field and whole-plant assays, lesion size on detached leaves and colony growth on tuber slices were all individually converted to a 0–9 interval scale for susceptibility. Field assessment was considered the most robust measure of resistance and therefore was used as the benchmark for comparing the other assays.

More than half of the genotypes had very little disease (scale value < 1), indicating they were probably expressing race-specific resistance. Susceptibility levels measured in the whole-plant assay were highly correlated (r=0.90) with field values, while the correlation was lower for detached leaf (r=0.63) and tuber slice (r=0.46) assays. Low correlation in the detached leaf assay was assumed to represent lower resolution of the single-cycle assay, and/or experimental error. Low correlation in the tuber assay may have also reflected genetic differences as foliage and tuber blight resistance are not always correlated.

Keywords: Assays, detached leaves, host resistance, late blight, quantification, tuber slice, potatoe

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Effects of High Temperature on R Gene Mediated Resistance to Rice Blast in two Genetic Backgrounds of Rice

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Breeding for resistance to rice blast (*Magnaporthe oryzae*), an economically important rice disease worldwide, has relied on broad spectrum resistance mediated by R genes for several years. However, higher temperatures associated with climate change probably modulate the defense response of rice to Magnaporthe oryzae infection. The aim of this work was to evaluate the resistance to rice blast pathogen at two temperature regimes (35°C and 28°C). Five broad spectrum resistance genes (Piz-t, Pib, Pik-h, Pi5(t) and Pita) in two genetic backgrounds; *Oryza indica* type and *O. japonica* type, their background parents (Co39 and Lijiangxintuanheigu (LTH)) and one cultivar from East Africa were evaluated for resistance to two strains, the highly aggressive TAN16 from Tanzania and UgM14 from Uganda. Disease incidence and severity varied significantly between isogenic lines. At high temperature (35°C), three R genes (Piz-t, Pib, Pik-h) conferred resistance in both backgrounds whereas one cultivar, NERICA 4, showed increased susceptibility. At normal temperature (28°C), the *O. indica* isogenic lines showed a shorter incubation period and increased rate of lesion expansion compared to the *O. japonica* isogenic lines. Slow-blasting was observed on LTH, the *O. japonica* background parent, at both normal and high temperature when compared to Co39. These results suggest that the genetic background and temperature play a role in expression as well as effectiveness of R gene mediated resistance in the rice-*Magnapothe oryzae* interaction. The comparison of the green house screening results with the gene expression studies will contribute to determine whether the R genes in the two genetic backgrounds share a common gene regulatory network at high temperature or otherwise.

Keywords: Genetic background, *Magnaporthe oryzae*, resistance genes, temperature

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Formulation of a Granulovirus-Based Biopesticide for Managing the Potato Tuber Moth in Stored Potatoes in Nepal

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The potato tuber moth, *Phthorimaea operculella* (Zeller) is one of the major insect pests causing significant economic losses during potato storage. The granulovirus infecting *P. operculella* (*Phop*GV) has been used as a dust-formulation for protecting stored potatoes in several South American and North African countries. In 2008, a *Phop*GV was also isolated in Nepal and *in vivo* multiplied at NARC for further propagation as a biopesticide. In this study, two formulation methods for a virus-talcum product (dry and wet), product's virus titer, and application rate was tested in laboratory bioassays. For the wet formulation the virus was mixed with water and talcum (1:1 w/w) and the dried product was used; while for the second formulation a virus-talcum mixture was prepared similarly but with a 20-fold and 60-fold increased virus titer and then further mixed with talcum alone until obtaining the same virus titers as in the wet formulation. For each formulation and application rate, six virus concentration levels (from 0.007 to 6.8×10^{-6} larval equivalents (LE) kg^{-1} potato) were tested. Application rates of the product were variable between 3 and 12 g kg^{-1} potato. Bioassays were conducted with 50 neonate *P. operculella* larvae inoculated onto 100 g of treated potato tubers. Each treatment was replicated 4-times (completely randomised). Probit regression lines were fitted in a parallel assay to each formulation and application rate and treatments compared by the relative potencies. All regression lines revealed a common slope of 1.3 (SE$\pm$0.24). Talcum increased larval mortality through physical protection described by a probit line (y=-1.56+1.15 ln[x in g kg^{-1}]). For the wet-formulated product data revealed a LC_{50}-value of 0.30 (CL95%: 0.25-0.35) LE ton^{-1} potatoes, independent of the product's application rate. For the dry-formulated product, LC_{50}-value were variable ranging from 1.34 to 6.55 LE ton^{-1} potatoes, corresponding to potencies of 0.22 and 0.04-0.14 compared to the wet formulation, for the 20-fold and 60-fold increased virus stock preparation. It can be recommended to apply the product at a rate of 5 g kg^{-1}; the product should contain 3.6 LE kg^{-1} talcum (LC_{99}). The dry formulation method might be simpler to produce; however, the virus titer should be increased to adjust for reduced potency.

Keywords: Biocontrol, entomopathogen, integrated pest management, *Phthorimaea operculella*, potato insect pests

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Efficiency of Push-pull Technology Dissemination Pathways for Stemborer and Striga Control in Western Kenya: Data Envelopment Analysis Approach

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"Push-pull" technology (PPT) has widely been promoted as a control measure for stemborer and *striga* weeds in maize fields in Kenya. The technology is relatively knowledge-intensive; and provision of information about it is critical for its adoption and continued use. Research funding is becoming limited thus knowledge of efficiency in resource utilisation is a prerequisite in optimising the adoption process. This study focused on the efficiency with which information about PPT is passed on to farmers. Efficiency analysis is linked to the relative difficulty encountered in estimating the performance of production units. In our case, efficiency was viewed as a ratio of inputs in terms of the expenditures on each dissemination pathway, to the output as the number of recipients who become aware of the technology and end up using it. Secondary data from project records was used and three dissemination pathways evaluated namely field days (FD), farmer field schools (FFS) and farmer teachers (FT) were evaluation. Data envelopment analysis (DEA) was used where each dissemination pathway was treated as a decision making unit (DMU). Two DEA models were estimated using the assumption of variable returns to scale (VRS): Model one considered the number of farmers trained per pathway as the output, while model two considered the proportion of adopters as the output. The results showed that in the first scenario, FD had the highest efficiency (90 %), followed by FFS whose efficiency was slightly above 60 % and finally FT with efficiency of 40 %. In the second scenario, FT led with an efficiency score of 70 %, followed by FD (58 %) and finally FFS (52 %). On average, the pathways were operating below the efficient scale suggesting that adjusting the scale of operation would probably improve the overall efficiency of the pathways. There is still a scope for the institution to increase the number of farmers trained for each pathway using the current levels of resources. Use of FD is more efficient than FFS and FT in the short-run, but in the long-run, use of FTs would be appropriate since the ultimate goal of dissemination is to optimise adoption.

Keywords: Dissemination pathways, efficiency, push-pull technology

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Characterisation of Plant Growth Promoting Rhizobacteria and their Potential as Bioprotectant Against Tomato Bacterial Wilt Caused by *Ralstonia solanacearum*

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Bacterial wilt caused by *Ralstonia solanacearum* is one of the most destructive bacterial diseases of tomato and several other economically important crops. To develop a biological control strategy against the pathogen, 150 strains of rhizobacteria were isolated from tomato and potato fields in Ethiopia and screened for *in vitro* antibiosis. Thirteen strains inhibited the growth of *R. solanacearum*. They were identified as *Pseudomonas putida*, *P. veronii* and *Pseudomonas* spp, *Serratia marcescens* and *Bacillus cereus*. These strains were further characterised for their plant growth promoting traits: 11 strains produced siderophores, 9 strains solubilised inorganic phosphate, all strains produced indole acetic acid and only 1 strain produced HCN. Only strain *P. putida* PP3WT produced the quorum sensing molecule and showed quorum sensing inhibition which was depicted by the lack of pigment production by the indicator culture in the vicinity of the test strain (PP3WT). Based on the *in vitro* screening, five strains BC1AW, BC2BA, BC3AW, BC4SS and PP3WT (*B. cereus* and *P. putida*, respectively) were selected for ad planta tests. Strains BC1AW and PP3WT significantly reduced bacterial wilt incidence in tomato genotypes King Kong 2 (moderately resistant) by 46.8, 44.7 % and L390 (susceptible) by 33.6, 30 %, respectively in pot experiments, while in split root experiments they reduced by 48.7, 43.2 % and 25.7 %, 20.1 % in King Kong 2 and L390, respectively. Shoot dry weight increased in plants treated with BC1AW and PP3WT and reduced the number of *R. solanacearum* in mid-stems of both tomato genotypes. Hence, BC1AW and PP3WT were selected as promising strains whose effectiveness under field conditions and their mode of action at molecular level should be investigated.

Keywords: Hydrogen cyanide, induced resistance, quorum sensing, *R. solanacearum*, rhizobacteria, siderophore, tomato bacterial wilt

Global Gene Expression of Rhizobacteria and/or Silicon Mediated Induced Systemic Resistance to *Ralstonia solanacearum* in Tomato (*Solanum lycopersicum*)

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After priming tomato (*Solanum lycopersicum*) plants with silicon and/or the rhizobacterium *Bacillus pumilus* and later inoculating them with *Ralstonia solanacearum*, a transcriptome analysis of stem tissues was done to examine gene expression. A total of 174 genes were differentially regulated of which 113 were up-regulated and 61 down-regulated. Functional categorisation of these genes revealed that most of the up-regulated genes were involved in signal transduction, defence, protein synthesis and metabolism, while a large proportion of down-regulated genes were involved in metabolism, photosynthesis, signal transduction and lipid metabolism. Silicon priming up-regulated defence related genes and transcripts belonging to the salicylic acid dependent pathway which leads to induction of systemic acquired resistance (SAR). Defence related genes such as peroxidase, PAL and PR proteins were up-regulated in *B. pumilus* primed plants. A greater number of defence related genes were up-regulated in silicone primed plants than in *B. pumilus* primed plants. When plants were primed with both silicone and *B. pumilus*, five genes were down-regulated which were up-regulated when plants were primed with either silicone or *B. pumilus*. This suggests an antagonistic interaction between genes, which was mediated by ethylene-jasmonate and salicylate pathways. In all the tested combinations, inoculation of *R. solanacearum* to the primed plant was decisive: the effect of silicon priming will only manifest in the presence of the pathogen. This was also observed in previous enzyme assays and ad planta experiments.

In conclusion, separate applications of either silicone or *B. pumilus* is recommended over their combined application for the induction of resistance to *R. solanacearum* in tomato, with silicon being the stronger resistance inducer than *B. pumilus*.

Keywords: Ethylene, jasmonic acid, priming, Ralstonia solanacearum, rhizobacteria, signal transduction, silicon, *Solanum lycopersicum*, transcriptome

Lines from Brazilian Dry Bean Breeding Programs with White Mold Resistance

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Dry bean lines developed for the State of Minas Gerais (MG), Brazil, are tested every year at several locations, but generally without white mold (WM) pressure. The experiments installed to test these lines are called "cultivation and use value" (VCU). Our hypothesis is that among the lines included in the VCUs there are some with levels of WM resistance higher than those of the current cultivars. Lines/cultivars tested in the VCUs conducted in 2008, 2009, and 2010 were assessed for their reaction to WM and yield in an area naturally infested with sclerotia, in Oratórios, MG. Based on the results obtained in the VCUs, seven lines (VC 17, VP 21, CNFC 10720, CNFC 10722, CNFP 10798, CNFP 11980, and CNFC 11965) and the cultivars BRS Vereda and Ouro Branco were selected. In a separate experiment, the reactions of these lines/cultivars to WM were compared with the reactions of the following current cultivars: Pérola, BRSMG Majestoso, Ouro Negro, and Ouro Vermelho. The line A 195, which is known for its WM resistance, was also included for comparison. White mold intensity (incidence + severity) was evaluated visually, using a 1-to-9 scale. Yield varied from 907 to 2716 kg ha^{-1}. Significant correlations were observed between WM intensity and yield (r = -0.69***) and WM intensity and lodging (r = 0.56***). Six lines, two of them of type III, were ranked in the group with the highest yield. WM intensity of these lines varied from 4.2 to 5.6. These VW intensities were similar to that verified for the line A 195. On the other hand, three current cultivars were ranked in the group with the lowest yield. WM intensities of these cultivars varied from 6.3 to 7.5. These results indicate that advanced breeding lines should be tested under WM pressure before being released as a new cultivar. They also suggest that good source of resistance to WM are present in the lines and cultivars of dry beanCultivars/lines with resistance to WM might require fewer fungicide applications than current cultivars.

Keywords: Common beans, integrated management, *Phaseolus vulgaris*, *Sclerotinia sclerotiorum*

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Population Cycles and Economic Losses Caused by *Zeuzera pyrina* in an Olive Orchard, Egypt

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The leopard moth, *Zeuzera pyrina* L. (ZP) (Lepidoptera: Cossidae), is an European species with an increasing importance in the last few decades in Egypt. Seasonal trends in light-pheromone trap catches for ZP over the period 2002 to 2009 in badly infested olive plots are presented. The ZP moths occurred continuously from late April throughout the growing season and into fall (beginning harvest). The ZP has an annual biological cycle in olives, in Egypt. The results provided evidence of periodic changes in population densities. It seems that the bearing pattern generate periodic oscillation, *e.g.* larger number of moths in off-year and smaller one in on-year. The ZP reached outbreak densities in the 8th year of the trapping study. The outbreak cycle may be within the range of 8–12 years. These findings are discussed in relation to bearing patterns of olive trees.

A three-year field experiment was conducted to show that olive strip cropping may reduce ZP infestation and crop losses in olive orchards. In the first 2 years two highly susceptible local varieties (Sennara and Toffahi) were planted and naturally injured by ZP at a severe level. Yield losses were estimated at 2.6 to 3.1 t ha^{-1} for Sennara and 2.1 to 4.8 t ha^{-1} for Toffahi. The value of these losses was estimated at US\$ 1605.7 to 1770.1 per ha for Sennara and 1433.1 to 3215.8 per ha for Toffahi. In the 3rd year we compared the response of eight olive varieties with different cropping systems (variety mixtures) to ZP incidence and their subsequent yield and value of losses. The results suggested that mixing olive varieties can assist in ZP control. Also, yield loss due to ZP damage is influenced by the companion variety and neighbouring vegetation.

Keywords: Economic loss, leopard moth, olive tree, population trend

Multi-Criteria Analysis for Identifying Appropriate Pest Management in Tomato Production in Chiang Mai Province, Thailand

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Pest management practised in commercial small-scale vegetable production has widely been criticised due to associated negative effects of pesticides use. In northern Thailand this issue has recently received increasing attention and alternatives to conventional production systems have evolved. These new approaches focus on differentiated spread of risks through the employment of (integrated) pest management as well as associated adaptations of production considering external conditions. Still, there is a lack of holistic scientific studies comparing the new approaches to conventional practices. The framework of the present study combines an economic analysis with a multi-criteria analysis. This aids in analysing the reasoning in qualitatively different pest management schemes in four small-scale tomato production systems in Chiang Mai Province, Thailand. Special attention is hereby given to the toxicity and environmental impacts of the applied pesticides as well as to associated production risks, financial risks, market risks and health risks in tomato production. In total 71 tomato producers were interviewed in pre-structured interviews. The obtained data was processed with the software package STATA. The results show a conventional open field tomato production system with comparably low profits of 9,886 baht ha^{-1}month^{-1} and the highest market risk, highest health risk and highest environmental impact of all analysed tomato production systems. An open field tomato production system, technically supported by Thailand's Royal Project Foundation, presents the highest profits of 42,297 baht ha^{-1}month^{-1}. However, the most efficient way of combining economically feasible pest management with the reduction of environmental impact and of other associated risks presents a tomato production system using transparent plastic roofing. The Royal Project Foundation also supports this group of tomato producers.

Keywords: EIQ, IPM, MCA, Pesticide use, risk assessment

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Cropping systems to maintain soil quality and available soil moisture

In-field Rainwater Harvesting: A Promising Production Technology for Improving Crop Yields in Semi-Arid Regions of South Africa

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Crop yields in semi-arid regions of sub-Saharan Africa continue to be low largely due to the low and unreliable rainfall. Research results from the region have shown that the low rainfall is further lost by evaporation from the soil and runoff from the fields. Water harvesting soil tillage technique to improve crop yields of small scale farmers in the Limpopo Province of South Africa was introduced during 2007/2008 and 2008/2009 cropping seasons. The aim of the study was to determine the effect of two tillage methods and intercropping on yield and water use parameters of sunflower (*Helianthus annuus* L.) and cowpeas (*Vigna unguiculata* L.). Tillage methods tested were in-field rainwater harvesting (IRWH) and conventional tillage (CT). IRWH is a special crop production technique that promotes runoff on 2-m wide no-till strip between crop rows and collects the runoff water in basins where it infiltrates into the soil profile. The experiment was configured as a split plot design with tillage as main plots and cropping systems as sub-plots. Cropping system treatments consisted of a single crop (sunflower or cowpea) and intercrop (sunflower $\times$ cowpea). The two year experiment proved that the IRWH technique significantly increased the yields of sunflower compared to the CT. The results showed further the single stand sunflower and cowpea crops produced significantly higher yields at lower water use levels than where these crops were intercropped. Thus, it was clear that the single stand cropping practice were more efficient than the intercropping practice in converting rainwater into food.

Keywords: Cowpea, intercropping, Limpopo Province, sunflower, tillage

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Medium-Term Impact of Tillage and Residue Management on Soil Quality and Crop Productivity

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Soil fertility depletion and degradation are major biophysical causes of stagnating crop yields in sub-Saharan Africa. Conservation Agriculture (CA) is widely promoted for its potential benefits including lower soil erosion, increased soil organic matter, and higher and/or more stable crop yields. CA refers to (i) continuous minimum soil disturbance; (ii) permanent organic soil cover; and (iii) diversification of crops grown in sequence or associations. However, rigorous empirical evidence of CA benefits from sub-Saharan Africa is still limited.

This study aimed to quantify the medium-term impact of tillage and crop residue management on soil aggregate stability, soil carbon and crop productivity in a maize-soybean rotation. A replicated tillage (conventional, reduced) and residue management (retention, removal) field trial was installed in sub-humid western Kenya in 2003. Soil aggregate fractions, soil carbon and crop yields were measured from 2005 to 2008.

Conventional tillage decreased water stable aggregate mean weight diameter by 50 % at 0-15 cm ($p < 0.001$) and 12% at 15-30 cm soil depth ($p = 0.027$), indicating increased susceptibility to erosion. Tillage or residue management alone did not affect soil C contents, but when residue was incorporated by conventional tillage, soil C increased at 15-30 cm ($p = 0.037$). Results did not suggest physical C protection within soil aggregates. Thus soil (aggregate) C results indicate that the potential of CA for climate change mitigation might be overestimated. The weak residue effect on aggregate stability and soil C may be attributed to insufficient residue retention, and removal by termites and rainstorms. Soybean grain yields tended to be suppressed under reduced tillage without residue retention, especially in wet seasons ($p = 0.070$).

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This is likely explained by high runoff, resulting from slaking and crust formation. Future research should investigate critical minimum residue retention levels for soil conservation and crop productivity and develop methods for smallholder farmers to retain sufficient residue cover.

Amazonian Dark Earths and the Potential of Biochar for their Re-Creation

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Amazonian Dark Earths (ADE), in Portuguese Terra Preta de Índio, are anthropogenic soils. Soils of Amazonia are mainly acid Oxisols, Ultisols and Inceptisols with low fertility. Characteristic feature of ADE is high C content, which is increased usually by addition of high amount of biochar. According to many previous studies these anthropogenic soils greatly improve the yields of cultivated crops. The aim was to prove the positive influence of biochar application on plant growth and biomass production and further explore the possibility of biochar to improve the current agricultural systems in Peruvian Amazon, and thus, decrease the deforestation. For the experiment we chose two locally grown crops and one native tree from three distinct families - rice, (*Oryza sativa* L. – Poaceae); cowpea, (*Vigna unguiculata* [L.] Walp – Fabaceae) and bolaina blanca (*Guazuma crinita* Mart. – Malvaceae). The plants were grown in plastic bags with two kilograms of Amazonian Ultisol and different additions of two types of biochar, partly decomposed chicken manure and inorganic NPK fertiliser. After six weeks of cultivation we measured the stems and roots, weighted above- and belowground biomass and analysed pH and soil and foliar nutrient contents. Additionally, study of charcoal production and utilisation was done with in depth interviews using questionnaires among local farmers and charcoal producers. Soil organic matter and pH were increased by all biochar amendments. Generally, biochar improved soil nutrient content and soil properties, but influenced biomass production and foliar content in smaller extent than it was expected. Significant increase of biomass production was observed only in case of cowpea, which was probably caused by the ability of cowpea to balance higher C:N ratio by symbiotic N fixing. Furthermore, we found generally higher influence on root growth which suggests that higher effect on aboveground growth could possibly be observed after longer cultivation time. Residues from charcoal production are potential source of low-cost biochar, however, these are not widely used in agriculture. Results indicate that agricultural method using biochar from charcoal production could be a potential improvement of recent agriculture in Peruvian Amazon. However, more especially long-term experiments need to be done.

Keywords: Biochar, nutrient content, Peruvian Amazon, soil fertility, Ultisol

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Resilience of Organic *versus* Conventional Farming Systems in Tropical Africa: The Kenyan Experience

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In Kenya, agriculture is largely carried out by smallholder farmers, in a mixed farming non-commercialised setting where application of synthetic fertilisers and pesticides is minimal. Agricultural production is low and constrained by declining soil fertility, pest and diseases and increasingly unpredictable weather due to global warming. This calls for more resilient farming systems. Conventional farming is widely advocated because it delivers more yields in the short-term, but it is less effective in combating climate change because of the high energy requirement during manufacture of fertilisers. Conversely, organic farming which is based on the use of natural soil biological cycles to boost nutrient cycling, enhancement of natural plant protection mechanisms, avoidance of pollution and use of nitrogen fixation systems and plants with a high carbon sequestration potential to fix nitrogen and carbon respectively is considered better suited at mitigating climate change. In 2007, a long-term project was established in Central Kenya to compare organic and conventional farming systems at commercial and local farmer input levels using agronomic, environmental and social economic data and to disseminate the findings to stakeholders. The trial features 4 treatments (Conventional High, Conventional Low, Organic High and Organic Low) in a Randomised Complete Block Design (RCBD). Nutrients in 'Conventional' treatments are supplied by farmyard manure, diammonium phosphate, calcium ammonium nitrate and compost, while *Tithonia diversifolia*, and rock phosphate supply nutrients in 'Organic' treatments. Pests are controlled using biopesticides and chemical products in 'Organic' and 'Conventional' treatments, respectively. A three-year, maize/baby corn based rotation system is followed. There were no treatment differences in yield ($p = 0.101$) in 2007, but stover weights in Conventional High were superior to Organic Low and indistinguishable from Conventional Low and Organic High ($p = 0.034$). Differences between treatments however were observed in 2011 yields ($p = 0.027$) and stover ($p = 0.003$). Dry matter yields in Conventional High and Organic High treatments were lower than in Organic Low and indistinguishable from Conventional Low. Whereas stover weights at the same input level were indistinguishable, they were higher at the higher input level. The results suggested that organic farming may be a viable option for tropical Africa.

Keywords: Baby corn, conventional, grain, maize, organic, stover

Responses of Different Tropical Forage Legumes under Stress Factors of Acid Soil and Drought

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Tropical savannahs represent about 43 % of the world's arable land and are among the few frontiers still available for agricultural expansion. The development of improved agropastoral systems forms part of the overall effort to increase the sustainability of farms in these regions. Forage legume species and genotypes exhibit a wide phenotypic variability in resistance towards aluminum toxic acid soil and progressive soil drying, as major constraints limiting productivity in tropical savannah ecosystems. Objective of this study was to characterise the adaptive response of rooting systems of three genotypes of each of *Canavalia brasiliensis*, *Arachis pintoi* and *Stylosanthes guianensis* to forms of abiotic stress in a greenhouse trial using a soil cylinder screening method. Plants were grown on a highly aluminum saturated, acid Oxisol with and without fertiliser application and liming (high aluminum saturation without fertiliser *versus* low aluminum saturation with fertiliser) under two levels of soil moisture (irrigated and progressive soil drying). Main parameters analysed were total root length (TRL), deep rooting ability (DRA), mean root diameter (MRD), specific root length (SRL), shoot dry weight (SDW) and leaf area (LA).

Results indicate that under all conditions plants which are able to faster establish DRA will have a greater TRL and SDW. Acid soil inhibited development (TRL, SDW) stronger than drought stress, while combined stress did not have any further negative effect on SDW, although plants reacted with adaptive root growth. *C. brasiliensis* and *A. pintoi* were found adaptive to toxic aluminum, as indicated by no significant inhibition of DRA or decrease of SRL and MRD compared with the control. Nevertheless, both species were strongly inhibited by nutrient deficiency under acid soil and had strongly reduced SDW. *S. guianensis* was found sensitive to aluminum for the same parameters and had a reduction of SDW of 96 % as compared with the control. Although, some adaptive responses could be observed (increased DRA) under drought conditions all plants had significantly reduced SDW. *C. brasiliensis* was found superior to *A. pintoi* and *S. guianensis* under all stress treatments, with accession Canavalia 905 performing overall best by combining an extensive root system, large leaves and vigorous seedlings.

Keywords: Aluminum toxicity, drought stress, forage legumes

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Impact of Mixed and Alley Cropping on Grain Yield and Water Use of Maize

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Mixed and alley cropping agro-forestry system have greater potential than other systems to increase the production and to control erosion on sloppy lands under tropical conditions. But the viability of such systems depends on their efficiency under limited soil conditions, which in turn makes them acceptable among the farming community. This study was conducted to investigate the effect of hedgerows on water availability in a maize-chili intercropping system on sloppy land. In 2009, the experiment was established on the Queen Sirikit Farm, Ratchaburi province, West Thailand as RCBD with three replicates. The treatments were T1: maize (*Zea mays*) monocrop, tillage, fertiliser; T2: maize intercropped with chilies (*Capsicum frutescens*), tillage, fertiliser; T3: T2 with minimum tillage, fertiliser, relay cropped with *Canavalia ensiformis*, and T4: T3 with *Leucaena leucocephala* hedgerows. The amount of fertiliser applied was 62, 11, 36 NPK kg ha^{-1}. Hedgerows were planted at three positions along the slope: top, middle and lower slope. Hedges were pruned regularly to reduce shading of maize rows close to it. Carbon isotopic discrimination (δ^{13}C) was monitored in maize leaf and grain samples at 100 days after planting and at harvest, respectively. Volumetric water contents (VWC) were measured with time domain reflectometry (TDR) at 0.25–0.45 m soil depth. The VWC varied from 10–30 % in dry to moist conditions. Soil moisture trends and δ^{13}C indicated greater water use by the plants growing in mixed cropping with fertiliser. The average row grain yield showed non-significant differences among treatments in the years 2010 and 2011 but T2 showed the highest yield per row followed by T4. Hedgerow treatments had reduced soil loss (≤ 50 %) and runoff (≤ 30 %) and increased soil moisture compared to non-leucaena treatments. Chili intercropping showed a positive yield impact on maize rows after the chili area by increasing the row grain yield while hedgerows negatively affected the maize row yield close to the hedge, more prominent in rows just after the hedge. The conservation technique was found effective in improving soil moisture during the crop growth period and intercropping was also found beneficial in raising row yields of maize.

Keywords: Alley cropping, chili, maize, mixed cropping, soil conservation, stable isotope discrimination, Thailand, water use

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Soil Organic Matter Fractions in Desert Tropics as Influenced by Application of Organic Residues

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The contribution of organic waste (crop residue and sewage sludge) to soil organic matter (SOM) in the sand size (particulate organic matter, POM) was investigated in soil samples (0–20 cm) collected from field experiments conducted from November 2008 to February 2011 at the experimental farm of Omdurman Islamic University, Sudan (15°19.9 N, 32°39′E, and with an elevation of 381 m above the sea level). The study was conducted for five seasons (wheat–guar–wheat–guar–wheat) to study the contribution of organic residues in sustaining yields of wheat (*Triticum aestivum* var. Imam) and guar (*Cyamopsis tetragonoloba* local var.) in a crop rotation system. Treatments included recommended inorganic fertiliser (NP) with crop residues (RF+CR), crop residues (CR), 10 t ha^{-1} sewage sludge (SS) and control (C). Each treatment was assigned to a plot of 4 m × 4 m and arranged in a randomised complete block design with four replicates. Soil organic matter size fractionation was carried out in samples collected after the harvest of the fifth crop (2011). Results showed that, dry matter content of POM in (RF+CR) and (SS) treatments were significantly ($p \leq 0.0001$) higher than the control (C) and crop residue (CR) treatments. Similarly, the N content was also significantly ($p \leq 0.0001$) affected by RF+CR and SS application. However, the C content was not significantly affected by the treatments. Dry matter weight and N content of the POM increased by 18.2, 68.2, 99.9 %, and 2.4, 14.4 and 14.7 % for CR, SS and RF+CR treatments, respectively, relative to the control. After five seasons, 44 % of the POM dry matter weight was recovered in the small size fraction (0.25–0.053 mm) compared to 7.2 % in the (2.0–0.85 mm) sand size particles. The results suggest that, in nutrients poor sandy clay loam soil of the desert tropics, continuous application of organic residues enhance accumulation of particulate organic matter (POM) in sand size particles.

Keywords: Crop residues, desert tropics, sewage sludge, SOM fractions

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Improvement of Sand Dune Properties with Organic Waste Application for Sand Dune Fixation

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Low organic matter content, low water holding capacity and low nutrients retention are the major problems in the soils of the dune in desertified area. These unfavourable conditions make sand dune fixation programme unsustainable. Application of organic waste as a fertiliser source not only improves sandy soil fertility, it also improves the physical and chemical properties of the dunes and provides effective methods for disposal of wastes. Sand dune fixation experiment was conducted in 2009 by planting seedlings of *Salvadora persica* L. in Elrawakeeb Dry Land Station located West of Omdurman between latitudes 15°2'–15°36' North longitudes 32°0'–32°10' East. The seedlings were treated with following treatments: chicken manure (CH), chicken manure combined with sawdust (CH + SW), sawdust combined with inorganic fertiliser (SW+IF), sewage sludge (SS) , sewage sludge combined with sawdust (SS+SW), sawdust alone (SW) and control (C) . Each treatment was assigned to a plot of $2\,\mathrm{m} \times 2\,\mathrm{m}$ and arranged in a randomised complete block design with 4 replicates. Soil properties were determined from soil samples (0–20 cm) collected from the fixed sand dune in the second year after application. Results showed that application of organic wastes, increased significantly ($p < 0.001$) soil organic carbon by 224 %, available P by 139.9 %, total nitrogen by 142.9 % and mineral nitrogen 83.5 %. On other hand, incorporation of organic waste had resulted in decrease soil pH by 5.6 %. The results showed that application of organic wastes in dune soil could be a useful practice in sustaining fertility of dune soils and improved sand dune fixation.

Keywords: Desertification, organic wastes, *Salvadora persica*, sand dune, soil property

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Effects of Management Options on Soil Fertility Attributes, Weeds and Maize Yields on a Nitisol, Acrisol and Ferralsol of Western Kenya

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Low soil fertility and high weed infestation are the main culprits for the declining maize production in western Kenya. Given the diversity of soil types and the resource endowment of farmers, the magnitude of this decline is likely to differ with farms. Seven organic and inorganic management options were compared with farmers' practice regarding their effects on soil fertility attributes and weeds in maize fields on three contrasting soils of western Kenya over two cropping seasons. Irrespective of the season, organic amendments were more effective than mineral fertilisers in enhancing soil carbon stocks and the labile and non-labile C fractions. The largest soil C content (4.1 %) and C pool (72 Mg ha^{-1}) were observed on the clay Nitisol after two seasons of reduced tillage, while the lowest C content (1.1 %) and C pool (22 Mg ha^{-1}) were observed on the sandy Acrisol with conventional tillage. The soil N supplying capacity increased with the application of both organic and mineral fertilisers and reached 210 mg kg^{-1} after two weeks of anaerobic incubation of the mineral N-amended Acrisol. Bray-I P content reflected the P application rates and was highest (50–66 mg kg^{-1}) on the Acrisol with mineral P fertiliser use. Weed biomass accumulation and species composition differed with soil types and management options. Zero-tillage combined with the use of a cover crop had the lowest weed biomass (<30 % of control) regardless of cropping season. A significantly negative relationship ($p < 0.01$, r=0.37–0.51) was established between weed biomass and leaf area index of maize. These differential responses to management options in different soil types were reflected in maize grain yields with highest cumulative yields of 4.7–9.4 Mg ha^{-1} a^{-1} in the Nitisol and 1.4–7.4 Mg ha^{-1} a^{-1} in the Acrisol or Ferralsol. We may conclude that the tested technology options differentially affected soil fertility, weeds and production attributes. The extent of this response depended on the soil type, supporting the need for site-specific technology targeting.

Keywords: Bray-I P, C fractions, N supply, weed biomass, weed species composition

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Optimisation of Rotation Cropping System, *Vigna subterranea - Oryza sativa*, under a Low Nutrient Availability in Malagasy Highland

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Soil degradation, in tropical zone as Madagascar, induced a low nutrient availability such as phosphorus deficiency that strongly limited plant production. Cultivation of less exploited highlands of Madagascar was studied through integration of legume as voandzou (*Vigna subterranea*) in upland rice (*Oryza sativa*) based-cropping system. It was expected that legumes increased the phosphorus availability in Ferralsol for the benefit of rice production. In this study, rotation cropping system as voandzou-upland rice *versus* rice monoculture system was tested in a mid-term field trial. The experiment was carried out during two consecutive years in which the effectiveness of organic (manure), mineral (TSP) and organo-mineral (manure+TSP) fertilisation at equivalent P rate of 0, 10, 20 and 30 kg P ha-1 were assessed. The rice yield measured during the second year showed the effect of the precedent legume crops under low nutrient input (<20 kg P ha^{-1}). Otherwise, a high phosphorus mobilization in plants was observed with rotation cropping system compared to rice monoculture system. The efficiency of (Triple Super Phosphate) TSP addition was increased by organic inputs in terms of yield and P content through protection of mineral P toward fixation reaction. According to the significant correlation between P balance and the stock of P availability of rhizosphere soil, the exogenous input efficiency was shown in rotation cropping system. The results after two years highlighted the high potentiality of the legume voandzou in low nutrient availability soils and its capacity to mobilise rhizosphere soil phosphorus in Ferralsol. This study revealed the importance of the functioning of legume at the rhizosphere scale to enhance phosphorus cycling in the soil plant systems. Then, legume via rotation cropping system in a low nutrient input as TSP combined or not with manure could be currently the way to increase sustainably the crops yields in Highlands cropping systems of the Madagascar island.

Keywords: Legume, low nutrient, phosphorus availability, rotation cropping system, upland rice

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Selection of Tolerant Crops to be Used in Tropical Salt Affected Soils

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Saline soils take up between 40 and 50 % of the whole planet and their expansion increases near $3\,\mathrm{ha}\,\mathrm{min}^{-1}$. Cuba has around one million hectares affected by this problem of which 228,000 hectares are situated in Granma province. In these areas, the introduction of genotypes with tolerance and wildness characteristics is an alternative to recover the salt affected soils. A series of experiments with the aim to evaluate and select salt-tolerant genotypes of cowpea (6 genotypes), tomato (8 genotypes) and bean (40 genotypes) was carried out under controlled, greenhouse and field conditions. The effect of 4 levels of salt stress (0.02, 3, 6 and $9\,\mathrm{dS}\,\mathrm{m}^{-1}$) was evaluated in controlled conditions using the germination percent, length of radicle, height of hypocotyl and dry matter of seedling parameters. The second experiment was established in a greenhouse to evaluate the effect of two salt levels (0.02 and $6\,\mathrm{dS}\,\mathrm{m}^{-1}$) on crops and measure physiological and biochemical parameters. The number of leaves, leaf width, tendril length, root and shoot dry matter, proline and glycine-betaine content and osmotic and water potential were also measured. In field conditions the crops were cultivated to investigate the effect of salt stress in yield parameters. The results showed that all varieties evidenced decrease of parameters in presence of salt stress and the seedling damage was moderate in $3\,\mathrm{dS}\,\mathrm{m}^{-1}$ and severe in $9\,\mathrm{dS}\,\mathrm{m}^{-1}$. A linear, significant and negative dependence between salts levels and germination, physiological and biochemical parameters was found. Some affectations were found in the growth and biochemical variables due to the content of salts in all the varieties. In relation to yield and its components, the results evidenced differences in tolerance levels to saline stress among varieties, being IT 86 D-715 (cowpea), Vita and Amalia (tomato), TR-VAM 2005 B-13 and TR-VAM 2005–14 (bean) the most tolerant ones. However, Cubanita-666 (cowpea), Vita and Amalia (tomato) and TR-VAM B-43 (bean) were strongly affected by salinity which revealed salt susceptibility. The results showed the great potential of these varieties to be used in salt affected soils.

Keywords: Crops, salt stress, tolerance

A Typology of the Rice Based Cropping Systems of the Mekong Delta, Vietnam

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In this study the rice based cropping systems of the Mekong Delta of Vietnam are structured with focus on their water pollution potential by agro chemicals.

Experts agree that primarily hydrological and secondly soil conditions explain the establishment of certain cropping systems in the Mekong Delta, whereas dykes, sluice gates and pumps are employed in most places. Often times socio economic factors rather than ecological conditions determine when and where those measures of water control are taken into use. Nevertheless, when elaborating an overview, cropping systems are still best structured according to ecological conditions that follow a natural gradient.

Rice based cropping systems can be characterised according to their water pollution potential because farmers display for each system a typical behaviour of fertiliser and pesticides' application whereas the residues or a misuse of these agro chemicals pollute the water bodies. Experts at the Can Tho University and farmers in three agro ecological zones have been interviewed to find out what are typical farming practices and by which factors other than ecological are they influenced. It was found that at the coastal zone where farmers typically practice integrated agriculture-aquaculture pesticides are sprayed the least frequently and thus the lowest water pollution should occur. In the intensive systems of two and three rice crops per year that are common in the upper and middle part of the Delta no difference in the use of pesticides was detected though a trend in the survey data suggests that farmers practicing double rice on acid sulfate soil are more reluctant to reduce agro chemicals than triple rice farmers on alluvial soil. Maybe that is because the more unfavourable ecological conditions that prevail with acid sulfate soils lead to a higher pest pressure. No difference in the amount of applied fertiliser among the three systems was found and it seems that the pollution potential by a misuse of synthetic fertiliser is generally small if not negligible. The influence of socio economic factors on specific farming practices could not be proven with this survey.

Keywords: Cropping systems, fertiliser, Mekong Delta, pesticides, rice, water pollution

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Near Infrared Reflectance Spectroscopy (NIRS): Prediction of Chemical Properties in Cuban Soils

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Soil chemical properties are important factors for soil fertility, successful plant growth and land management. Conventional methods to determine chemical fertility are often too difficult, costly, and time-consuming, therefore economic and environmental drivers have promoted the development of new techniques of management agricultural systems. For that reason this research investigates the potential of Near Infrared Reflectance Spectroscopy (NIRS) as a cost- and time-effective technique to determine the fertility of a soil as an input for to optimise the fertilisation for this field. NIRS in the context of precision agriculture might be an alternative to the conventional analysis methods employed in Cuba for determining organic matter (OM), phosphorus (P and P_2O_5) and potassium (K_2O) using a single spectrum per sample. The whole process included sampling of Cambisols from different agricultural fields of Villa Clara province located at the central part of Cuba, chemical traditional analysis and soil reflectance measurements. Samples were air dried before scanning by means of a diode array spectrophotometer covering the wavelength range from 399 to 1697 nm. Calibration models were built using Partial Least Squares Regression (PLSR) and Support Vector Machine (SVM). The prediction performance of the calibration models was evaluated based on the calibration statistics R^2 (the square of the correlation coefficient), RMSEP (root mean square error of prediction) and Bias (systematic deviation). The best prediction results were obtained for organic matter ($R^2 > 0.90$; RMSEP$\leq$0.11) and in the other properties were variably acceptable, so K_2O ($R^2 \geq 0.80$; RMSEP$\leq$2.90); P ($R^2 \geq 0.80$; RMSEP$\leq$0.55) and P_2O_5 ($R^2 \geq 0.75$; RMSEP$\leq$3.00). It was concluded that NIR spectroscopy has potential to rapidly determine the fertility of Cuban soils as an input to optimise the fertilisation.

Keywords: Calibration models, near infrared reflectance spectroscopy, soil chemical properties

Cultivation on Polluted Areas with Heavy Metals and Naturally Enriched Areas

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For many soil metal contaminants, especially Zn and Ni, within a metal contaminated area, hyperaccumulator plants are likely to do well since foliar concentrations will be high.

Cadmium tends to have few effects on plant growth, yet can still exhibit toxicity to animals. While this does not obviate the ecotoxicity of high Cd plants, Cd hyperaccumulators will not be able to grow beyond the area of soil contamination. Thus, escape of Cd hyperaccumulators beyond the area of contamination is not likely to be a concern. These observations suggest that escape from the original site must be assessed based upon both the plant and soil.

Cultivation of hyperaccumulators on naturally enriched areas offers the greatest promise for use in phytomining. Phytomining is a more specific form of phytoremediation where the purpose of metal removal from soil is economic gain. For example, millions of acres of Ni rich ultramafic soil are found around the world. These soils are potentially amendable to Ni phytomining. However, many of these areas are populated by a number of rare and endangered species. For example, serpentine soils in northern California and southern Oregon are populated by rare and endemic species that exist only on these soils. Given the unique flora of enriched soils, concern has been raised that highly competitive and aggressive introduced

hyperaccumulators may displace some of the natural flora. Another method to reduce the potential for escape from the original site of planting is to harvest plants prior to seed set. Most hyperaccumulators set seed in mid summer. Since most hyperaccumulators are perennials, they will typically be harvested at the time of maximum metal accumulation, then plants will continue to grow for an additional harvest the same year or in the following year.

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Relationships between Aggregate Stability and Selected Soil Properties in Tertiary Marly Soils of Iran

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Identification of the critical soil properties affecting aggregate stability is central to understanding where erosion might be located within a catchment as a result of natural patterns in aggregate stability. There are many literature references on which the relationship between soil properties and aggregate stability investigated, but these references show that location and soil type play major roles in determining relationships between aggregate stability and soil properties. Relation of aggregate stability to soil properties thus, differs with climatic zones and soils. There is, therefore, a need to study these relationships in different regions in order to isolate which properties to manage for improving soil aggregate stability in a given location. While there is wealth of research on aggregate stability and its relation to soil properties, only few studies have focused on marly soils especially in Iran. Marl or marlstone is a calcium carbonate or lime-rich mud which contains variable amounts of clays. Eighty soil profiles from calcareous marly soils were selected to study the relationships between soil structure as mean weight diameter and eighteen soil properties. The degree of similarity among different aggregate stability indices as well as identifying the main mechanism of instability was investigated. The aggregate stability was measured using Le Bissonnais's method. Under fast wetting situation, aggregate stability of marly soils in Iran is poor, so that, 80 % of the samples studied had a mean weight diameter (MWD) less than 0.4. Therefore, we can conclude that the breakdown we observe corresponds to the breakdown caused by the compression of entrapped air during wetting. This mechanism is simulated by fast wetting treatment. The results of the correlation analysis showed that aggregate stability was positively affected by silt, very fine sand, fine sand and organic matter contents while clay content, calcium carbonate equivalent, soil saturation and acidity negatively affected aggregate stability, from which some of this correlations are unexpected.

Keywords: Aggregate stability, Iran, Le Bissonnais's method, marly soils, soil properties

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The Contribution of Innovative Agricultural Systems to Sustainable Water Reservoir Use in NE-Brazil

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The construction of the Itaparica dam and reservoir induced changes concerning the agricultural production systems in the micro-region Itaparica, Sao Francisco river basin. Traditional systems – mainly a combination of dryland farming in the river flood plains and livestock farming in the adjacent dryer areas – were replaced by irrigation agriculture. Even though wide areas with irrigation infrastructure were established the sandy soils of many areas are not suitable for irrigation farming. Lack of adequate arable land causes a shortage of income opportunities for local farmers. Thus large share of many household incomes is derived by compensatory payments from the dam operator. Persistent problems are inappropriate farming practices in irrigation, inaccurate use of agrochemicals and overstocking of livestock. As a consequence soil salinization, overgrazing, erosion, and contamination and eutrophication of the reservoir increase and threaten local peoples' livelihoods.

The joint research project INNOVATE aims at innovative coupling nutrient cycles to counteract erosion, soil degradation, and emission of greenhouse gases. The agriculture-related sub-projects "Terrestrial Production" and "Economy" will do research with the implementation of a sustainable and productive agriculture with closed nutrient cycles. This can contribute to reduce the above mentioned negative impacts, ensure food supply, and additionally provide an important income source for the local population. Biochar, lake sediments, and manure combined with micro-catchments and multipurpose leguminous perennial food crops and feeds, shall improve soil quality and water storage capacity. The combination of local and fast-growing trees to the crop areas meets the needs for firewood and forage for the dry season and reduces the pressure on natural vegetation, conserving its biodiversity. The results will be

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assimilated in a model system quantifying soil organic matter dynamics. Economic analyses on farm level monitor the profitability of these systems and facilitate recommendations for extension service and policy makers to sustainable establish them. Field trials for soil amendment and micro-catchment will be installed on dryer areas next to the main irrigation areas, while surveys and measurements on livestock systems and socio-economic data will be assessed on farm level by structured questionnaires, participatory methods, and structured observations and measurements.

Keywords: Agriculture, micro-catchment, soil-amendment, reservoir

Conservation Agriculture: Is it the Way Forward for Resilient Rainfed Farming Systems in India?

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Past food surpluses in India were mainly achieved by intensifying irrigated farming systems. However, crop yields in these favourable areas have not greatly increased for more than a decade. In order to meet future food needs and to foster economic development among the rural poor, there is a growing consensus that development efforts must prioritize rainfed agricultural systems where current productivity is low and soils are often degraded. Rainfed agriculture in India occupies 67 % of the net sown area, contributing 44 % of food grains and supporting 40 % of the population. Climate change has influenced the recurrence and spread of drought in these regions, increasing production risks. In total, some 450 M Indians earn their livelihoods under rainfed conditions. This paper addresses the economic and environment viability of conservation agriculture (CA) in rainfed farming systems of Jharkhand, India. Conventional *vs.* conservation agriculture practices are compared within the IFAD supported project "Sustainable Intensification of Smallholder Maize-Livestock Farming Systems in Hill Areas of South Asia" to examine the potential of conservation agriculture in a rainfed context. Overall, 27 group interviews have been conducted in 9 blocks of 3 districts in Jharkhand after stratified random sampling. The results are also based on 2 on-station trails and 118 village level trails of maize-wheat farming systems. Despite low productivity, severe soil erosion and associated socio-economic constraints in these farming systems, there is scope to minimise soil disturbance and enhance productivity for sustainable intensification through tailored and location-specific modifications of resource conserving technologies (RCT's). The results indicate that improved water management, the implementation of conservation agriculture (CA) principles, improved agronomic practices and the introduction of modern crop cultivars could double or even triple yields. The maize yield of on-station maize trial was $7.6\,t\,ha^{-1}$ compared to the state average of only $1.8\,t\,ha^{-1}$. Although, the proposed technologies have the potential to reduce production costs up to 30 % while increasing production and enriching the soil for sustainable intensification and increased climate resilience, questions remain how researchers, policy makers, extension agents, governments and donor agencies can more effectively disseminate these beneficial technologies for adoption by smallholder farmers?

Keywords: Conservation agriculture, Jharkhand, RCT's, smallholder

The Importance of Crown Root Angle and Mycorrhiza for Adaptation of Sorghum Genotypes from West Africa to Low-P Soils

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Sorghum (*Sorghum bicolor* L. Moench) is a staple crop of the savannah zone of West- and Central Africa (WCA). Most of sub-Saharan African soils (75 %) are deficient in mineral nutrients for plant growth. Limited phosphorus (P) availability in soils is a serious and frequent constraint to sorghum cultivation in West Africa. Previous research has shown that breeding under low-P conditions is necessary and effective in identifying sorghum genotypes which are specifically adapted to low-P soils. However, there is limited knowledge on the specific adaptation mechanisms of these genotypes. The objective of the present study is to investigate the role of root-architecture and mycorrhiza-symbiosis in the adaptation of WCA sorghums to low-P soils.

In 2011 we conducted a pot experiment with 188 sorghum genotypes originating from WCA, which represent the Guinea, Durra and Caudatum races of Sahelian and Sudanian zone genotypes from different West African countries. The 188 genotypes were grown for 38 days on a low-P soil at ICRISAT-Mali. Plant height, vigor score, biomass, P-uptake and crown root angle were recorded for each pot. Furthermore fine root samples were taken from each pot to evaluate mycorrhizal colonization at the University of Hohenheim, which was still in progress by the time of writing this abstract. Preliminary results suggest significant genotypic differences for all measured traits, including crown root angle and intensity of mycorrhizal root colonization. Once measurements are completed, the relationships among the various traits within and across groups of germplasm will be assessed. Furthermore, genotypic performance in the pot trials will be tested for correlations with yield performance under field conditions, in order to elucidate the importance of the various traits for low-P tolerance. All 188 tested genotypes are currently also being genotyped as part of an association study. This will provide the opportunity to identify the gene loci and associated markers involved in low-P tolerance for use in marker-assisted sorghum improvement targeting low-P soils.

Keywords: Breeding, mycorrhiza, phosphorus, root angle, sorghum

Viability of Soil Conservation on Steep and Fragmented Lands – Recent Experiences from Northwest Vietnam

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As a consequence of an increasing animal feed demand, maize production area of Northwest Vietnam has strongly increased in the past, mainly by expansion into forested uplands. Farmers usually slash and burn their fields to prepare a tidy field for a new season. Exposed to heavy rainfalls at the onset of the monsoon rains this leads to severe erosion and barren lands in the long run. Changes in rainfall pattern associated with increasing flood risks pose another threat. This study aimed at quantifying benefits of soil conservation in relation to soil loss, soil cover and yield in maize based systems to foster their adaption by local farmers. In 2009, we established a field trial on a Luvisol with slope gradients of 47-62 % in the Son La province of Vietnam. The treatments were maize under farmer's practice (T1), with *Panicum maximum* grass barriers (T2), under minimum tillage and *Arachis pintoi* as cover crop (T3) or relay cropped with *Phaseolus calcaratus* (T4). The results showed that erosion mainly occurred few weeks after sowing when high rainfall intensities coincided with a low soil cover (T1). Later when maize covered the soil well, erosion was minimal. Well-established grass barriers reduced soil loss (60 %) and provided animal fodder but significantly reduced maize yields (34%) compared to T1. In dry years maize yield declined up to 21 % but grass production increased by 26 % compared to a normal rainy season. Minimum tillage either with simultaneous growing cover crops or relay cropped strongly reduced soil loss compared to conventional cropping. Already established cover crops significantly reduced maize yields due to competition (T3). But a cut and carry system based on *A. pintoi* additionally provided a protein-rich animal fodder (3.3 t ha^{-1}). The most promising option, however, was maize with relay cropping, where maize yield reached the same level as T1 and, in addition, produced 1.16 t ha^{-1} of *P. calcaratus* beans. Such extra-benefits from soil conservation may help promoting adoption by local farmers, particularly in view of markets. Sound management of cover crops, however, is necessary to minimize competition for water, nutrient and light.

Keywords: Cover crop, maize, minimum tillage, relay cropping, soil cover

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An Integrated Approach to Assess Land Use History in a Watershed in Northwest Vietnam

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In the past decades, the introduction and extended cultivation of hybrid maize and hybrid cassava provided higher income for farmers but replaced traditional crops, such as upland rice and local maize and cassava varieties, in the upland area which surrounds a reservoir in Chieng Khoi, Yen Chau district in mountainous Northwest Vietnam. Furthermore, new cultivation areas are still expanding into protected forest, grazing areas and fruit tree plantations. Consequently, primary forest on the upper, steep slopes is illegally cleared for hybrid maize and cassava cultivation.

Detailed Geographic Information System (GIS) based classification of land uses is difficult when crops are planted during the same period of the year and reflect similar spectral bands. Therefore, this study aimed to reconstruct ground cover maps, to distinguish characteristic upland land uses before and after the reservoir was installed and to determine the sediment contribution of different land uses to the reservoir. Hybrid classification combining remote sensing data (aerial photograph 1954, Landsat 1973 and 1993) with farmers' information were used to obtain detailed classification of past land cover.

Compound specific stable isotope (CSSI) analysis of fatty acid methyl ester (FAME) and fallout radionuclide (FRN) measurements were chosen to support and match the data obtained by remote sensing - GIS and farmer interviews. The integration of FRNs and CSSI-FAME markers enables apportioning sediment bodies to land use specific erosion rates. This is achieved through the following steps: 1. FRN are used to distinguish sediment strata at the deposition sites. To receive an estimate of sediment volumes, a statistical analysis of sediment strata is based on spatially distributed sediment profiles. The approach is capable of converting measurements of FRN soil inventories to estimate soil erosion and deposition rates. 2. The land use specific mass accumulation represented within a stratum is estimated by multiplying the mass of the stratum (FRN) by the land use specific soil proportion (CSSI-FAME). 3. Linking the land use specific mass accumulation to land use information from GIS allows the evaluation of land use specific erosion dynamics corresponding to the sediment strata.

Keywords: Compound specific stable isotopes, fallout radionuclides, GIS, land use history, remote sensing

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Legume Small GTPase MtROP9 and its Role in Establishment of Plant Defense During Pathogenic and Symbiotic Interactions with *Medicago truncatula*

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Legumes are among the most economically important crop families providing excellent sources of protein, vitamins, minerals and other nutrients to human and animal diets. Production of legume crops such as peas, soybean, dry beans, etc, which form an essential protein source for majority of population in semi-arid and tropical regions is hampered by soil borne pathogens. Ability of these crops to defend temselves against infections by oomycete root rot pathogens like *Aphanomyces euteiches* and interactions with symbionts (nitrogen fixing bacteria and abascular mycorrizal) involves small GTP-binding proteins that function as molecular switches controlling the signal transduction pathway resulting to host defense response.

We investigated the role of *Medicago truncatula* small GTPase MtROP9 (*M. truncatula* Rho of plants) orthologous to *M. sativa* Rac1 via an RNA interference silencing approach. MtROP9 deficient plants whose roots were transformed by *A. rhizogenes* carrying RNAi vector were produced and infected with pathogenic oomycete *A. euteiches* symbiotic arbuscular mycorrhiza fungus *Glomus intraradices* as well as rhizobial bacteria *Sinorhizobium meliloti*. Phenotypic observations clearly showed a retarded growth in MtROP9i transgenic lines. Neither ROS generation nor MtROP9 and MtRBOH gene expression resulted after microbial infections. The knockdown of MtROP9 clearly promoted mycorrhizal and *A. euteiches* early hyphal root colonisation, while rhizobial infection was clearly impaired. The results of our study suggest a key role of small GTPase MtROP9 in development of host plant defense involving ROS-mediated early infection signalling.

These results contributes to the investigation on the development of new techniques for the control of soil borne pathogens and provides an outlook to the investigations on opportunities for disease resistance development in legumes and in plant breeding to capture possibilities of raising crop yield, nutritional quality, limited pesticide use and over all poverty alleviation.

Keywords: *Aphanomyces euteiches*, arbuscular mycorrhizal symbiosis, *Medicago truncatula*, MtROP9, plant defense proteins, rhizobia bacteria symbiosis, small GTPase

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Organic Amendment, Composting, Soil Fertility Improvement and Climbing Bean Yield in Degraded Soil of Rwanda

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The soils in the Gatumba sector of Rwanda are highly degraded due to increased land use pressure, mining activities and low inputs use. A study was undertaken at a degraded tantalum mined site to (1) identify different sources of organic materials usable as amendments, (2) evaluate the effects of improved *versus* traditional composting on physical and chemical properties of soils, and (3) assess the impacts of nutrients recycled under the two systems on climbing beans growth and yield. A survey using 50 households (HH) in Gatumba area, and 200 HH from Muhanga, Huye, Nyamagabe and Nyanza Districts was also conducted. These districts have been selected for being the biggest producer of solid wastes around Gatumba sector. Materials collected for the study were: (i) farm yard manure (FYM), solid wastes (SW) and tithonia biomass (TB) from and around Gatumba and (ii) SW from Muhanga. Composting was done under plastic roofing (improved, IR) and tree leaves shade (local system). The treatments under plastic roofing were: (i) SW, (ii) FYM, (iii) SW plus Minjingu phosphate rock (MPR, 13-15 % P, with neutral ammonium citrate solubility of 4.4%), (iv) FYM plus MPR , (v) FYM plus SW, (vi) FYM plus SW plus MPR , (vii) TB plus FYM plus SW. Treatments under tree leaves shades included: (viii) SW, (ix) FYM and (x) SW plus FYM. MPR was added at the rate of $50\,g\,kg^{-1}$ dry matter (DM) FYM/SW. The quality of organic materials collected from rural and urban areas was very poor with 0.30 % total N, and 0.064 % total P for rural and 0.73 % total N and 0.133 % total P from urban SW. Similarly, traditional composting yielded poor quality material (0.23 – 0.30 % total N and 0.060-0.072% total P), while plastic roofing increased total N from 0.96 to 1.65 %, and total P from 0.13 to 0.30 %). The effects of improved compost on growth and yield of climbing beans were assessed using replicated experiments (four trials in un-mined and four in degraded sites). We measured plant height, number of pods, biomass, and grain yield. Improved compost $(5\,t\,DM\,ha^{-1})$ improved total DM yield from 1.99 – $3.54\,t\,ha^{-1}$ grain compared to traditional compost $(0.76 – 0.90\,t\,ha^{-1})$ at the same rate of compost application. For the growth parameters, improved compost promoted the plant vegetative growth, which could be arranged in descending order of treatmsnts as follows: TB-enriched compost – MRP-enriched compost – FYM – SW. The highest climbing beans biomass and grain yield was $20.06\,t\,ha^{-1}$ and $15.55\,t\,ha^{-1}$, and 3.06 and $3.54\,t\,ha^{-1}$ (on a dry matter basis) for FYM+SW+MPR IR and TB+FYM+SW IR, respectively. Improved compost can contribute to the legumes development in small-scale low-input farming system of Rwanda.

Keywords: Climbing beans, compost, degraded, mined, rock phosphate, soil

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Regeneration of *Vigna* subgenus *ceratotropis* Collections in Thailand

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The implementation of this project was carried to regenerate and safety duplicate 656 accessions of *Vigna* species in 2009–2010. Mungbean (*Vigna radiata*), blackgram (*V. mungo*) and wild *Vigna* spp. were regenerated. Morphological characteristics, preliminary evaluation data, agronomic evaluation data and photographs were recorded. The results showed that, given the differences in their own genetics, *in situ* conservation sites, soil type, microclimate and imposed threats, the morphological characteristics and agronomic traits of 374 accessions of mungbean varied dramatically. The number of pods per plant was from 3 to 36 pods, the number of seed per pod varied between 7–19. Seed size of mungbean varied between 25.0–89.5 g per 1000 seeds. Seed weight per plant varied between 2.1–41.3 g plant^{-1} while the total seed yield was from 0.01–2.93 kg per 20 m^2. For 100 accessions of blackgram, it was found that seed yield per plant was 4.7–37.9 g. Seed size of blackgram varied from 30–57 g per 1000 seeds. Plant height ranged from 63–162 cm and the number of pods per plant was 17–103 pods. The number of seed per pod was 6–8 seeds. For wild *Vigna* species a total of 94 accessions from 19 species were grown in 2009, and 88 accessions from 7 species were grown in 2010, the number of seed per pod varied between 3–14 seeds. Seed size varied between 5–82 g. Seed weight per plant varied between 0.5–96.1 g plant^{-1}. Seed size varied between 8.8–108 g per 1,000 seeds. The morphological characteristics and agronomic traits were then recorded in a database for a sustainable and efficient use in breeding programme. In summary for two years, 656 accessions could obtain the seed for further research and safety duplication. All accessions were already deposited at the Thai-Department of Agriculture genebank.

Keywords: Blackgram, genebank, genetic resources, mungbean, wild *Vigna*

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Social Local Factors that Determine Maintenance of Knowledge on Medicinal Plants Species in the Municipalities of Zetaquira and Campo Hermoso, Boyacá-Colombia: With an Analyses of the Local Depletion of Plant Species and Suggestions for Preservation

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Analyses of the relation of social factors that determine conservation of traditional knowledge on plants species need to be extened in order to understand the reasons that communities have to preserve or on the contrary to deplete local traditional plant species. The main objective of this study was to identify local social factors that promote the knowledge on medicinal plant species in the municipalities of Zetaquira and Campo Hermoso, Departamento de Boyacá, Colombia, using quantitative and statistical means and to analyse the relation between social factors and the depletion of plant species within the localities. The targeted groups were students and adults from different localities within each municipality. Structured and semistructured interviews were applied. The results indicate that students who inhabit in rural areas far from the core of the municipalities have the tendency to describe a large knowledge on native plant species. In the case of adults, large knowledge was described in the urban area in Zetaquira, while those groups who inhabit in rural areas described the highest knowledge in Campo Hermoso. Some factors appeared not to be statistically significant. Nevertheless, it is worthwhile to mention them here, such as age and the way of transport to reach to the health care centre. The adults between forty to sixty years old were able to describe the largest total number of traditional plant species and their uses.

Social factors identified and the lists of disappeared species, species in danger according to the perception of the interviewees, and the list of the most valuable species (IUV) described during the interviews might be of interest to the design of future projects, that aim to preserve medicinal plants within the studied areas. Agroforestry systems would be an option that could include production of food and medicines based on the interest of the locals.

Keywords: Ethno-botany, social factors, traditional knowledge conservation

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Microbial Biomass Dynamics in Eight Ecosystems During a Climatic Transition Phase at Mt. Kilimanjaro

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To understand impacts of climate and land use changes on biodiversity and accompanying ecosystem stability and services at the Mt. Kilimanjaro, detailed information about the soil microbial biomass and fluxes are needed. Transition phases within the bimodal tropical climate are of special interest since several parameters experience changes in a short time period. Each of the affected parameters has a different effect on soil microbes. As an important factor for soil fertility, microbial biomass C and N will be described on different pedon depending on land use (natural *vs.* agricultural ecosystems) and climate (altitude gradient). Microbial C content will be quantified in different depths and in various dominant ecosystems, *i.e.*, maize fields, coffee plantations, lower montane forests, homegardens, savannah, Podocarpus forest, Ocotea forest and grasslands. Microbial contents of the different land use types will be compared with the conversion of natural ecosytems to agriculture as well as to the changing plant diversity. A comparison of all investigated ecosystems - during the transition period - should provide a better understanding about the change from natural to agricultural land as well as further land degradation.

Keywords: Climate transition, land-use change, microbial biomass C, montane ecosystems

Mineral fertilisation and resilience of cropping systems

Mineral Fertilisation for Higher Agronomic Benefits and Nutritional Value

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Currently, poor soil fertility, improper nutrient management and imbalanced mineral nutrition are still widespread problems in many developing countries, resulting in both food and nutrition insecurity. An adequate and well-balanced mineral fertilisation is essential in achieving and maintaining high crop production and also harvesting products with adequate nutrient density. Generally, crop production takes places under stressful environments. There are a number of published examples showing that mineral fertilisers play a key role in mitigating adverse impacts of environmental stress factors on crop plants such as water deficiency, heat stress, salinity, and aluminium toxicity.

Inadequate supply of mineral nutrients to plants diminishes not only productivity but also seed nutrient density. Using seeds with low nutrient density is often associated with impairments in seed vitality and seedling vigour, leading to reduced agronomic performance of seedlings and low yield capacity. Plants emerging from seeds with low nutrient reserves are highly susceptible to environmental stress conditions and infection by pathogens. Ensuring sufficient nutrition of seeds with mineral nutrients during reproductive growth stage is, therefore, a critical issue in achieving positive agronomic impacts on productivity and improving nutritional value of the harvested products for human health. Currently, zinc (Zn) and iron (Fe) deficiencies are well-documented nutritional problems in human populations, resulting in poor public health, especially in the developing world. Reduced dietary intake of those micronutrients represents a major reason for high incidence of micronutrient deficiencies where cereal grains are the major source of calorie intake. Cereals are inherently very low in micronutrients and contain even lower Zn and Fe levels when grown on micronutrient-deficient soils. Increasing concentration of Zn and Fe in food crops is, therefore, an important global agronomic target and humanitarian challenge. Mineral fertiliser strategy represents a quick solution to alleviate micronutrient malnutrition, and highly advantageous strategy as it may also contribute to better yields on Zn and Fe deficient soils. In case of Zn, increasing evidence available from field experiments shows that foliar application of Zn fertilisers both fortifies grain Zn concentration up to 2-fold as well as improving crop yields. The results available suggest that fertiliser strategy is a useful agronomic practice for an effective enrichment of cereal grains with micronutrients and thus for contributing to nutrition and well-being of human populations.

Keywords: Human nutrition, mineral fertilisation, seed quality, stress tolerance

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Triticum aestivum Yield and Water-use Efficiency in the Draâ Oases at South East Morocco: Irrigation and N-fertiliser Effects

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More erratic and decreasing rainfall in the Mansour Eddhabi Dam catchment had severe impacts on irrigated agriculture in the downstream Draâ Oases. Among other practices, N-fertiliser quantity and source and timing of irrigation are possible mitigation measures to increase grain yield and water-use efficiency (WUE) of *Triticum aestivum* (cv. Achtar). Field experiments were conducted during 2009–2010 at two oases (Mezguita and Ktoua). The experiments were laid out as split-split plot design: main plot was irrigation (farmer's practice or scheduled at sowing, beginning of tillering, beginning of elongation, beginning of ear formation and end of flowering), subplot was N-fertiliser (urea or FYM) and sub-subplot was N-fertiliser quantity (0, 50 or 100 kg N ha^{-1}). At Ktoua, only two fertiliser rates could be tested (0 and 100 kg N ha^{-1}). Another experiment was carried out at Ouarzazate, upstream of the Draâ, to identify the grain yield for the area under "unstressed" conditions. There was no significant difference between the proposed stages irrigation and farmer's irrigation at both sites. Average grain yields were 2.0 and 3.2 Mg ha^{-1} and WUE were 2.7 and 5.7 kg mm^{-1} in Mezguita and Ktoua respectively. N-fertiliser quantity and source had significant effect on grain yield and WUE in Ktoua. Control treatment yielded 2.3 Mg ha^{-1} grain and 3.9 kg mm^{-1} WUE. Application of 100 kg N ha^{-1} as FYM led to an increase of 60 % grain yield and 66 % WUE. Urea 100 kg N ha^{-1} doubled both grain yield and WUE. At Mezguita, the effect of N-fertiliser was less pronounced. Application of 100 kg N ha^{-1} as urea increased the yield by 50 % and WUE by 77 % over control (1.9 Mg ha^{-1} and WUE of 2.6 kg mm^{-1}). FYM at a rate of 100 kg N ha^{-1} yielded a slightly significant increase. The intermediate 50 kg N ha^{-1} of either N-fertilisers showed no advantage over control. The highest yield attained at Ktoua of 4.6 Mg ha^{-1} is still only 60 % of the 7.8 Mg ha^{-1} unstressed grain yield obtained at Ouarzazate. N-fertiliser as urea appears to have a great potential in the area, especially in the poorer oasis of Ktoua, where most farmers seldom use fertilisers. Wheat-phases irrigation might be advantageous over usual farmers' practices in dryer years.

Keywords: Achtar, grain yield, Ktoua, Mezguita, Ouarzazate, winter wheat

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Maize Productivity and Response to Fertiliser Use as Affected by Soil Fertility Variability, Manure Application and Cropping System in Africa

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To counter growing food insecurity in sub-Saharan Africa (SSA), there are renewed efforts to support farmers to intensify crop production mainly by increasing the use of fertilisers and improved crop varieties. However, the impact of these efforts will be very limited, unless the fundamental issues of providing the crops with balanced and adequate nutrients are addressed, and fertiliser recommendations are fine-tuned to account for highly variable soil fertility conditions. We conducted multi-location nutrient omission trials in sites with high potential for maize production intensification (> 800 mm annual rainfall) in East and southern Africa to determine (i) nutrient-induced yield gaps; and (ii) nutrient requirements for balanced fertilisation of maize under variable soil fertility conditions. Nutrient were applied at rates to achieve a yield target yield of $7\,\mathrm{t\,ha^{-1}}$. Fields were demarcated into three categories of soil fertility (low, medium and high) based on soil organic matter contents. Experimental results revealed that N deficiency accounted for the largest yield gaps $1–4\,\mathrm{t\,ha^{-1}}$ across all categories of soil fertility. On the high fertility fields, $90\,\%$ of the maximum attainable yields were achieved with application of N+P. In medium fertility fields, additional nutrients (K, Mg Ca, S, Zn and B) were required to significantly increase maize yields above the N+P treatment. On the degraded soils, baseline yields were very low, and were increased to less than $2\,\mathrm{t\,ha^{-1}}$ by applying N+P and to less than $3\,\mathrm{t\,ha^{-1}}$ by applying all macro and micronutrients. In the degraded soils, replenishing organic matter through strategic fertiliser application with incorporation of crop residues may provide an option to increase attainable yields over time. Use of compost and animal manures, may also play a role, but available quantities are limited and the quality is often poor. To support sustainable intensification of maize production in SSA, we have developed the nutrient expert decision support tool to build capacity among extension systems and smallholder farmers for the practical identification of soil fertility variability and local adaptation of site-specific fertiliser management practices.

Keywords: Maize, yield gap

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Season of Burning Influences Fire Induced P-Losses in Ghana

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Between November and February of each year about 45-60 % of the northern region (29 % Ghana) of Ghana gets burned. The fires are associated with plant nutrient transfers of which local losses of P is of major concern given that it is relatively unavailable to crops in the prevailing Fe rich soils. Bush fires, however, provide essential cultural and socio-economic goods and services (as in hunting and land preparation for agriculture) at relatively cheap cost to the local population: making it difficult to implement fire prevention strategies across the region. The need arise therefore to device means by which fires may be used to provide the usual services but at a reduced cost to soil P losses. In this study early (November) and late (January) burn season losses are estimated by a difference in P load before (plant tissues) and after (ash) combustion for each combusted IGBP (International Geosphere Biosphere Program) land cover type. The seasonal variations are then compared to provide ecological insights into efficient means of reducing the nutrient losses during burns. Least mean loss (kg km^{-2}) occurs across shrublands (127–148) while highest losses occur across grasslands (129–402). Given that 88 % and 10 % of the annual burns occur across savannah and woody savannah vegetations, the respective P losses of 170–260 and 158–270 kg km^{-2} has greater impact on local P losses than the relatively high losses across shrubland and grassland vegetations. Besides woody savannah vegetation where P losses are highest during early burns than late burns, late burn losses across savannah, grassland and shrubland vegetations are higher than early burn losses due to comparable tissue concentrations but higher combusted dry material in the late season. Comparatively low tissue moisture also enhances combustibility and render late burns vulnerable to higher P losses. Early burns are suggested to reduce local P losses. The patches of unburned vegetation created by the early burns also inhibit late burn occurrence, may enhance wildlife sustenance and promote tree seedling growth and establishment for carbon capture and storage.

Keywords: Bush fire, food security, fuel load, phosphorus nutrition, savannah

Farmers' Adoption of Improved Nitrogen Management Strategies in Maize Production in China: An Experimental Knowledge Training

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Chemical fertiliser plays an important role in increasing food production in China. Nevertheless, excessive nitrogen fertiliser use in China has resulted in severe environmental problems. Scientists attribute the excessive use of nitrogen (N) fertiliser in China to inappropriate farming management and propose site-specific nitrogen management that targets input applications more precisely to match the spatial and seasonal variability in soil conditions has been studied. However, despite great efforts made by scientists to improve the efficiency of fertiliser use, N fertiliser use continues to rise while its efficiency remains low, which has brought economists' attention to the rationality of overusing N fertiliser.

The goal of this paper is to examine the impacts of an improved nitrogen management (INM) training experiment on farmers' chemical N use behaviours in maize production in China. The knowledge training of INM was randomly assigned to 18 treated villages while keep the 12 villages in the neighbourhood as a control. Uniquely, this training was delivered by the public extension system so that the research results have profound policy implications in its generalisability.

The research was conducted in Shandong, China, where household data was collected from 813 maize farmers. This study finds that while INM training can significantly reduce farmers' N fertiliser use, an INM training is not sufficient to change farmer's practices significantly, and farmers only partially adopted the recommended INM. The recommended INM technology requires farmers to spend additional time on fertiliser application, which is a significant challenge for a farming system dominated by small-scale farms, many with family laborers who engaged in off-farm employment in urban areas where wages have been rising significantly since the early 2000s. This study reveals that China faces challenges to transform its agriculture to a low-carbon one. The research also sheds light on China's extension system and future technologies in meeting the objectives of reducing the excessive nitrogen fertiliser use in agricultural production.

Keywords: China, farmer, maize, nitrogen, training

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Nutrient Deposition During the Harmattan Dry Season Across the Northern Region of Ghana

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The harmattan dry season (November to February) across West Africa is associated with dry nutrient deposits that are attributed to external dust sources and the redistribution of nutrients from local soils. Quantities of dry nutrient deposits are mostly estimated at single sites or in a single (North to south) direction; limiting data and knowledge on the two dimensional spatial nutrient deposits. In this study, the geospatial distribution of dry nutrient deposits across 15 (5 latitudinal zones and 3 longitudinal zones) sites of the entire northern region of Ghana is investigated through a modified stratified contiguous unit based spatial technique in order to ascertain the spatial variations and the mean dry nutrient inputs. Deposited nitrate-N showed no apparent trend in spatial distribution. However, quantity of deposited P, K, Ca, and Mg positively correlates with latitude ($p < 0.05$) and with longitude ($p > 0.05$), with latitude being the greater predictor of dry nutrient deposits. Negative correlations between Ca and Mg concentrations on one hand with Na and K concentrations on the other hand for all sites suggest that substantial amounts of deposited Na and K may not have come from same sources as Ca and Mg. Variation in mean nutrient concentration (mg kg^{-1}) with month (NO$_3$$^{-1}$-N: 24-640; P: 23-56; K: 2720-4150; Ca: 1680-2010; Mg: 740-930) and not space is attributed to temporal differences in nutrient sources. High nutrient concentrations of dry deposits compared to the concentrations of soils of harmattan dust sources and to concentrations of local soil nutrients (total N: 710; P: 12; K: 25; Ca: 610; Mg: 200) given similar chemical treatments as the dry deposition, suggest the return of burned vegetation debris to be a major contributor to dry nutrient deposits besides dust transport and redistribution from local soils. Given the relatively low amount of total annual dry deposits per unit area (95 % confidence interval: 53 122 Mg km^{-2}), the total supply of plant nutrients (kg km^{-2}) by dry deposition (NO$_3$$^{-1}$-N: 3-40; P: 1-6; K: 100-620; Ca: 70-200; Mg: 40-90) is however minimal to the soils available nutrient pool.

Keywords: Burned ash, food security, geospatial distribution, harmattan, nutrient source

Effect of Sowing Date, Irrigation Intervals and Fertilisers on Safflower (*Carthamus tinctorius* L.) Yield

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Despite the importance of safflower in the world, this crop has received only little research attention in Sudan. Therefore, a field experiment was conducted at the College of Agricultural Studies, Sudan University of Science and Technology in Khartoum, to study the effects of sowing date, irrigation intervals and different types of fertilisers on yield, yield components and pigment of safflower (*Carthamus tinctorius* L.) Geeza cultivar during 2010/11 and 2011/12. To this end a split-split plot layout was used with four replications. The main plots were two sowing dates (S1) on 13th and (S2) 28th November. Subplots were three irrigation intervals (7, 14 and 21 days) and sub-subplots were three fertiliser levels (urea 80 kg ha^{-1}, pellet granules 105 kg ha^{-1} and farm yard manure 2000 kg ha^{-1}).

Sowing date had significant effects on seed yield in the first season and on seed yield, dry weight and pigment yield in the second season ($p < 0.05$). Irrigation significantl affected seed yield and pigment ($p < 0.05$) and on shoot dry weight in first and second season ($p < 0.01$), respectively. The interaction of sowing date and irrigation intervals had significant effects on seed yield in the first season and on pigment in the second season. There were no significant effects of fertilisers on all parameters, but farm yard manure had some influence on yield components at S2.

The results showed negative correlations between harvest index, shoot dry weight (-0.3), number of seeds per head (-0.04), between pigment and 1000-seed weigh (-0.08) and also between seed yield and seed per head (-0.004) in the first season. Moreover, there was a negative correlation between pigment yield kg ha^{-1} and seed per head (-0.13) in season two. The higher seed yield of 2700 kg ha^{-1} and 2300 kg ha^{-1} achieved from S1 and S2 in season one, respectively, as compared to 1600 kg ha^{-1} and 1000 kg ha^{-1} from S1 and S2 in season two, respectively. Decreased seed yield in season two was due to infestation by *Orabanche crenata* which was the first record in Sudan. It can be concluded that for safflower under this condition the most suitable sowing date was 13th November with an irrigation every 14 days.

Keywords: Irrigation interval, pigment, safflower, sowing date

Pattern of Nitrogenase Activity in Root Nodules of two Contrasting Tropical Soybean Types

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Soybean (*Glycine max* L) production in marginal areas particularly in smallholder cropping systems (SCS) in Africa is useful for improving soil fertility through biological nitrogen fixation (BNF) and provision of an affordable source of protein for the communities. Production of the crop requires either seed inoculation with commercial rhizobial strains (inoculants) at planting or application of nitrogenous fertiliser. In SCS in Africa, both the inoculants and fertiliser are often not available readily leading farmers to cultivate tropical soybean types which do not require seed treatment with inoculants in order to nodulate and attain optimum yields. The tropical soybean types are compatible with indigenous rhizobia ubiquitous in African soils. However, there is inadequate information about BNF capacity of the tropical soybean types. This study assessed the BNF capacity of contrasting tropical soybean genotypes using three indicators namely nodule dry weight (NDW), shoot dry weight (SDW) and nitrogenase enzyme activity. F2 soybean plants segregating for tropical nodulation, were selected randomly from two phenotypic classes consisting of yellow (or chlorotic and stunted) and green (or healthy) plants. The nitrogenase activity in nodules was assayed *ex situ* using the Acetylene Reduction method. The highest nitrogenase activity (125.09 nmoles h^{-1}) per plant was found in the effective nodules associated with the fixing genotypes. There was a negative but significant (r = - 0.827; $p < 0.05$) correlation between nitrogenase activity per unit nodule weight and SDW suggesting that a relatively high energy requirement for producing a unit SDW. The NDW per plant was significantly and positively correlated with SDW in both chlorotic and green genotypes. The mean ethylene production per unit nodule weight was at least four-fold higher in effective nodules compared with ineffective nodules. The results indicated that nitrogenase activity at the whole plant level was not indicative of shoot dry matter accumulation and tropical types of soybean can be selected for under N depleted growth conditions that are common in marginal areas in Africa.

Keywords: Fixation, nitrogenase, nodules, tropical soybean

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Application of Straw Compost and Biofertilisers to Remediate the Soils Health and to Increase the Productivity of Paddy Rice in Indonesia

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The intensive use of inorganic fertilisers and agrochemical products during the green revolution (early 1960s) had a great impact on the decline of soil health and soil quality. Based on the latest investigations, the soil organic content has decreased shraply within 30 years. Various field studies revealed that most of the paddy soils in Indonesia have been exhausted, as indicated by a low organic matter content ($<1,5$ - 2%) and depletion of some essential nutrients, such as K and Si. Restoring the paddy soil fertility can be done by managing straw and biofertiliser application combined with output oriented integrated fertiliser management. Since 3 years, straw compost and biofertilisers as environmentally friendly low cost fertilisers were introduced to remediate soil health and to increase paddy rice productivity in several areas in Indonesia. The application of 2–5 ton ha^{-1} of straw compost combined with 400–1000 g ha^{-1} of biofertiliser inoculants (consortia of non-symbiotic nitrogen fixers and phosphate solubilising bacteria) or *Azolla* had a significant positive effect on soil organic carbon, the biodiversity of beneficial soil organisms, as well as on the growth and yield of paddy rice. In addition, the application of inorganic fertilisers was reduced by 25–50 % and the productivity of paddy rice was increased by at least 25 %. Particularly carbon, silica and potassium were supplied by straw compost. Consequently, the remediation and maintenance of soil health for sustainable rice cultivation can be achieved by rice straw and biofertiliser application.

Keywords: Biofertilisers, organic fertilisers, paddy soils, soil health, straw compost

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An Assessment of Soybean-Maize Rotations and Biological Nitrogen Fixation on Smallholder Farmers' Fields in Malawi

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Soils in cereal-based smallholder cropping systems in southern Africa are often characterised by nitrogen deficiencies which result in low yields. Soybean (*Glycine max*) production can address this problem by biological nitrogen fixation (BNF) which, if crop residues are returned to the soil, benefits the following cereal crops.

This study was conducted to quantify atmospheric nitrogen fixation by soybean crops under different external input levels and to assess the rotational benefits of soybean on subsequent maize crops under smallholder farmers' management techniques in central Malawi.

Soybean biomass samples from 150 plots and reference maize and broadleaf weed species were collected at mid pod filling stage from 60 on-farm trials in the 2009 and 2010 growing seasons in Dowa, Mchinji and Salima districts. Soybean treatments included farmers' usual practices, improved variety, inoculation and fertiliser application. Samples were analysed for ^{15}N contents and BNF was quantified using the natural abundance method. In 2010, 53 farmers compared yields of maize planted after the zero-input soybean plots of the 2009 season with maize planted after maize. Farmers used their own inputs and practices but similar in each plot. Soil sampling, field measurements and structured questionnaires generated data on plot history, crop management, yields and farmers' perceptions on rotation.

The soybean plots yielded on average 1 202 kg ha^{-1}. At mid pod-filling stage the crop accumulated an average biomass dry weight of 2 761 kg ha^{-1} containing on average 103 kg nitrogen per ha. Depending on the reference plant used, soybean fixed 47.3 % (for maize) or 56.5 % (broad leaf weeds) of this nitrogen from the atmosphere. There was no relationship between nitrogen fixation and fertiliser application or inoculation. Average maize yields were 1629, 2941 and 4 365 kg ha^{-1} in Dowa, Mchinji and Salima respectively and maize crops planted after soybean showed 22.4, 56.2 and 33.0 % higher yields compared to continuous maize in these sites.

This study indicates that under current crop management practices, farmers experience significant yield gains from planting maize after soybeans. This can partly be explained by BNF which results in reduced nitrogen depletion of the soils.

Keywords: Crop rotation, natural abundance method, nitrogen fixation, soil fertility, soybean

Effect of Nitrogen Source, Soil Type and Depth of Application on Ammonia Volatilisation

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A field experiment was conducted to study the effect of soil type and methods of fertiliser application on the ammonia volatilisation when three orders of Sudan soils (Aridisols, Vertisols and Entisols) were fertilised by three types of nitrogenous fertilisers; namely, aqueous ammonia, urea and ammonium sulphate, in Berber, Gezira and Shambat, respectively. These fertilisers were applied by three methods: superficial application with irrigation water and injection in depth of 5 cm and 15 cm at a rate of 200 kg N ha^{-1}. A closed system was prepared around the points of application to collect volatile ammonia gas on diluted sulfuric acid 0.25 N and ventilation was ensured by using a semi-permissible membrane called parafilm. Sulfuric acid was analysed using steam distillation apparatus, and then titrated with hydrochloric acid. The results indicated that the rate of ammonia loss by volatilisation in Aridisols was lower than on Vertisols and Entisols and this is attributed to the different climatic conditions. In Berber the experiment was carried out during winter when temperature is low, causing a decrease in volatilisation, while in Gezira and Shambat the experiment was carried out in summer, and high rate of ammonia loss by volatilisation was observed in Entisols. This may be ascribed to the high silt content in this soil. The results demonstrated that surface application of nitrogen fertilisers increased loss of ammonia by volatilisation more than in the injection method since the fertilisers applied on the soil surface are more exposed and this increases volatilisation. In Vertisols and Entisols, the rate of ammonia volatilisation decreased gradually from the first week to the fourth week. But in Aridisols, increased rate of volatilisation occurred in the fourth week due to negative impact of cold season on the microbial growth which limits the hydrolysis of ammonium carbonate resulting in delaying of volatilisation process. In Vertisols and Entisols, high rates of ammonia volatilisation were noticed in aqueous ammonia more than in urea and ammonium sulphate due to the fast hydrolysis of aqueous ammonia compared with other types of fertilisers, while in Aridisols, the ammonia volatilisation recorded inconsistent values which attributed to cold weather.

Keywords: Ammonia, fertilisers, soil, volatilisation

Fate of Fertiliser N Applied to a Guar-Wheat Rotation System as Influenced by Crop Residue Incorporation in a Semi-Arid Vertisol

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Guar or cluster bean (*Cyamopsis tetragonoloba*) is an interesting crop adapted to the semi-arid tropics. Nitrogen recovery from inorganic fertiliser in the crop/soil systems was monitored for six seasons in a guar-wheat (*Triticum aestivum*) crop rotation using 10 % ^{15}N atom excess urea (12,72 kg ha^{-1}). N15 recoveries in wheat straw, wheat head and total recovery were 22.46 %, 15.55 % and 38.01 % , respectively on plots without crop residue removal and 21.16 %, 15.55 %, and 36.71 %, respectively, on plots with crop residue removal. It was observed that continuous incorporation of fertiliser without crop residue removal improved the N recovery with 20.46 % as compared to the application of inorganic fertiliser with crop residue removal. In the 2nd, 3rd, 4th, 5th and 6th crop cycle, incorporation of inorganic fertiliser without crop residue removal increased N retention of the topsoil by 4.6, 10.1, 3.4, 11.9 and 1.6 %, respectively, as compared to the inorganic fertiliser application with crop residue removal.

N derived from fertiliser (Ndff) in the seeds or pods through all seasons, except the 2nd season, was higher on plots with crop residue left and the application of inorganic fertiliser then on plots without crop residues and the application of inorganic fertiliser, by 8.98 %, 7.77 %, 33.33 % and 1.37 % for the, 3rd, 4th ,5th and 6th season, respectively. It could be concluded that continuous application of crop residues along with fertilisers improved N recoveries in a guar-wheat rotation.

Keywords: Crop residues, crop rotation, guar, N15, semi arid, wheat

Maize Production Risks in Pendjari Region, Benin: Chemical Fertliser and Termite (*Macrotermes bellicosus*) Fertlity Effects

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Since the decline of cotton prices on the international market, maize as other crops is being cultivated intensively in Benin for income enhancement. As the chemical input prices are increasing, farmers are looking for alternative inputs. Termites are known to play important roles in soil fertilisation, and through termite mounds and the medicinal plants they host, they contribute to health care. It has been noted that biased estimation of production function estimates results from the lack of accountability risks. Since maize production in Benin has increased at a varying rate since 1998 it is important that we examine the risks associated with input use. The data for this study were collected from farmers from 6 villages in the district of Tanguieta, Pendjari Region, Benin. A total of 222 farmers were surveyed. Data from 128 respondents were found usable in the current analysis. Econometric techniques were used to estimate a Just-Pope maize production function, which was used to compute marginal products of inputs, and to identify quantity of chemical fertiliser and density of inhabited termite mound associated with the boundaries between stages I, II, and III of the production function. The response of maize yield to the density of inhabited termite mound is elastic, same to the quantity of chemical fertiliser used. The values of 1 inhabited termite mound and 5 inhabited termite mounds represent the boundaries for the stage II of the maize production function. However, as the density of inhabited termite mounds and the quantity of chemical fertiliser used per hectare increase, the production risk is expected to increase. Hence, farmers may be cautious in increasing the quantity of fertilisers and to a high density of inhabited termite mound on crop plot. Thus farmers may increase yield and production by augmenting cautiously the quantity of chemical fertiliser and choosing cautiously the crop plot hosting inhabited termite mound, other factors remaining constant.

Keywords: J-P production function, Pendjari, risk, termites

Translocation and Utilisation of Fertiliser N in Tropical Sloping Land as Affected by Soil Conservation

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Fertilisers are essential inputs for maintaining or increasing soil fertility in intensive agricultural systems. Due to high fertiliser costs and limited supply in developing countries, enhanced nutrient management needs to be pursued through maximising the efficiency of nutrient uptake, in order to sustain increased crop productivity and simultaneously enhance nutrient cycling and soil and water conservation. The fertiliser N consumption of Thailand, moreover, increased from 0.78 million tons in 1997 to 1.04 million tons in 2007 and is expected to further increase in the future. Both chili (*Capsicum annuum*) and maize (*Zea mays*) are important upland crops of Thailand. Particular maize receives substantial amounts of fertiliser due to its increasing market demand in the past. However, the fertiliser N utilisation (FNU) and translocation (FNT) in maize-chili and maize-chili-leucaena systems have yet not been studied, especially on sloping land. This research examined FNU and FNT in hillside agriculture as affected by crop management and soil conservation. Therefore, a field experiment was conducted in 2010 at Queen Sirikit farm, Suan Phueng District, Ratchaburi province in West Thailand (on hilly terrain with slope gradients up to 25%). The treatments consisted of four maize based cropping systems were (T1) maize monocrop, tillage, (T2) maize-chili intercrop, tillage, (T3) as T2 but with minimum tillage, relay cropped with *Canavalia ensiformis*, and (T4) as T3 but with *Leucaena leucocephala* hedgerow. ^{15}N labeled urea (10 atom % ^{15}N) was applied to a maize row in the upper part of each plot. 62 kg ha^{-1} of N was split applied at 30 and 60 days after maize sowing. Plant and soil samples of various positions along the slope, sediment, runoff and resin core samples of each plot were collected for stable isotope analyses to study the N recovery from fertiliser application and the N translocation. Total FNU in maize was highest in T4 indicating that the hedgerow system had positive effects on FNU due to reduced runoff. Only very small movements of ^{15}N labeled fertiliser were detected along the slope in all treatments, indicating most of the N losses were of volatile nature.

Keywords: Chili, hedgerows, intercropping, maize, minimum tillage, nitrogen fertiliser use efficiency, relay cropping, soil conservation, stable isotopes, Thailand, translocation

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Innovations in cropping systems

The Use of the Musa Diversity to Address the Challenge of Climate Change Agriculture and Food Security

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The majority of edible and cultivated bananas arose from interspecific crosses of *Musa acuminata* (A genome) and Musa balbisiana (B genome). Currently bananas are used as staple food crops in the tropic and subtropics and banana production systems are affected by drought, frost and flooding as results of climate change and unfortunately we are not using the diversity of Musa germplasm to adapt the best cultivars to address these problems. It is well established that cultivars with balbisiana genome are more resistant to frost than cultivars with acuminata genome, for example in the subtropics in Brazil Prata cultivars (AAB) are more resistant to frost than Cavendish (AAA). In Central America, cooking banana like Bluggoe (ABB) is more resistance to drought than plantain cultivars (AAB). However the farmers remain with the susceptible cultivars, although a replacement must be the solution to address these problems. Concerning to dessert banana for exporting, we are using just Cavendish cultivars (AAA), which are the most susceptible not just to drought, frost and flooding, but also to pests and diseases, such as Black Sigatoka (*Mychosphaerella fijiensis*) and the burrowing nematode (*Radopholus similis*). However there are hundreds of dessert banana cultivars, which are more resistance to biotic and abiotic stresses and can be exported, but we are not using them. Bred hybrids, such as FHIA 18 and FHIA 17 are more resistance to Black Sigatoka than Cavendish and countries like Cuba and Bolivia the farmers are cultivated them for local consumptions. In Dominican Republic, FHIA 21 (AAAB) has partial replace the black Sigatoka susceptible plantain cultivars Macho X Hembra (AAB) and the farmers are saving application of fungicides just with the use of FHIA 21. Finally it is important to use the diversity of Musa germplasm, not only to address the climate change effects, but also to improve the food security and nutrition of the population mainly in tropical and subtropical countries.

Keywords: Bananas, biotic and abiotic stresses, bred hybrids, germplasm, local cultivars, resistance

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Homegardens in Sudan - Domestication Spots for Wild Fruit Trees: The Case of *Ziziphus spina-christi* (L.) Willd.

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The Christ's thorn jujube, *Ziziphus spina-christi* (Rhamnaceae) is one of the most important indigenous fruit tree species in Sudan. It has multiple food and cultural uses and contributes to income generation, particularly of women. Most fruits are collected in central and southern Sudan and traded all over the country. Fruits show a high phenotypic diversity with regard to colour, size, and taste, but so far the existing populations have not been characterised.

To fill this knowledge gap and to assess possible domestication processes 250 individual trees were sampled from agroforestry homegardens (N=125) and adjacent forests (N=125) of five different locations in the Nuba Mountains. Trees and fruits were morphometrically characterised and dried leaves used for molecular analysis by AFLP (amplified fragment length polymorphism). Pearson's coefficient was used to compute bivariate correlations and means were statistically analysed by t- and Mann-Whitney tests at $p < 0.05$. Regression analysis was used to identify environmental factors influencing fruit traits.

The sampled trees and fruits showed a high morphological diversity regarding stem diameter at breast height, fruit size and fruit weight. Fruit sizes decreased with increasing latitude and elevation (r=-0.352 and -0.405 respectively). Individual trees in homegardens had a significantly larger mean stem diameter at breast height than those in forests (16.1 and 12.6 cm, respectively). Multiple regression analyses showed a positive influence of the site 'homegarden' and the tree's canopy area, but a negative effect of elevation on fruit size and fruit dry weight (model adjusted R^2=0.315 and 0.384, respectively). First results of AFLP analysis revealed a clear genetic separation of populations from homegardens and forests, indicating differences among the populations' seed flow and history.

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Semi-domestication by human selection combined with environmental effects may have caused the above mentioned differentiation of *Z. spina-christi* populations in the Nuba Mountains. This information on population structure of *Z. spina-christi* can be used to develop local domestication and *in situ* conservation approaches.

Keywords: AFLP, agroforestry, *in situ* conservation, indigenous fruit tree, molecular marker, morphological characterisation, Nuba mountains

The Dynamic Role of Homegardens for Providing Food, Income and Ecological Services in Central Sulawesi, Indonesia

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Traditional agroforestry homegardens with their high plant diversity contribute to households' food security and fulfil important social, cultural and ecological functions. Generating cash income in a commercialised homegarden may weaken its contribution to providing food. In Central Sulawesi, the cash crop cacao was integrated into traditional homegardens about 10 years ago. The aim of this study was to assess the possible influence of cash crop production on plant species richness and use over time.

In 42 homegardens randomly selected from five villages in the Napu valley, Central Sulawesi, inventories of all useful plants were conducted in 2012. Most of these homegardens were already surveyed in 2001, 2004 and 2007. Gardeners were interviewed about the main use of each species and the importance value 'SDR' calculated per village for each use category.

In total, 210 useful plant species were documented in 2012. Forty-six species were mainly used for medicine, 36 for fuelwood/timber, 35 for vegetable, 31 for fruit, 26 for spice, 10 each for staple and stimulant/cash crop and the remaining 16 for other uses. In three villages inhabited by locals, spices had the highest SDR value in 2012, followed by fruits or vegetables. In 2007, however, staples had the highest SDR in two local villages, possibly as a reaction on the global food price crisis. In one of the villages inhabited by migrants and located on infertile soils, staples had the highest SDR in most of the years. After arrival, these migrant families had not yet access to paddy rice fields, thus growing staples for subsistence in their gardens. In the other migrant village, located on more fertile soil, stimulants, including the cash crops cacao and coffee, constantly had the highest SDR. These migrant families largely depended on cash income generation from their gardens as they were only supplied with paddy fields for subsistence after arrival, but not yet with plots for tree crop plantations. Over time, however, the dominance of staples or cash crops decreased in the respective migrant villages and gardens diversified. Homegardens are thus resilient agro-ecosystems that contribute in a dynamic and flexible way to food security and income generation of rural communities.

Keywords: Agroforestry, commercialisation, food security, plant diversity

Analysis of Genotypic Diversity in Sesame as Based on Morphological and Agronomic Traits

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Germplasm banks, as pools of the genetic variability are fundamental for the developmental research of crop species. This variability must be characterised by genetic and phenotypic parameters for the identification of duplicates and the organisation of core collection, and as a support in the choice of parents for breeding programs. When genetic variability is narrowed using traditional breeding methods for a long period then induced mutations are one of the most important approaches for broadening the genetic variation to circumvent the bottleneck conditions. Although, sesame is an ancient and advantageous oilseed crop it is still at an early stage of breeding which is reflected by its' poor yield performance. This study aims to analyse genetic diversity of sesame germplasm and mutants from India and Ethiopia. Agro-morphological variation in the sesame germplasm was estimated using 14 morphologic and agronomic descriptors to characterise and identify genetic diversity. A total of 36 sesame landraces were collected from the sesame growing areas throughout India and Ethiopia. The collection was evaluated for seed yield, yield related characters and morphological characters. A large amount of variation was recorded for 14 morphologic and agronomic traits. D2 analysis and cluster analysis indicated no strict or narrow relationship between observed genetic diversity and geographical differentiation. Cluster analysis identified seven main clusters based on agro-morphological characters indicating the diversity which could mainly be attributing to diverse agro-climatic conditions. D2 analysis revealed that the crossing between the genotypes, Utawadia, Humera, and DSS would most likely express a considerable amount of heterosis in F1 generation and also provide a wide spectrum of recombinants in segregating generations. Principle component analysis revealed that the first three vectors explained 70.52 % of total multivariate variation. Canonical correlation studies indicated that the development characters such as capsule number per plant, capsule length, days to flowering, plant height, branches number per plant, and seed yield were the major determinates of the genetic diversity in the collection. Single plant selection was made from these populations based on different agromorphic traits and yield potential. These results have an important implication for sesame germplasm characterisation, improvement, agro-morphological evaluation and conservation.

Keywords: Capsule length, genetic diversity, germplasm, multivariate analysis

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Effects of Activated Charcoal and Tannin Amendments on Yields of Sweet Corn and Radish on an Irrigated Sandy Soil in Northern Oman

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Crop production in Northern Oman is characterised by irrigated agriculture on sandy soils under hot climatic conditions which favour fast microbial turnover of soil organic matter. Nutrient losses are high due to the soil's low CEC and water holding capacity. Charcoal and tannins are known to have positive effects on soil physico-chemical properties and may help retain nutrients in the soil. To test this, activated charcoal or tannins were added to goat manure, either by mixing with goat manure or by adding to the goats' feed. Amended manures were applied to sweet corn and radish plots at rates of 1.7 t activated charcoal ha^{-1} a^{-1} and 2.2 t tannins ha^{-1} a^{-1} in a two-year field experiment. Manure was applied at a rate of 200 kg N ha^{-1} on sweet corn and 135 kg N ha^{-1} on radish. Phosphorus (P) and potassium (K) in manures was determined and application rates adjusted with mineral fertiliser to reach 56 kg P ha^{-1} and 130 kg K ha^{-1} in sweet corn and 38 kg P ha^{-1} and 90 kg K ha^{-1} in radish. Mineral fertiliser and un-amended manure served as controls. Yields were generally low for both, sweet corn (1.26–8.66 t ha^{-1}) and radish (4.2–10.8 t ha^{-1}). Tannins had a negative effect on plant growth and yield of both sweet corn and radish (27–32 % yield reduction for sweet corn and 42–46 % yield reduction for radish in the vegetation period 2011/12). SPAD values indicate that nitrogen (N) availability was insufficient which might result from lower mineralisation rates due to tannin effects on mineralisation. When fed to goats, charcoal had a slightly depressing effect on sweet corn and radish growth compared to un-amended manure, whereas charcoal mixed to manure had no or a slightly positive effect on sweet corn and radish growth. To determine whether it was possible to increase the efficiency of nutrient release from manure for plant nutrition and reduce nutrient losses using activated charcoal or tannin amendments, soil analyses, leaching losses and gas emissions are under way.

Keywords: Charcoal, nutrient turnover, oasis agriculture, organic matter, tannins, vegetable production

Making Effective Use of Climate Information by Small Scale Farmers in Managing Rain-Fed Maize Production: A Case Study in Bole, Ghana

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Crop production under rain-fed conditions largely depends on rainfall for moisture supply to crops. The rainfall received is unevenly distributed both geographically and seasonally and sets limits on crop production leading to high risk and low yield of crops due to water stress. With proper understanding of the major or important climatic factors such as rainfall, water and humid periods, important decisions for planning and management of rain-fed maize production can be made in Bole. Mean monthly historic rainfall and evapo-transpiration data covering the period of 1961–2002 for Bole were used to obtain the rainfall amount and its expected pattern and distribution, standard deviation, coefficient of variation of each month, aridity indices, risk factors, length of growing and humid periods. The results from the analyses showed that the growing period for Bole is 214 days, implying that it has a higher agricultural potential and a longer drying period. The coefficient of variation and standard deviation indicate the dependability of rainfall in each month. The information developed could serve as a useful tool for a small scale rain-fed maize farmer during crop selection, timing of farming activities (supply of labor, land preparation, time of planting, harvesting and drying of crops) and also for agricultural entrepreneurs who are new to this particular environment. The information developed could serve as a useful tool during crop selection, timing of farming activities (supply of labor, land preparation, time of planting, harvesting and drying of crops) and also for agricultural entrepreneurs who are new to a particular environment.

Keywords: Aridity indices, climate, cropping calendar, evapo-transpiration, rainfall, risk factor

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Economic Viability of Biochar Use in Aerobic Rice Production in the Brazilian Cerrado

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In Brazil, biochar, a by-product of charcoal production from plantation timber (*Eucalyptus* sp.), is being tested as a soil amendment to improve soil fertility and in turn increase sustainability of aerobic rice production systems (mainly rainfed). Thus, this study aimed to assess the economic viability of biochar use in aerobic rice production in the Brazilian Cerrado. The study has been carried out with field experiments at two sites: Nova Xavantina (MT) and Santo Antonio de Goiás (GO). At MT site, results were based on cropping seasons 2008/2009, 2009/2010 and 2010/2011; and at GO site, results were based on seasons 2009/2010 and 2010/2011. Treatments consisted of a combination of two nitrogen fertiliser levels (0 and 90 kg N ha^{-1} in GO; and 0 and 75 kg N ha^{-1} in MT) and four levels of biochar (0, 8, 16 and 32 tons ha^{-1}). Biochar was obtained from *Eucalyptus* charcoal residues of 2.00 mm particle size. Biochar was incorporated into the soil only once, before the sowing of the first crop. It was done in one single application, in season 2008/2009 in MT and in season 2009/2010 in GO. Revenues were generated by paddy rice yields, considering market price in April of each considered year (R\$ 32.30/bag of 60 kg paddy in 2008/2009, R\$ 29.00 in 2009/2010 and R\$ 27.00 in 2010/2011). Production costs considered are mulching, direct seeding, fertilisation, weed control and harvest operations. Under market price conditions, in all treatments, the costs were higher than the revenues. After using a sensitivity test, varying the market prices for a 60 kg bag paddy rice from R\$ 30 to R\$ 45, only at GO in the cropping season 2009/2010 the results were promising. The most promising economic results were obtained using 90 kg N and 8 tons biochar per hectare. At current market prices for conventional long-grain rice, however, it was not as viable as expected. If aerobic rice yields increase and producer get an additional price for their production (niche markets), then it may become an interesting option under certain conditions.

Keywords: By-product, economic feasibility, Eucalypt charcoal fine, sensitivity analysis, soil amendment

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Potential Yield of Venezuelan Maize Varieties under Variable Water Supply

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Erratic rainfall patterns have caused severe drought conditions in Venezuela directly affecting white maize (*Zea mays* L.) production, increasing the economic risk for smallholders and compromising food security. Maize varieties resistant to drought are among the few options smallholders can employ to increase yield stability in their production system, but selection tools are needed to better identify varieties tolerant to water deficit. To this end we evaluated the differences in yield response based on secondary traits in five Venezuelan white maize hybrids (D-3273, Danac-842, D1B-718, D1B-283, Danac-223) subjected to variable water supply. At 55 days after sowing (DAS), plants were subjected to two contrasting water supplies; (1) full irrigation (WW) and (2) a shock-like drought (DW) where irrigation was withheld for five days, followed by resumption of full irrigation. Under drought conditions, soil water content sharply decreased at 60 DAS, due to a combination of leaf, root and shoot responses. Flowering length and grain-yield of the five hybrids were negatively affected. However, Danac-223 plants were less affected with no reduction of their harvest index. Drought stress also significantly affected gas exchange parameters, with stomatal control being the major factor affecting photosynthesis. Under variable water supply, intrinsic water use efficiency improved in D1B-278 and Danac-223, whereas it decreased considerably in Danac-842. In all hybrids, water stress induced a decrease in root hydraulic conductivity which highly correlated with leaf water potential. Danac-223 was found to be a promising hybrid for cultivation in the western plains of Venezuela under variable water supply, due to its medium specific leaf area, a more efficient root water transport, enhanced WUE, and stable yield production under drought stress.

Keywords: Drought tolerance, secondary traits, water use efficiency, white maize

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Radiation Absorption and Use Efficiency of Sesame as Affected by Biofertilisers in a Low Input Cropping System

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Cultivation of crops that use water and radiation efficiently is important for sustainable agriculture. To estimate light extinction coefficient and radiation use efficiency of sesame a randomised complete block design with three replications was conducted in the 2009-10 growing season. Treatments were three different types of biofertilisers plus control, including 1-Nitroxin (containing *Azotobacter* sp. & *Azospirillum* sp.), 2-Biophosphor (PSB, containing phosphate solubilising bacteria, *Bacillus* sp. & *Pseudomonas* sp.), 3- Biosulfur (SSB, containing *Thiobacillus* ssp.) and 4-control (no fertiliser).

The results showed that application of biofertilisers resulted in a 15 days shorter period to achieve maximum leaf area index compared to the control and as a result, the maximum fraction of absorbed radiation and consequently sesame dry matter produced at 60 days after emergence, 15 days earlier than the control treatment. Although the light extinction coefficient in the control (without biofertiliser) was higher than in the biofertiliser treatments (0.78 *vs.* 0.69), radiation use efficiency (RUE) in SSB and nitroxin was higher than in the control (1.31, 1.24 and 1.09, respectively). This led to highest biological and seed yield, seed oil, protein and harvest index. The results indicated that the application of biofertilisers enhanced the utilisation of intercepted radiation by sesame canopy and consequently improved quantitative and qualitative yields without chemical or synthetic inputs. This may be of high importance in arid and semiarid regions under low input conditions.

Keywords: Biosulfur, ecological system, light extinction coefficient, sesame

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Performance of Farmland Terraces in Maintaining Crop Productivity in Wello, Northern Highlands of Ethiopia

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Soil-erosion-induced land degradation and crop production loss is a great challenge in the Ethiopian highlands. Consequently, the government has invested in soil and water conservation (SWC) measures where farmland terracing is among the widely implemented practices. The purpose of this study was to analyse the performance of terracing with respect to crop productivity. Yield differences across the slope of the terrain, within a terrace and across terrace age were evaluated. The study was conducted in the Maybar soil conservation research site (MSCRS) in Wello, northern Ethiopia. It is located between 10°58' and 11°02' N latitude and 39°38' and 39°40' E longitude. Yield data (grain and biomass) of seven crops such as wheat (*Triticum* spp), emmer wheat (*Triticum* spp), horse bean (*Vicia faba*), field pea (*Pisum sativum*), barley (*Hordeum* spp), maize (*Zea mays*) and teff (*Eragrostis tef*) collected between 1995 and 2009 from 40 fixed plots on three terrace positions (upper, middle and lower) were statistically analysed using a mixed linear model that employed Tukey-Kramer adjustment in SAS (Version 9.2). Generally, yields of all crops except wheat decreased significantly (on average 0.37 to 0.15 t ha^{-1}) from the upper terrace position towards the lower position. Unlike in other studies, the differences could be due to the soil depth gradient that in turn influenced nutrient and soil-water storage. On the other hand, yields showed insignificant differences across the terrain, they showed a decreasing tendency with slope increase. This indicates that terracing reduced soil erosion and nutrient translocation. With terrace age, yields showed only slight changes. The stable yield under limited fertility improvement measures and reduced fallowing indicates that terracing reduced soil and nutrient loss through erosion. However, terracing alone does not improve soil fertility and thereby crop production. Thus, in order to significantly increase yields terracing should be supplemented by soil fertility amendments.

Keywords: Crop yield, farmland terrace, Maybar, northern Ethiopia, soil erosion

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The Influence of Humic Acids on the Metal Bioavailability and Phytoextraction Efficiency in Long-Term Sludge Applied Soil

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Heavy metal pollution of soils causes many environmental and human health problems. The bioavailability of metals in soil may be manipulated to improve heavy metal phytoextraction. Although phytoremediation has revealed great potential and synthetic chelators have shown positive effects in enhancing heavy metal extraction, a vast number of negative side-effects was revealed. There exists a need for low cost-effective and environmental friendly materials as an alternative to synthetic chelators. The term humic substances refers to a category of naturally occurring organic materials resulting from the decomposition of plant and animal residues. Humic acids (HA) provide organic macromolecules with an important role in the transport, bioavailability, and solubility of heavy metals. In this research the ability of HA on phytoextraction of heavy metals from sludge polluted soil by the use of tobacco plant under greenhouse conditions was examined. Long-term sludge treated soil enriched with heavy metals (Zn, Cu, Ni, Pb and Cd) was used in the experiment. The influence of exogenous HA on the bioavailability of Zn, Cu, Ni, Pb and Cd from sludge applied soil and heavy metal uptake of tobacco plant was examined in this greenhouse experiment. HA were applied to long-term sewage sludge polluted soil at 1 % and 2 %. Soil samples were collected after harvest and total and DTPA-extractable Zn, Cu, Ni, Pb and Cd contents of soil were determined. Diethylenetriaminepentaaceticacid (DTPA)-extractable Zn, Cu, Ni and Pb concentrations and plant uptake of metals increased significantly by HA applications. While HA treatment at 2 % rate to soil increased the heavy metal concentration in the shoot tissue, plant growth was diminished. The results suggest that soil amendments with HA can be considered as an alternative approach to reduce the availability and mobility of heavy metals and to increase phytoextraction efficiency of heavy metal polluted soils.

Keywords: Humic acids, metal bioavailability, phytoremediation, sludge, tobacco

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Partial Horizontal Carbon and Nutrient Balances in Homegardens of the Nuba Mountains, Sudan

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The transformation of traditional homegardens in the Nuba Mountains, Sudan, towards more intensified production systems raises concerns with respect to the sustainability of these systems, particularly regarding carbon and nutrient management. To assess these different horticultural systems, a nutrient budget approach was used to quantify the management related partial horizontal fluxes of carbon (C), nitrogen (N), phosphorus (P) and potassium (K). To this end, six representative homegardens, comprising three traditional (low input) and three intensified (high input) sites, were selected. In each garden, four to five observation plots with site-specific crops were monitored daily to quantify management-related carbon and nutrient inputs and outputs.

Horizontal C balances were positive for all homegardens ($1{,}922\,\mathrm{kg\,ha^{-1}\,a^{-1}}$ for low and $3{,}706\,\mathrm{kg\,ha^{-1}\,a^{-1}}$ for high input systems). In low input homegardens nutrient balances amounted to $-84\,\mathrm{kg\,N\,ha^{-1}\,a^{-1}}$, $-10\,\mathrm{kg\,P\,ha^{-1}\,a^{-1}}$ and $-117\,\mathrm{kg\,K\,ha^{-1}\,a^{-1}}$ versus $15\,\mathrm{kg\,N\,ha^{-1}\,a^{-1}}$, $7\,\mathrm{kg\,P\,ha^{-1}\,a^{-1}}$ and $-168\,\mathrm{kg\,K\,ha^{-1}\,a^{-1}}$ in high input gardens. Manure amendments provided most nutrients in both types of homegardens (low input: $29\,\mathrm{kg\,N\,ha^{-1}\,a^{-1}}$, $9\,\mathrm{kg\,P\,ha^{-1}\,a^{-1}}$, $19\,\mathrm{kg\,K\,ha^{-1}\,a^{-1}}$; high input: $112\,\mathrm{kg\,N\,ha^{-1}\,a^{-1}}$, $27\,\mathrm{kg\,P\,ha^{-1}\,a^{-1}}$, $70\,\mathrm{kg\,K\,ha^{-1}\,a^{-1}}$). A significant N input by biological N fixation was only observed in low input systems ($17\,\mathrm{kg\,N\,ha^{-1}\,a^{-1}}$) indicating a possible change of plant species composition through intensification. The main C source estimated at 3,900 to $5{,}000\,\mathrm{kg\,ha^{-1}\,a^{-1}}$ for low and high homegarden types, respectively, was photosynthetically captured C stored in the rooting zone.

The horizontal balances approach indicated nutrient deficits which might result in long-term declines of crop yields, in particular for traditional homegardens. Adapted management strategies to improve soil fertility through increased organic fertilisation and higher nutrient use efficiency are recommended.

Keywords: Carbon fluxes, East Africa, nutrient fluxes, nutrient use efficiency, soil surface nutrient budget approach

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Effects of Activated Charcoal and Tannin Added to Soil and Compost on Carbon and Nitrogen Emissions

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The use of organic fertilisers such as compost and goat manure is an important approach to sustainable soil fertility management under irrigated subtropical condition, particularly in organic agriculture starting to be practised in Oman. However, high losses due to leaching and especially volatilisation are hampering the efficiency of substrate applications. This study was therefore conducted to quantify changes of gaseous carbon (C) and nitrogen (N) emissions after application of activated charcoal and tannins to compost or directly to the soil. For this, gaseous emissions of carbon dioxide (CO_2), ammonium (NH_3) and nitrous oxide (N_2O) were measured by a dynamic closed chamber system consisting of a cuvette connected to a photo-acoustic infrared multi-gas monitor (INNOVA 1312–5). Carbon and N emissions were monitored for 69 days of composting. Activated charcoal and tannins were added to compost consisting of goat manure and plant material at a rate equivalent to 0.5 t activated charcoal ha^{-1}, 0.8 t tannin ha^{-1} and 0.6 t activated charcoal and tannin ha^{-1} as a mixed application. Based on the observations in Oman, a 20-day incubation experiment under greenhouse conditions was conducted in Germany. Carbon and N emissions from soil amended with goat manure (equivalent to 135 kg N ha^{-1}) and additionally mixed with either 3 t activated charcoal ha^{-1}, 2 t tannin ha^{-1} or the sum of both these additives were determined.

The results showed that peaks of gaseous C and N emission were reduced and/or temporally shifted in tannin amended compost and also whith tannin application to the soil. Tannins applied directly to the soil significantly reduced N_2O (17 %) and significantly NH_3 (51 %) emissions in comparison to the control. Application of tannins to compost reduced cumulative gaseous emission for C by 2100 g C m^{-2} 69 d^{-1} (36 %) and for N emissions by 6 g N total m^{-2} 69 d^{-1} (40 %) compared to the unamended compost. In contrast to these results, emissions of all gases increased in activated charcoal amended compost. Based on these results, tannins appear to be a particularly promising amendment to composts to mitigate gaseous emissions and to soils as organic fertiliser amendment, especially under subtropical conditions.

Keywords: Organic fertiliser, photo-acoustic gas monitor

Vertical Distribution of Dissolved Organic Carbon in a Sandy Soil Treated with Different Quality Litter

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Dissolved organic carbon (DOC) is a constituent of soil solution and plays a key role in many chemical and biological processes in soils, notably forming organo-mineral complexes with micronutrients increasing their availability, cycling of carbon in the soil-plant system, mobilising soil pollutants in soils and acting as microbial substrates. Distribution of DOC in soils is partly determined by chemical composition of organic residues applied to the soils. The objective of this study was to investigate the effects of organic residues differing in chemical composition applied yearly for 13 years on vertical distribution of DOC in a sandy soil. There were five residue treatments: 1) no residue addition, 2) rice straw (RS) (low quality) with low N, lignin, and polyphenols but high C/N ratio and cellulose, 3) groundnut stover (GN) (high quality) with high N but low lignin, polyphenols, and C/N ratio, 4) dipterocarp leaf litter (DP) (low quality) containing low N but high lignin, polyphenols, and C/N ratio, and 5) tamarind litter (TM) (medium quality) with medium N, lignin, and polyphenols. The results showed that GN and TM treatments produced higher total DOC concentrations than DP and RS. Two patterns of vertical distribution of DOC in the soil profile as determined by quality of organic residues could be distinguished. They were 1) low DOC in topsoils but high DOC accumulation in subsoils indicating high vertical DOC movement, and 2) high DOC in topsoils but no accumulation in subsoils indicating low DOC movement. RS had higher DOC in subsoils than other treatments indicating higher vertical movement of DOC. GN treatment had extremely low DOC movement as seen in high DOC accumulation in topsoils and no DOC in subsoils throughout the decomposition period. Meanwhile, DP and TM treatments had moderately low vertical DOC movement as shown by some DOC accumulation in subsoils.

Keywords: Dissolved organic carbon, dissolved organic carbon movement, molecular weight, organic residue quality

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The Challenges of Maintaining Soil Productivity and Food Security in Sudan

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The Republic of Sudan is the largest Arab country in terms of area (with more than 250 M ha total area). While 16.7 M ha is already used for farm production (irrigated and rain fed systems), potential arable area is much larger. Furthermore, Sudan has substantial surface water resources, especially in the Blue and White Nile which have been partly developed for irrigation purposes. In spite of these natural resources, Sudan suffers from food shortages in many years and lacks the resources to cover the needs of over 32 million inhabitants, 10 % of them was classified as living in severely food insecure households. In order to evaluate soil productivity and food security challenges, a survey was conducted where interviews were held with Agricultural Ministry officials along with data collection from field visits , sampling and analysis of 80 soil samples from irrigated and rain fed schemes during the summer season between May and July 2011. The results of the survey revealed that Sudan suffers from a range of environmental threats that have affected the productivity of soils and crops. Increases in temperature and reduction in rainfall, especially between the years 1930–1990, have increased the dry areas up to 51 % of total area. The availability and prices of crop commodities was also affected. Sorghum, wheat and millet production was reduced to 45 % and the prices of sorghum, millet and groundnut were doubled compared to February 2012 prices. Results of the soil survey showed generally poor soil fertility; in the irrigated schemes the organic matter was often < 1 %; low total nitrogen; neutral pH 7.8; extremely low plant available $p < 0.08$ ppm (Bray) and CEC 54 cmol kg^{-1}. In the rain fed areas the organic matter ranged between 1.14 to 2.3 %; N <0.05 %; pH neutral to alkaline and low plant available P and CEC comparable to the results of the irrigated survey. While inherently low soil fertility is a feature of much of the agricultural lands of Sudan, a shortage of rains, the lack of proper fertilisation management and agricultural plans exacerbated the effects on agricultural output.

Keywords: Soil management, food security, Sudanese soil quality

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Maize, Soybean and Cassava Yield Response to Bat Manure in Congo Democratic Republic

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The Democratic Republic of the Congo (DRC) had the highest increase of the hunger index over the last 10 years. The agricultural input sector is virtually absent and fertiliser costs are prohibitive. In Bas Congo province large deposits of bat guano remain largely unused. Insectivorous bats are abundant across the western lowlands and their droppings (manure) are easily collected from attics of houses. We investigated the effects of bat manure on maize, soybean and cassava, to assess if regular collection of the manure or exploitation of the deposits has the potential to increase crop production.

In 2009 and 2010, 0, 500 and 1000 kg ha^{-1} bat manure were applied to maize, followed by soybean or maize without manure application. In one site cassava received 0 or 500 kg ha^{-1}. Bat manure contained 6–10 % N, 0.7–1.5 % K and 0.9–1.8 % P. Bat manure was applied at seeding about 5–10 cm from the seed or planting stick and covered with soil.

In site 1 maize grain yield increased significantly from 3.14 to 3.85 Mg ha^{-1} by 500 and 1000 kg ha^{-1} of bat manure, without a difference between the rates. The following soybean grain yield in the 500 kg ha^{-1} manure treatments was 1.74 Mg ha^{-1} yet failed the significance level ($p = 0.052$) compared to the control (1.39 Mg ha^{-1}). In site 2 maize grain yield increased from 1.78 to 2.54 Mg ha^{-1} after 500 kg ha^{-1} manure application, yet did not further increase at 1000 kg ha^{-1}. The grain yield of the following maize crop was numerically higher when the previous maize had received manure but differences were not significant. In site 3, on alluvial clay soil maize grain yield was 2.0 Mg ha^{-1} across treatments without significant differences. Cassava produced 30.3 Mg ha^{-1} fresh roots with manure, significantly higher than the control (26.0 Mg ha^{-1}, $p = 0.039$).

Bat manure did not generally increase yields, but appears to have potential to increase agricultural production. Because the manure is free of charge and constantly replenished it appears worthwhile investing in research on conditions under which the effects are greatest and optimal application rates and techniques.

Keywords: Bat guano, cassava, insectivorous bats, nutrient supply, soybean

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Methane and Nitrous Oxide Emission from the System of Rice Intensification (SRI) under Rainfed Lowland Ecosystem in Cambodia

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The system of rice intensification (SRI) receives considerable attention for its potentials to increase rice productivity in marginalised rice-growing environment. SRI differs from conventional rice management by several parameters, including water management. The intermittent irrigation (as opposed to permanent flooding) under SRI was carried out in order to improve soil aeration, root activities, reduce ineffective tillers and remove toxic substances. This practice may significantly reduce methane (CH_4) emissions, a potent greenhouse gas. However, this benefit may be offset by increased nitrous oxide (N_2O) emissions, which has much higher radiation absorbing capacity. The present field study measured the fluxes of CH_4 and N_2O under SRI practices and compared the emission of greenhouse gases from SRI with a Conventional Management Practices (CMP) production system under which continuous flooding was applied. The effects of nutrient amendment (composted farmyard manure (FYM), mineral fertiliser (MF) and FYM+MF) were also investigated under each production system. The results indicated large seasonal variations of CH_4 patterns during the growing season with a peak emission of about $1300\,mg\,CH_4\,m^{-2}\,d^{-1}$ under both production systems two weeks after rice transplanting. N_2O emissions were not detected in any treatments, which indicates NO_3^- and available C were limiting in the field trial. Under each production system, the highest emission of CH_4 was under FYM+MF treatments ($282\,kg\,CH_4$ emission ha^{-1} under CMP and $213\,kg\,ha^{-1}\,CH_4$ emission under SRI). Total CH_4 emission under SRI practices was reduced by 22 % in FYM treatment, 17 % in MF treatment and 24 % in FYM+MF treatment compared to CMP practices. There was no effect of water management on CH_4 emission in the non-fertilised control. Grain yields were not significantly affected by the production system. Thus the CO_2-equivalent emitted per kg grain produced is lower under SRI than CMP, namely 21 % in FYM+MF treatment, 8 % in MF treatment and 21 % in FYM treatment, respectively. The results therefore suggest a potential of SRI to mitigate the greenhouse gas emission from rice production without compromising rice yields.

Keywords: Cambodia, methane, nitrous oxide, nutrient, system of rice intensification, water management, rice

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Soil Coverage Evaluation with Calendula (*Calendula officinalis* L.), Crotalaria (*Crotalaria* sp. L.) and Oat (*Avena* sp. L.) in *Meloidogyne* spp. Control in Quito Orange (*Solanum quitoense* Lam.)

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In the department of Nariño the area cultivated with quito orange (*Solanum quitoense* L.) is 600 ha. This crop shows a productivity decrease due to pathogens such as the root knot nematode *Meloidogyne* spp. of up to 50-79%. On the other hand, allelopathic plant species release nematotoxic compounds, nematostatics or biocides, interfering in the nematode life cycle. This research was carried out in the village La Caldera (Pasto), in order to search alternatives of root knot disease management. For it a randomised block design was used, with three replications and five treatments, which consisted of three soil coverages: Calendula (*Calendula officinalis* L.), Crotalaria (*Crotalaria* sp. L.) and oats (*Avena* sp. L.) sown one month before the crop was planted and incorporated at flowering time, a chemical control with the application of carbofuran at sowing and every third month, and a control. Each experimental unit had 12 quito organges planted at 3×3 m. Incidence and severity of the nematode population were evaluated and quito orange production measured. The results showed a 100 % incidence in all treatments, but a positive effect of the soil coverage on the nematode severity. Regression analysis allowed to prove that with an increasing severity of the nematode population the quito orange production was significantly reduced. *Meloidogyne incognita* was the most abundant species. We conclude that calendula, oats and crotalaria are viable alternatives for dealing with the problem of root knot nematode.

Keywords: Management practices, plant coverage, root knot

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Plant Genetic Resources in Vietnam: Current Situation of Conservation and Utilisation

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Vietnam, a country in Southeast Asia with an enormous richness in genetic resources, counts about 12,000 plant species, and more than 19 percent of them have been used in daily life of the inhabitants. Nevertheless, the various resources are seriously extinct or threatened by climate change and human activities. Therefore, it is very important to find appropriate methods for conservation of the indigenous plants and landraces. *In situ* and *ex situ* are two main methods used for conserving national plant genetic resources in Vietnam. With the support of local (ASEAN) and global (FAO) organisations, Vietnam had established more than 2.4 million hectares in order to protect valuable biological resources. Among that, 43.4 % are national parks, more than 49.3 % are natural conservation areas, and the rest are cultural historical environment sites. On-farm conservation is practised in the plant genetic resources centres of Vietnam with fruit trees, root crops, vegetable crops, ornamental crops, medicinal herbs, and forage plants. *Ex situ* conservation method are highly investigated for seven main groups as crop grains, fruit crops, annual and perennial industrial crops, vegetables, ornamental crops and forage plants. In a network of 13 Vietnamese plant genebanks, 9,408 accessions are conserved. 15,760 accessions are stored in seedbanks with medium-term condition, and 152 accessions are conserved for recalcitrant food crops in an *in vitro* bank. Research and utilisation of plant genetic resources are also applied. 7.057 accessions are accessed for quantitative and qualitative traits. 1.093 accessions of 18 genera are used as breeding materials in national breeding programs; some new promising cultivars have been released and used in agricultural production.

Keywords: Conservation, *ex situ*, genetic resources, *in situ*, indigenous

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Water Availability and Agrobiodiversity Indices - A Case Study of Non-Hunting Gharaviz Region

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Water availability is a fundamental key element in developing agricultural biodiversity in rural arid and semi arid farming systems. Gharaviz non-hunting area with 418 mm annual average precipitation and annual average temperature of 20°C is located in western Iran. A fieldwork survey was carried out to investigate the relationship between water access and agrobiodiversity indices during July to August 2011. Seven different villages were randomly selected, of them 3 inside and 4 outside the marginal regions of Gharaviz region. Agricultural biodiversity data were gathered through face-to-face interviews of farmers. Altogether, 134 semi-structured questionnaires were filled out. Data analyses proceded employing ecological methodology program (EMP) as well as SAS and SPSS. Regression test was employed to evaluate species richness affectability from distance of village to water resource. The relationship between distance from water sources and biodiversity indices was evaluated by simple regression test. The results showed the signifance of this relationship as well as a negative correlation with average species richness indices ($p < 0.01$), Shannon ($p < 0.01$) and evenness ($p < 0.05$). This means that indices values decrease as distance to water resources increase. There was a positive correlation to Simpson index ($p < 0.01$) as distance increased. The number of cultivated species in villages within non-hunting area restricted to eight species, which was significantly less than species richness in marginal areas (17 species). The main reason for this is less water availability in "inside" villages compared to "outside" villages. The Golam Kabod Sofla village had the highest species richness (10 species) among others due to small land plots and nearness to Golam Kabod River. Wheat, barley and chickpea are being cultivated in these regions due to drought tolerance. This survey concluded that distance to water resource could significantly affect agricultural species richness and other biodiversity related indices.

Keywords: Gharaviz, iran, species richness, water availability

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Importance of Flying Foxes in Reproductive Performance of *Adansonia digitata* in Benin

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Baobab (*Adansonia digitata*) is a socio-economically important agroforestry woody plant mainly pollinated by flying foxes (*Pteropus*). Different populations of baobab exist in the three different bioclimatic zones of Bénin: the guinea-congolian zone, the transition zone and the sudanian zone. According to a recent study the baobab tree in the tranisition zone showed a high rate of flower abortion just at the starting of fructification. The present study aimed to assess the importance of flying foxes pollination in the fruiting success in order to find out factors that contribute to flower abortion. We characterised flowers measuring sepal and petal sizes as they provide the landing area for pollinators, assessed nectar production in baobab populations through the three major bioclimatic zones and compared the flower visited/lacerated by bats with the fruit production successes in the two first months. We finally bagged some flowers avoiding flying foxes visits / laceration and assessed the subsequent fruit productions. We reported comparable flower sizes while the nectar production was significantly different between the three bioclimatic zones. The fruit production successes with bagged flowers were 1.5 %, 10.3 % and 3.3 % respectively in the southern, the transition and the northern zone while the bat visited flowers produced respectively in the same zones 49.4 %, 22.4 % and 25 %. The fruit production successes were not directly correlated with the nectar production that was 17.07 ± 9.25 ml (southern zone), 14.83 ± 5.62 ml (transition zone) and 26.26 ± 10.22 ml (northern zone). We proved the importance of flying foxes in the fruiting success of baobab in Benin.

Keywords: Baobab, Benin, flying foxes, fruit production, pollination

Biomass and Carbon Stocks Related to Ecological Complexity and Tree Diversity in Three Different Cacao Production Systems

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In tropical regions, large forest areas are constantly converted into agriculture contributing with about 17 % to global greenhouse gas emissions. Given that tropical areas are most vulnerable to climate change impacts, the need increases to identify and to implement sustainable land use systems that sequester carbon and provide ecosystem services at the same time. Cacao as a perennial crop which grows well in association with shade trees is one option for vulnerable agricultural areas on tropical rainforest margins. The aim of this research was to compare C-stocks in complex and simple cacao agroforestry systems and common practice monocultures in Bolivia, and to evaluate the role of local organisations for agricultural diversification. Carbon stocks were then linked to the different types of cropping systems and the related variables age of the plantation, tree and crop diversity and ecological complexity. In 15 plots of 2304 m^2 each, aboveground and belowground biomass as well as tree and crop diversity was sampled. Then the role of the affiliation to a cacao cooperative and/or other local organisations for diversity was evaluated by interviewing cacao farmers with and without affiliation to a local organisation. Results show that C-stocks correlated significantly with the Holdridge-Index for ecological complexity, as well as with tree diversity and with the proportion of shade trees. The results of the interviews indicate that local institutions enhance agricultural diversification and agroforestry by awareness rising, further education, and opening markets for agroforestry products. The integration of ecological and social data allows to conclude that cacao producers diversify their cacao plots if provided with agricultural extension services from local organisations, most of all those working with organic certification. This indicates that organic cacao cultivation, if oriented towards diversified agroforestry, not only contributes to climate change adaptation but also to its mitigation by sequestering more carbon than common practice cacao plots.

Keywords: Agroforestry, Bolivia, cacao, cooperatives

Improving Peri-Urban Soils with Recycled Waste from the Municipality of Patancheru: An Indian Case Study

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Cities have been centres of rapid development. But, urbanisation not only results in benefits, it often leads to environmental and social problems due to lack of appropriate environmental sanitation services and food insecurity. Rapid changes in peri-urban land use puts agriculture under pressure and leads to land fragmentation and increased production costs. However, peri-urban agriculture could play an important role in supplying fresh, perishable fruits and vegetables to city markets, while contributing to solving environmental and social challenges.

This study describes a framework for participatory processes that was used to develop a public-private partnership between the Greater Hyderabad Municipal Cooperation (GHMC) and socially inclusive groups as well as a method for converting the organic component of the city waste to compost (pilot study), that has the potential to revitalize the peri-urban soils of Hyderabad. A participatory institutional analysis revealed that the GHMC Sanitation and the Community Urban Development wings, were important partners. Meetings with farmers, waste pickers, self-help groups (women) and rickshaw pullers enabled the selection of a socially inclusive group to develop entrepreneur skills.

Garbage generation in the city of Patancheru is 26'357 kg d^{-1} (0.57 kg cap^{-1} d^{-1}). The organic fraction is estimated at 14'286 kg d^{-1} (0.31 kg cap^{-1} d^{-1}). Assuming a reduction of volume of 75 % and a nutrient content of 1 % N, 0.3 % P and 0.9 % K, it would be possible to recycle about 36 kg N, 11 kg P and 32 kg K d^{-1}. Annual production would amount to 13,035 kg N, 3,911 kg P and 11,732 kg K. Business ideas jointly developed with stakeholders revealed that the organic fraction from the vegetable markets and organic city waste can effectively be collected. But, the moist and nitrogen rich material has to be composted with rather sparse carbon rich material from farms and other industries.

Preliminary findings will be verified by more in-depth studies of the pilot project and an on-farm fertiliser comparison trial. These follow up studies will also determine if the establishment of composting units generate sufficient income, and if farmers are willing to use the compost.

Keywords: Compost, municipal solid waste, Patancheru, peri-urban agriculture

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Expansion of Quinoa Crop (*Chenopodium quinoa* Willd.) and Soil Quality Analysis in the Bolivian Intersalar

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The grain of the quinoa was traditionally cultivated by the inhabitants of the Andean region and constituted the principal food of the Incas. It is characterised by its high nutritive value due to its composition and relationship quantity/quality of protein.

The principal production of quinoa is obtained in the highland areas of Bolivia. Traditionally, the quinoa was sown in small quantities and it was used for self-consumption. The location of crops was in hills and slopes, under a manual system management. As a consequence of the growing international demand and rising prices, expansion of the cultivation in the form of intensive monoculture took place, which generated a negative impact on the fragile ecosystems of the altiplano region. In recent years, the production of quinoa increased from $9,000\,\mathrm{t\,y^{-1}}$ in 1970 to more than $30,000\,\mathrm{t\,y^{-1}}$ in 2009.

The present study identifies the quinoa crop evolution in time and space through satellite images of the years 1975, 1990 and 2010 in the Bolivian Intersalar. At the same time, it employs the physical-chemical soil analysis made by the AUTAPO Foundation, in order to perform a detrended corresponse analysis (DECORANA) and a classification analysis using a two way indicator species analysis (TWINSPAN).

A socioeconomic diagnostic was also carried out through interviews and surveys, to determine the impacts generated from the extension of the quinoa cultivation.

The maps generated through satellite images show that between 1975 and 2010, the cultivation of quinoa, increased from 70 % to 300 % on flat surfaces and decreased from 16 % to 32 % on hillsides. Multivariate analysis indicated that the patterns of soil quality are basically determined by Sodic soils. With the socio-economic analysis, it was demonstrated that in the studied community, the increasing income for the quinoa cultivation had impacts on lifestyle's changes, eating habits, and social conflicts over unequal land ownership and monetary income.

Keywords: Bolivian Intersalar, land-use change, soil, sustainable agriculture, quinoa

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Participatory Cotton Breeding for Organic and Low Input Farming in Central India

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Up to 80 % of world's organic cotton is produced in India. However, involved producers are facing increased difficulties to find suitable cultivars. Few hybrids selected for high input farming and genetically-modified (GM) cotton, which is explicitly excluded in organic farming, are presently dominating the Indian seed market. In addition farmers have lost their traditional knowledge on seed production and hybrid seed needs to be purchased each season. Moreover, there is a big risk of contamination with GM cotton and the loss of locally adapted genetic resources. Therefore fast action is needed to re-establish a GM-free seed chain and breeding programs to support organic and low input cotton farmers in India. Participatory plant breeding (PPB) offers a great opportunity for developing locally adapted cultivars as well as for maintaining and increasing genetic diversity. The close collaboration of farmers, extension agents and breeders allows to identify cultivars that suit the circumstances of resource-poor farmers in marginal environments. This study was conducted in collaboration with FiBL, bioRe an organic cotton producer in Central India and the University of Agricultural Sciences (UAS) Dharwad. The main aim of the study was to introduce participatory breeding approaches and to test improved cotton cultivars in smallhoders' organic cotton fields and to gain information about the suitability of different types of cotton cultivars for organic and low input farming in Central India. The study combined on-station with on-farm trials and was conducted transdisciplinary involving the joint expertise and knowledge of organic farmers and breeders. On-station seven different cultivars, including different species and plant types were tested under high and low input conditions for genotype × management interaction. On-farm in farmers fields five commercial cultivars were tested among 20 organic farmers representing different soil fertility levels for genotype × environment interaction. In addition, 49 cultivars of different species and plant types and five F2 progenies all received from UAS Dharward were examined on-farm at bioRe for their suitability under organic and low input farming. First year results of this long-term study will be presented.

Keywords: Cotton seed, *Gossypium*, low input farming, organic farming, participatory breeding

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Effects of Salt-Alkali Stress and Clipping on *Stipa baicalensis*

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Stipa baicalensis is one of the dominant species in Songnen grassland, where soil salinisation-alkalisation is serious problem. In addition, overgrazing is other major cause contributing to grassland degradation. Due to above mentioned stresses, the population size of *S. baicalensis* in the grassland dramatically decreased during the last four decades. However the response of S. baicalensis to salt-alkali stress and overgrazing has not been well understood.

A two factorial experiment was conducted in the natural field with the addition of mixed salt-alkali solution (NaCl: NaHCO3: Na2CO3 = 1:1:1) and clipping (removal 60 % of aboveground biomass). The aboveground biomass (AB), plant density and height, proline and soluble sugar content were measured. The results showed there is no significant interaction between salt stress and clipping on AB. Clipping significantly reduced AB regardless of salt stress, whereas salt stress has no significant effect on AB. Overall, clipping has no significant effect on plant density and height, while salt stress significantly increased plant density and height. The content of proline and soluble sugar was significantly reduced by clipping and salt-alkali stress in shoot, but not in stem-base. As to root, salt-alkali stress and clipping have no significant effect on proline content, while salt-alkali stress significantly reduced soluble sugar content. In summary, overgrazing has more adverse effects on *Stipa baicalensis* community than salt stress. Since this species didn't show any morphological and physiological resistance to clipping, while it exhibits salt resistance by increasing plant density and height in spite of no physiological salt resistance ability. Further, our results suggest reducing stocking rate may be an effective way to restore *Stipa baicalensis* community, and the measurements could include rotational grazing, seasonal exclosure and even complete exclosure at the overgrazed sites.

Keywords: Aboveground biomass, clipping, salt stress, *Stipa baicalensis*

Organic Management Practices Enhance AM Biodiversity in Tropical Agricultural Soils

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Arbuscular mycorrhizal fungi (AMF) have been recognised as an important component of organic agriculture. Modern agricultural practices, such as chemical fertilisation, pest control, continuous monoculture and tillage impact AMF and plant interactions. To study the impact of these practices, investigation was undertaken to compare the AMF diversity in trap cultures raised on conventially managed as well as on organically managed fields. Spores of AMF were collected from trap cultures of both fields (northern India) and based on their morphology were grouped into morphotypes. Partial sequence analysis of rDNA from single spore of each morphotype was undertaken using either a small-subunit internal transcribed spacer (SSU-ITS) or a large subunit (LSU) region and fatty acid methyl ester profiles (FAME) of similar morphotypes were compared.

Organic managed sites contributed 18 AM species belonging to genera *Rhizophagus* and *Funneliformis* and 7 AM fungi of *Acaulospora*, *Gigaspora* and *Scutellospora*. In contrast, conventional managed sites selectively favour only smaller size AM species belonging to genera *Rhizophagus* and *Funneliformis* species. We observed that organically managed farmland showed the largest AMF species richness and colonisation potential, which suggests that factors contributing to the diversity of AMF are indeed complex: for example, chemically managed farmland not only causes loss of fungal biodiversity but also selectively favours smaller spores (*Rhizophagus* sp.), thereby affecting ecosystem functioning adversely. The present study showed that both abundance and diversity of AMF is favoured by low-input agriculture incorporating planting on raised beds (RB) and organic practices such as zero tillage that do not disturb the physical properties of the soil.

Keywords: Arbuscular mycorrhizal fungi, fatty acid methyl ester profiles, large subunit, raised beds, Ribosomal DNA

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Soil Seed Banks in Degraded Pastures Recovered by Forest Plantations in the Eastern Amazon, Brazil

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In the Eastern Brazilian Amazon the primary forest has been replaced through a process of colonisation, to intensive agricultural activities. In degraded areas, characterised by loss of the natural recovery capacity after a natural disaster or man-made disturbance, seed banks can be used to make predictions on the floristic composition and to understand the dynamics of forest ecosystems and their recovery strategies. The objective of this study was to evaluate the floristic composition of the soil seed banks present on degraded grassland in four properties of family farming in the municipalities of Bragança, Capitão Poço and Garrafão do Norte. These sites are proposed for mixed forest species plantation by the Legal Reserve Areas (LRA). From each site were collected six soil samples, using a wood guide of 0,25 m^2 to a depth of 5 cm, to compose one sample. The experiment was performed from the composite samples in a green-house at EMBRAPA, Eastern Amazon, and monitored daily. The seedlings were identified and classified according to: life habits, environmental groups and types of dispersion. After nine months were accounted a total of 6,141 seedlings, Bragança: 1,282 individuals, 51 species within 22 families; Capitão Poco: 1,260 individuals, 36 species within 16 families; and Garrafão do Norte: 3,599 seedlings, 57 species within 22 families. In all studied areas there was a predominance of herbaceous vegetation (more than 71%; herbaceous and herbaceous vines), while the woody vegetation (tree, shrub and woody vine) ranged from 19 to 29 %. The pioneer species were more than 57% and species with barochory seed dispersal ranged from 39 to 44 %.

Keywords: Floristic composition, forest plantation, land reclamation

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Linking Indigenous Knowledge System and Molecular Genetic Analysis for Management and Conservation of Enset (*Ensete ventricosum*), a Food Security Crop in Southern Ethiopia

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Intra-specific diversity of neglected and underutilised crop species (NUS) is a key element in resilience of smallholder-based agricultural systems and farmer's livelihood strategies in many developing countries. There has been growing call for inventories and integrated methods evaluating utilisation, diversity and distribution of NUS, especially in context of the changing farming systems. The enset crop in indigenous enset-based farming systems of Southern Ethiopia plays an ecological, economical as well as a food and nutrition security role for over 15 million households in the region. We are applying an interdisciplinary approach which combines indigenous knowledge system (IKS), molecular genetic analysis (MGA) and geographic information system (GIS) to investigate socio-cultural values, level of genetic diversity and geographic distribution of enset (*Enset ventricosum*) landraces cultivated in 12 communities of Wolaita and Gamogofa Zones in southern Ethiopia. Cultural use values, local management practices, farmer's unit of diversity (FUD) and descriptors of landraces were documented and *de novo* microsatellite markers were developed using next generation sequencing and data mining approaches. The application of this interdisciplinary approach is anticipated to highlight on (i) current use status and potential benefit of enset genetic resources; (ii) extent and eco-geographic distribution of enset landraces across communities and landscapes; and (iii) detailed prioritisation of community centred *in situ* conservation areas (microcentres of conservation) for enset agrobiodiversity. The methodological approach utilised in the study and the molecular tools developed imply the multi-functionality of integrated approaches for conservation and improved utilisation of crop genetic resources in general and NUS crop species such as enset in particular.

Keywords: Biodiversity conservation, Enset, Ethiopia, indigenous knowledge system, molecular genetic analysis, neglected and underutilised species

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Transpiration Response of C3 and C4 Plants of Northern Chinese Steppe Ecosystem to Water Vapor Pressure Deficits (VPD)

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Since water is often limiting plant growth in semi-arid ecosystems, the regulation of transpiration is an essential component of adaptation strategies. Transpiration of plants is usually increasing with water vapor pressure deficits (VPD) of the atmosphere; however, different species vary in the regulation of water losses which might help to explain plant community dynamics in semi-arid environments. Chamber experiments were performed with five dominant plant species originating from steppe ecosystems of northern China. These comprised three C3 plants and two C4 annual grasses. Canopy transpiration of these five plants cultivated in pots under full water supply was measured in a chamber allowing to adjust VPDs ranging from 0.5 (low pressure deficit) to 2.5 kPa (high deficit). The results showed that C3 plant *Leymus chinensis* reached a maximum transpiration rate at VPD 1.3 kPa with little or no further increase in transpiration rate above this value as VPD was increased. In contrast, the other four species showed continued linear increase in transpiration rate with increasing VPD. The annual dicotyledonous species showed highest transpiration rates, while C4 annual grasses showed less water loss per unit leaf area. These results indicated different water household strategies of dominant plant species in the Songnen grassland. *L. chinensis* with high transpiration under low VPD and down regulation under higher VPD indicate effective stomata regulation during mid-day VPD peaks resulting in water conservation. Low transpiration rates of C4 annuals might be explained with comparably small rooting systems limiting the water uptake under high pressure gradients. The C3 annual dicotyledonous plant, however follows an opportunistic strategy with high water consumption. Plants photosynthetic performance combined with morphological and functional traits are promising indications for studying the adaptation mechanisms of plant species under semi-arid conditions.

Keywords: C3, C4, stomata, transpiration, vapour pressure deficit, grassland

Knowledge and Usage of Bitter Gourd as an Anti-Diabetic Plant in Tanzania

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Diabetes mellitus type two is on the rise all over the world with an alarming incidence rate in many low and middle income countries. In Tanzania, the national prevalence rate of diabetes is 2.3 per cent. The increasing trend is especially common in urban areas. Insufficient supplies of oral anti-diabetic drugs and insulin call for alternative strategies to treat this disease. *Momordica charantia*, the so-called bitter gourd, is one promising plant. In some countries, it is used as a phyto-medicinal plant to reduce blood glucose levels. The current survey assessed the knowledge and usage of it among diabetic patients at the Kilimanjaro Christian Medical Centre, Tanzania. Of the 155 interviewed patients, only 7 per cent have heard about the plant, while only 5 per cent used it, in addition to oral anti-diabetic agents, as a medicinal plant. Preparation of the bitter gourd varied from eating it as a juice, cooked, or cooked and mixed with other vegetables. Most patients used it once per day. Although the bitter gourd was not well known among patients, the concept of using traditional medicine was widely accepted. *Aloe vera*, *Moringa oleifera*, and African plum tree were among the mostly named plants, used for diabetes mellitus, hypertension, wounds, and cancer. Generally, patients were very open towards the idea of using bitter gourd as a treatment or adjunct treatment for their diabetes mellitus. Further interviews were conducted among health workers in the area surrounding Kilimanjaro Christian Medical Centre. Here, 35 per cent knew bitter gourd and its health related effects; while 8 per cent already recommended its use for diabetic treatment. Others would hesitate to recommend it due to lack of scientific and reliable data.

In summation, this survey shows that there is high potential to apply alternative strategies to treat diabetes mellitus. However, scientific studies on efficacy and safety of such phyto-medicinal plants are needed. In regard to *Momordica charantia*, clinical trials are planned for 2013 in India and Tanzania by the World Vegetable Center to test the viability of utilising the gourd as an alternative strategy for treating diabetes mellitus.

Keywords: Diabetes mellitus type two, *Momordica charantia*, Tanzania, traditional medicine

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Skyfarming – Staple Food Production in Cities – Light *vs* Energy Demand

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Multi-level indoor plant production systems, also referred to as vertical farming or skyfarming systems are drawing more and more attention. In the context of climate change and population increase accompanied by greater risks of global food shortage, such systems could secure food production particularly in mega cities and take pressure off arable land. Additionally, such systems minimise water and nutrient use if build as closed circulation systems *e.g.* with biogas production from crop residues and its use for thermal regulation. However, even though plenty of design studies for vertical farming concepts exist, the total energy demand for plant growth and the potential output in terms of yield biomass in such systems is largely unknown. Supplying light to the plants assumedly having the greatest share of the total energy requirements for such a facility, we calculated the efficiency of high end light emitting diodes (LEDs) of different colours in terms of emitted quantum per electrical watt and linked the results with a parametric model for the quantum demand of rice. The results showed that there are several potential ways to meet the theoretical energy demand for light supply in an artificial environment, depending to a large extend on the plant's physiological responses to illumination duration and light quality. In order to further develop the model, we designed and constructed a semi-closed chamber system allowing control of temperature, vapour pressure deficit, light intensity and quality (ratio of blue, green and red wavelengths) and the measurement of canopy gas exchange parameters. Those experimental data will also help optimising the basic light management in a closed plant production system such as reflection rate from surfaces and rate of direct *versus* diffuse light. Preliminary results of growth experiments will be shown and possibilities for increasing the radiation use efficiency in closed plant production systems will be discussed.

Keywords: Artificial lightning, energy demand, light emitting diodes, rice, sky farming, vertical farming

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Genetic Variability in Wild and Domestic Populations of *Inga edulis* Mart. (Fabaceae) in Peruvian Amazon

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Human activity in the Peruvian Amazon causes native vegetation fragmentation into smaller units resulting on the increase of agricultural systems. Understanding the level, the structure and the origin of morphologic within and among populations variation is essential for planning better management strategies aimed at sustainable use and conservation of *Inga edulis* Mart. species. We evaluated the genetic variability in wild and domestic population to unfold cultivation changes over the species genetic resources. We have studied 400 adult trees: 200 cultivated on arable land and 200 wild growing in untouched lowland rain forest. The individuals were randomly selected. Sampling sites were selected and defined on the basis of the geographical coordinates: longitude, latitude and altitude. Phenotypic variation was monitored using the proposed descriptor of qualitative and quantitative features (*e.g.*, weight of hundred seeds). For each individual a voucher specimen was kept. The total genomic DNA was extracted from young leaves, conserved in silica gel, with INVITEK, Invisorb ®Spin Plant Mini Kit. Samples were then genotyped with five microsatellite (SSR) loci. One locus (*Pel5*) was cross-transferred, developed previously for *Pithecellobium elegans*. The remaining four loci (*Inga*03, 05, 08, 33) were previously developed for the species. Polymerase chain reaction (PCR) was made using a Biometra® T1 Thermocycler using the following profile: 95°C for 2 min; 95°C for 15 s, 55/59°C for 30 s, 72°C for 30 s, 30 cycles; 72°C for 15 min. The PCR products were fluorescently labelled. The visualisation of fragments was carried out according to standard protocols on genetic analyser, ABI PRISM® 310 (Applied Biosystems), using ABI GENESCAN and GENOTYPER software. The phenotypic and genotypic results of wild *versus* domestic populations are under evaluation to verify if cultivation is altering the allelic variation considering that morphology is considerably changed.

Keywords: *Inga edulis*, DNA, microsatellite locus, native vegetation, PCR, peruvian Amazon, population, variation

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Effects of Land Use Change on Soil Organic Carbon: A Pan-tropic Study

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Tropical forest deforestation is recognised as one of the major contributors to anthropogenic greenhouse gas emissions. In contrast to aboveground carbon stocks, comparatively little is known on deforestation's affect on the magnitude and the factors affecting soil organic carbon (SOC). In this regional scale study we focused on tropical sites with deeply weathered, low-activity clays soils in three countries: Indonesia, Cameroon and Peru. Using a clustered sampling design we compared SOC stocks in the top three meters of soil in undisturbed forests (the reference) with converted land uses that had been deforested. The most predominant land use trajectories relevant for each region were investigated. These included (a) conversions from forest to cash-crop plantations (rubber, oil palm, cacao), (b) conversions from forest to cattle grazing pastures and (c) conversion from forest to shifting cultivation. Preliminary results from the three case study regions found that the conversion of forests to intensively managed land uses such as oil palm, rubber and cattle pastures caused significant losses of SOC in the top soil. In contrast, the extensively managed shifting cultivation land use trajectory in Peru showed no significant change in SOC stocks. In all land use trajectories there are indications that SOC may be translocated to deeper depths in the soil profile.

Additionally, regional scale constraints such as soil physical and chemical characteristics (soil texture, soil pH) and climatic variables (precipitation, temperature) effect on SOC stocks and the changes in SOC stocks associated with land use change have been identified using multivariate statistical methods.

Keywords: Cacao, deforestation, oil palm, plantations, rubber, shifting cultivation, soil carbon

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Effects of Geohumus on Physiological Traits of Maize (*Zea mays* L. cv. Mikado) under Variable Water Supply

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Drought is one of the most important abiotic factors affecting food security worldwide especially in arid or semiarid regions. Geohumus, known as a new generation of hydrophilic polymers, can absorb and release water for crops. Thus it was hypothesised that applying Geohumus to sandy soils (SS) would increase soil moisture resulting in improved performance of maize under water deficit conditions. Plants were grown in a split root system filled with 500 g SS (control) and 500 g SS mixed with 10 g Geohumus. The roots were divided between the two compartments and plants were watered daily to maintain field capacity. Fertiliser was supplied every three days in form of nutrient solution. 26 days after germinating, plants were subjected to one of three water supply levels (Full irrigation (FI) receiving 100 % FC; partial root drying (PRD) with half of the root system exposed to 100 % FC and the other half maintained at 50 % FC; and deficit irrigation (DI) with equal 50 % FC for both sides of root system) for 40 hours before sampling. At sampling plants were decapitated, root water potential determined in a scholander bomb and xylem sap sampled at permanent pressure 20 % above water potential for 10 min. Geohumus application compared to the plants grown in sand alone resulted in increases in pHxylem under DI, and strong increases in leaf and xylem abscisic acid concentration ([ABA]leaf and [ABA]xylem) under FI, PRD and DI. In contrast, there were significant decreases in leaf and root water potential and xylem osmotic potential under PRD and DI under Geohumus but leaf osmotic potential. However, no significant differences in photosynthesis, stomatal conductance, and transpiration between SS and and Geohumus were found. In summary, plants with Geohumus application responded stronger to drought stress than those grown in SS.

Keywords: Physiological traits, SM, water deficit

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Structural Analysis of Rosette Desert Scrub in Northeast Mexico

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Ecosystems in arid and semiarid regions of Mexico like the desert scrub rosette (MDR) are highly diverse, and one of the most abundant, most widely and historically more used. It has been studied earlier, but the available information is almost nonexistent, therefore its richness and diversity of its natural resources is unknown. In the absence of studies related to these ecosystems, the present research examined the differences in vegetation, composition and structure of two areas of desert scrub rosette, a valley and a hill. In each area were estimated ecological indicators of abundance (Ar), dominance (Dr), frequency (Fr) and importance value index (IVI). The index of Shannon & Wiener (H') to estimate the diversity and Margalef index (Da) to estimate species richness were used also. The statistical significance of the variables between the evaluated areas was calculated by an analysis of variance (ANOVA) using the average values of the sampling sites. The results of the analysis showed significant differences ($p < 0.05$) to abundance and coverage variables between both areas. More than 40 % of individuals sampled had diameters smaller than 2 cm. The most representative family with 12 of the 35 different species was Cactaceae. The valley area had 40 % more species than the hill zone. In both (hill and valley) cases the species *Lechugilla torr* was the most abundant and dominant species, with the highest importance value. The Shannon index and Margalef showed that both areas are highly rich and diverse in relation to other arid and semiarid sites of northeastern Mexico.

Keywords: Agave, *Lechuguilla torr*, importance value index, plant diversity, Shannon

Ethnoecological Analysis of Bacuri (*Platonia insignis* Mart.) Extractivism in the Chapada Limpa Reserve (Maranhão, Brazil)

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A central issue of agroecological research is the combination of scientific and traditional knowledge, within a pluralistic perspective and covering both natural and social sciences. This way it is possible to optimise agroecosystem functioning and maintain harmony between society and environment. The rural 'territory' is key within this context, and those production techniques should have priority that are capable of providing a future closely connected with the societies in which they live and the ecosystems in which they produce. In Maranhão State, eastern periphery of Amazonia, there are 5 extractivist reserves, one of which is the Chapada Limpa Reserve, located in Chapadinha county, central Maranhão State. This project strives to gain an understanding on how local population interacts with local environmental resources, based on their traditional knowledge, and how their management affects the natural resources in the environment. For this purpose, we mapped the most significant areas of occurrence of the bacuri fruit tree (Clusiaceae – *Platonia insignis* Mart.) in 4 communities of the reserve: Juçaral II, Chapada Limpa I, Chapada Limpa II and Chapada do Riachão. We established our selection of these 4 areas as main areas of bacuri extractivism based on informal interviews with local population at initiation of this project. We subsequently applied semi-structured questionnaires, as well as participative observation, botanic sampling of vascular plants at flowering, plant physical parameters (height, diameter, thickness and weight of bark, seed weight, pulp weight, number of seeds per plant) and chemical indicators (pH, total acidity, titratable acidity and degree brix) of fruits, as well as the quantification of plant population structure based on phytosociological methods. Our preliminary results confirm the prominent role of Platonia insignis in our study area and thus confirms its ecological and cultural importance. However, management does impact the biodiversity of the associated vegetation.

Keywords: Extractivism, Maranhão State, *Platonia insignis*

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Management Options for Sustainable Land-Use of Inner Mongolia Typical Steppe: Lessons from a Comprehensive N Balance

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Inner Mongolian semi-arid grasslands are substantially affected by land degradation as a consequence of excessive overgrazing during the last decades. Nitrogen (N) is considered as a key element for ecosystem functions and therefore of fundamental importance to maintain forage production.

N pathways of Chinese typical steppe were quantified at sites representing different land-use practices including heavy grazing (HG) and haymaking.

Results showed that grassland NPP requires 3–7 g N m^{-2} yr^{-1}, which is mainly provided by N mineralisation from the large soil organic matter pool. Our N balances indicated that HG must be considered as N source with annual total net losses of up to 1.7 g N m^{-2}, mainly due to dust emissions and excrement export, the latter resulting from keeping sheep in folds overnight. Soil N mining by HG was indicated by reduced pool sizes of both topsoil organic N, and above- and belowground biomass N. Haymaking contributed to substantial annual N losses (up to 1.4 g N m^{-2}), but sites were not affected by wind erosion and thus balanced with regard to N gains and losses. Management options in terms of a sustainable N balance could include sheep excrements redistribution to grazing areas with a potential to decrease up to 70 % of annual N loss related to animal feed intake. N losses due to export of live weight and wool were relatively small and could be sustainable as soon as stocking rates are reduced to a level at which remaining biomass prevents wind erosion. The establishment of haymaking sites ameliorated by *e.g.* the cultivation of legumes may improve regional N balances. Small amounts of mineral N fertiliser can further contribute to a sustainable land-use with regard to the N balance and forage production. Most N-related processes were more intensive in seasons of higher water availability indicating complex interactions between land-use intensity and climate variability.

Land use practice (*e.g.* pastoralists in context of socio-economic systems) will be increasingly important for the management of N dynamics in Chinese typical steppe and, therefore, must be considered as a key component to maintain and optimise ecosystem services.

Keywords: Grazing, N-balance, semi-arid grassland

Investigation of Weed Community Diversity in Forage Crop Fields in Iran

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Agricultural biodiversity or "agrobiodiversity" refers to the diversity of all living organisms including animals, plants and microorganisms functioning at genetic, species and ecosystem levels and contributing to agricultural food production. It also involves the interactions between environment and practices made by human for food production. In order to evaluate weed diversity in forage crop fields in different provinces of Iran, a study was conducted by using data from reports of the plant protection organisation, Ministry of Agriculture.

The results indicated that the number of weed species and families found in alfalfa fields were 37 and 18, respectively. The largest family of monocotyledonous and of dicotyledonous weeds were Poaceae and Asteraceae. In sainfoin fields, 9 species of 5 different families were observed with Poaceae having the highest species diversity. In clover fields, with 20 different weed species of 11 plant families, was the highest species diversity found among the Poaceae family with 6 species and the Brassicaceae family showed 4 species. The highest similarity index for alfalfa fields (100 %) was observed between West Azerbaijan - Ardabil, West Azerbaijan - Zanjan, West Azerbaijan - Kordestan, Ardabil - Kordestan, Zanjan - Kordestan, Zanjan - Gilan, Kordestan - Gilan, West Azerbaijan - Gilan and Ardabil - Gilan. The highest similarity for sainfoin fields (60 %) was between East Azerbaijan - West Azerbaijan and West Azerbaijan - Fars. Also, in clover fields, the highest similarity index was obtained between Fars and Isfahan provinces.

In general, these results suggest that the use of high level of inputs in conventional cropping systems has caused a tremendous change in the structure of weed communities. In this respect, for instance, herbicides are normally used to control broad leaf weeds and this allows narrow leaf species which are resistant to herbicides to dominate and hence reduces the functional diversity of weeds as a whole.

Keywords: Alfalfa (*Medicago sativa*), clover (*Trifolium* sp), sainfoin (*Onobrychis* spp.), similarity index, species diversity

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Forestry

Forestry

Access to Credit and Value Additions to Some Non-Timber Forest Products in Egbeda Local Government Area, Nigeria

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The capacity to promote sustainable use of Non-Timber Forest Products (NTFPs) and facilitate increased financial benefits to local users as incentives for forest conservation is low due to neglect by governments particularly in Nigeria. Such capacity is however imperative to stemming rural poverty and can be enhanced by incorporating NTFP collection and commercialisation research into forest management development programs. But sustainable production and conservation of forest products is influenced by a number of factors, largely socioeconomic and institutional in nature. Men and women also play different roles in the collection and utilisation of NTFPs. This paper reports collection and sales of NTFPs against some socioeconomic background of identified collectors in Egbeda Local Government Area (LGA), Oyo state, Nigeria. Purposive simple random sampling was used to select respondents from the study population using the medium of the Egbeda Farmers Association of Nigeria (EFAN). Egbeda LGA has 10 cell groups of EFAN and twelve (12) farmers were selected from each of the cell group. A total of 120 sets of structured questionnaire were used to document demographic information, involvement in NTFPs business and access to credit facilities among respondents. Oral interview were also conducted to know if they engage in the NTFPs business as a primary occupation or secondary occupation, the type of NTFPs specialised in, their sources, number of gathering trips per week, and the amount made from the sales of the NTFPs. The data collected was analysed using descriptive and inferential statistics. More than half (53.3 %) of respondents involved in the NTFPs business in the study area was of the male gender and 62.5 % had secondary education. Majority of the respondent (88.2 %) engaged in NTFPs gathering as a secondary occupation. Their access to credit facilities was low. The amount made from sales without credit facilities is reasonable. Inadequate funding, lack of credit facilities, inadequate information about how to market their products and its neglect by government were identified as a major constraints to sustainable collection and use of NTFPs. NTFPs would contribute more to livelihood in the study area, provided access to credit can be facilitated.

Keywords: Credit access, Egbeda local government area, NTFP, value addition

Analysis of Natural Regeneration of *Boswellia papyrifera* Stands in Southern Kordofan State, Sudan

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Sudan is characterised by a diversity of natural woody perennials which produce non-wood forest products. However, gums and gum resins are among the products that contribute significantly in the livelihood of the local inhabitants and in the economy of the country as a whole. The genus *Boswellia* which belongs to the family *Burseraceae*, is native to the dry areas of Africa, Middle East and India. It is considered to be very important as some of the species produce gum resin (Frankincense or olibanum), which has various applications locally and world-wide. It is used in local cultures in terms of wood, fodder, and traditional medicine, in commercial industries and conservation of the environment.

Boswellia papyrifera (Del.) Hochst. is a multipurpose perennial tree that grows on the rocky shallow soils of the dry land slopes. It produces gum resin that has various local applications, pharmaceutical and industrial. In addition to the multiple uses of its wood, the leaves are used as fodder and it appears to play a great ecological role. One of the serious problems in the *B. papyrifera* stands in South Kordofan State is the lack of natural regeneration.

Therefore a regeneration experiment in the natural *B. papyrifera* stands was carried out to analyse the regeneration in tapped and untapped stands. Eight areas were selected, based on tapping. In each area three random sample plots (20 m by 20 m), were established based on altitudinal range (low, medium and high). In each plot regeneration seedlings were counted and recorded, in both tapped and untapped stands. The results showed that the number of the germinated seedlings was higher in the untapped plots and there was a significant difference in regeneration at ($p > 0.05$) between the tapped and untapped plots of *B. papyrifera* stands, which reveal that tapping has influence on the natural regeneration. It is recommended that the current intensified tapping methods to be improved and reduce its effect on natural regeneration. In addition to the use of alternative methods of regenerating these *Boswellia papyrifera* trees through enrichment planting by branch cuttings.

Keywords: *Boswellia papyrifera*, natural regeneration, South Kordofan, tapped, untapped trees, NTFP

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Benefit Sharing in Community Forestry in Nepal: Do Poor Actually Benefit?

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Community forestry (CF) in Nepal is said to be a successful, innovative and future-oriented participatory forest management program. 17,600 Community Forest User Groups (CFUGs) manage more than 1.6 million hectares of national forest, and in thirty-two years of its initiation CF approach has evolved as a viable mechanism of handling forest to autonomous user groups with legal status with perpetual succession and as a means to generate benefit - that the group can mobilise on its own interest. Benefit sharing among the members within the group is less emphasised even though it determines the socioeconomic upliftment of marginalised groups in caste and class based hierarchical Nepalese society.

Five, three and two CFUGs were selected from Dolakha, Gorkha and Chitawan district respectively. 136 forest users and 39 committee members, 9 political partie leaders and 3 district forest officers were interviewed. Records on the forest products and income sharing were used from district forest offices and CFUGs. Moreover, group discussions with the pro-poor identified by the respective groups were conducted. Ten, one in each CFUG, pro-poor houses were visited and family members were consulted to know if they are satisfied with the existing mechanism. CFUGs' constitution, operational plan and minutes were assessed.

Result showed that one of the approved objectives of all CFUGs was status upliftment of socioeconomically marginalised sections of the group. The CF had fulfiled around 68 % of the demand of products and users depend on other sources such as agricultural fields. Poor users, and users facing problems, got the forest products free-of-cost or in discount - up to 90 %. 16, 4 % and none of the income was expended by the poor in Dolakha, Chitawan and Gorkha respectively. None of the CFUGs from Chitawan and two in Gorkha did not conduct well-being-rankingin order to identify the poor, so that the actual poor did not get their benefits.

Poorïdentification through well-being-ranking like in Dolakha could ensure that the real poor got their benefits. Implementation of legal obligation to expend at least 35 % of CFUGs' total income in pro-poor programmes could improve the socioeconomic status of marginalised groups.

Keywords: CFUG, marginalised, pro-poor, socio-economic upliftment, well-being-ranking, community forest

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Can Development Interventions Reduce Human Pressure on Forest? A Case Study of a Long Term Observation in India

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We re-assessed the number of people and their purpose for entering a degraded dry forest in the plains of Tamil Nadu (South India) after 21 years. We found a drastic reduction in the number of people visiting the forest for the utilisation of forest products. These changes seem to be driven by the unavailability of local markets, agricultural programmes of local NGOs and better employment options than 21 years ago.

The increasing human pressure on tropical forest is of worldwide concern but data on local level that support this trend are hardly available resulting in a lack of information for appropriate management strategies. The Palni Hills Conservation Council conducted a foot-path survey around the Kadavakurchi Reserved Forest (KRF), a degraded dry forest on a 10 km^2 hillock at the foot of the Western Ghats in 1990/91. Interviews at 19 interview points were done simultaneously on one day a week over seven weeks, covering all seven week days. Numbers of people entering the forest were assessed, and they were asked about the importance of forest products for their livelihoods, as well as about forest-product collection patterns and marketing strategies. The survey was redone in 2012 during the same season as in 1991.

We found an almost 40 % decrease in the number of people entering the forest between 1991 and 2012, while amongst the different forest uses the number of people collecting fuel wood in the forest showed the strongest reduction of 90 %. Heads of livestock entering the forest for grazing have increased by 25 % mainly due to a rise in the number of goats.

In interviews with local development institutions in the area, both government agencies and NGOs, as well as in 75 households we found that several employment generation and watershed development programs have been conducted over the last 21 years. Household respondents stated that alternative incomes triggered by agricultural and small-scale employment programmes underlay their reduced or abandoned utilisation of forest products. The main reason for the reduction in fuel wood collection, on the other hand, was stated by households as reduced availability of local markets.

Keywords: Development work, dry forest, forest degradation, India, long term observation, reduced anthropogenic pressure

Tree Seed Procurement in Loja, Ecuador, Including a Concept for a Regional Tree Seed Program

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South America hosts 22 % of the world´s forests with its unique biological diversity. Ecuador is considered being one of the countries with the highest biodiversity, but unsustainable land use and forestry practices threaten this diversity. Up to today Ecuador has the highest deforestation rate in South America. To counteract the forest losses wide-ranged reforestation has to take place but is still at the very beginning. The reforestation efforts up to now do not compensate for the high losses in forest cover. About 140,000 ha of forest plantations exist in the Andes of Ecuador and the commonly used species are *Eucalyptus globulus*, *Pinus radiata* and *Pinus patula*. Just recently Ecuadorian organisations paid particular attention to tree species native to Ecuador and their reforestation potential. The major obstacle to use native species on a larger scale for reforestation is the lack of high quality forest reproductive material. Sound information about appropriate seed procurement, propagation methods and silvicultural treatment options have to be acquired, applied and communicated.

The objectives of our study are to evaluate the current seed procurement and management, and to develop a concept for a regional tree seed programme for the Province of Loja which is practicable and adapted to the local circumstances.

Data on the current practices were gathered through questionnaire survey and structured observations among provincial tree nurseries. National and regional forestry strategies and plans were revised to understand the encountered situation. Based on the model of DANIDAs national tree seed programme framework a regional seed programme was developed, which assesses the main areas of improvement of seed management and highlights facts in need for special consideration.

Our contribution can act as a model for other tropical regions in providing public authorities and politicians with an elaborated concept to improve tree seed management.

Keywords: Native tree species, reforestation, seed supply, tree seed program

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Livelihood of Local People and Dependence on Forest Resources: A Case Study in Son Lang Commune Located in Ha Nung State Forestry Company, Vietnam

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The local people in the State Forest Enterprises (SFEs) in Vietnam have been traditionally dependent on the forests for their livelihood and their living habits have become closely integrated with the forest. Since SFEs began to manage the forests for timber extraction in 1954, changes in forest policies have had an impact on the livelihood of local people, and they have come into conflict with the SFEs over their traditional right of forest use and the laws of forest management and protection.

This research was conducted to determine the extent of dependence on forest resources by local households and the level of cooperation between the SFEs and the local people. A household survey was conducted in eight villages in the forest area managed by Ha Nung State Forestry Company (SFC, previously called as SFE) in Son Lang commune, K'Bang district, Gia Lai province. Eighty households were chosen by systematic sampling for survey and interview.

Research findings indicate that the migrant Kinh (also called as Vietnamese) people have a higher annual income (approximately 2.7 times) than that of the indigenous Bahna people. The main source of income for the Kinh is from coffee (66 %), whereas the Bahna people are more dependent on forest (44 %) and less upon coffee (31 %). Other agriculture and animal husbandry represent minor sources of income for both groups.

Most of the local people, especially the Bahna, desire greater involvement in the SFC forest management, but local people were not considered in forest planning by the Ha Nung SFC as participatory, and complaints over lands, forest use, and benefits have been frequently registered. The research shows potential impacts of land use on forest patterns, and examines conflicts and cooperation in forest management practices in the case study region. Recommendations are given for better forest management of the Ha Nung SFC with greater involvement of the local people.

Keywords: Forest dependence, income source, local people, state forest enterprise, sustainable forest management

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Farmers' Decisions Concerning the Rainforest in Land Reform Settlements in the Brazilian Amazon

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Land reform is a sensitive topic in public Brazilian debate due to the landless workers movements' national and international visibility, due to the social and economic inequality in Brazil and due to the complexity of interests and positions involved. But, as a matter of fact, land reform settlements in the Amazon are amongst the fiercest destructors of tropical rainforest in the region. This reality is against customary explanations for deforestation, presuming traditional population (including ribeirinhos (riverside dwellers), indigenous people, rubber tapers, and small peasants do not destroy nature (*i.e.* tropical rain forest and the general environment). In considering this reality common to other regions in the Amazon, there is one central question unanswered, far behind political and environmental debates on tropical rain forest and land reform: Why do people deforest? During my fieldwork in land reform settlements in the Brazilian Amazon, it became evident that there are several options and behavioural patterns that lead some settlers to conserve the legal resereve areas (80 % of the soil) and others to log nearly every tree on their land-reform allotments. Additionally, further questions should be asked about settlers' options, motives, and strategies. Finally, we might ask whether it is truly possible, as land reform proposes, to combine conservation of the tropical rain forest with the search for social equity.

The focus of this contribution is on decisions made by settlers regarding rain forest conservation or destruction on their land allotments, as vital element of their livelihood-strategies. Therefore, this case study of landless people in the Amazon (in the state of Pará) attempts to analyse the decision-making of settlers in a complex social, political, economical, and environmental reality, which represents for recently established settlers a new situation at different degrees, according to former experiences and actual assets available. For most of them, it is a challenge endowed with multiple uncertainties and vulnerabilities. Furthermore, in this context, we have to consider the weight of the State and its development strategies through the land reform programme and environmental policies on peasants' decisions and actions

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Rare Tree Species in Limestone Mountain Forests of Northern Vietnam

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In consequence of land use changes, some tropical tree species that have always been rare become endangered due to their shrinking habitat and population. In this study, we analysed five species, which are named in the red list, in terms of their abundance on limestone mountains in northern Vietnam. Three of these species (*Excentrodendron tonkinense*, *Chukrasia tabularis* and *Garcinia fagraeoides*) are largely restricted to such limestone mountain forests and considered typical to this environment, whereas two studied species (*Parashorea chinensis* and *Melientha suavis*) have a wider distribution range. We asked about the appropriate method to estimate their population density, how many trees there might be, and on which sites they preferably occur. In an old-growth forest of 6.5 km^2, a random sampling approach was applied as well as adaptive cluster sampling, which is specifically designed for rare events and spatially clustered distributions. In these species, adaptive cluster sampling resulted in higher mean values of trees per unit ground area and lower variances than random sampling. Considerable numbers of trees were found for all the species. The three limestone mountain forest species increased in abundance with steepness of the slope, increase in rock-outcrop cover and decrease in soil depth; in short, with the severity of site conditions. The two species with a wider distribution range (*Parashorea* and *Melientha*) did not occur on very severe sites. We conclude that adaptive cluster sampling is an appropriate method for estimating the population density of these rare tree species in this study region, a national park, where some of the red list species still occur, and the typical limestone forest species are particularly found on severe sites.

Keywords: Adaptive cluster sampling, limestone mountains, random sampling, red list, trees

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Adapting Landscape-Scale Criteria and Indicator for Sustainability Assessment and Improved Natural Forest Management

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In the last two decades, the concept of sustainable development and more specifically of sustainable forest management has been widely discussed. To assess the sustainability of forest management, different sets of criteria and indicators (C&I) have been developed and implemented, mostly at international and national level. However, there is a scarcity of application at the local and respectively forest management unit level.

In order to measure the sustainability of different forest use types in the project area "Dinh Hoa District, northern Vietnam", this study developed a locally adapted set with a number of criteria and indicators, focusing on ecological, economical and social aspects. A generic set was developed based on existing international templates and was adapted to local needs of the Dinh Hoa District using two methods: (1) multi-criteria decision making attended by national, regional and local experts and (2) participatory methods attended by local stakeholders. The study showed that a combination of these two approaches combines scientific validity of the set with recognition of local values, increasing its acceptance among all stakeholders.

An assessment tool was designed for the evaluation of the impact of different natural resource management approaches on a specific target group. The focus lies on local concerns by communities and individuals with regard to natural resource management on landscape-scale, intentionally including parameters further than from forest management.

The applied methods provide a framework to compare different perceptions of sustainable forest management, as well as the impact of different forest use types or management approaches on the livelihood of the adjacent communities.

However, the assessment tool can easily be adjusted to different research requirements.

Keywords: Criteria and indicators, livelihood assessment, sustainable natural forest management

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Distance Correlations Do Not Scale with Size Correlations of Tree Species in a Tropical Rain Forest Stand

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Spatial patterns of forest trees have long been recognised as evidences of underlying biological processes within the forests. We used point pattern analysis methods and process-based models to uncover the demography and dynamics of trees in a primary rainforest stand.

A fully mapped 1 ha plot was investigated in the tropical rain forest, Cucphuong National park, Vietnam. Trees were stem-mapped, diameter-measured and classified into four life-history stages: sapling, juvenile, premature and mature based on diameter at breast height. Spatial patterns and tree size correlations of life-history stages, within species and between species were analysed using the pair-correlation and r-mark-correlation functions to reveal scale dependent patterns.

At community level, sapling and juvenile stages were clustered up to large scales, while premature and mature trees were regular and had random distributions. The strong evidence of competitive interaction was showed by distance correlations. However, tree sizes did not correlate significantly to the same tendency with tree-tree distances. In intra-specific interactions, three of four abundant species were significantly clustered while negative correlations in tree size were clearly showed within *Hydnocarpus kurzii* and *Saraca dives*. In addition, marginal repulsions were found in distance correlations approved by size correlations when considering the inter-specific interactions with dominant species.

We suggest that self-thinning was an important driver of the forest community dynamics. Clustered distributions were predominant among conspecific trees. Weak inter-specific interactions between light demanding species (*S. dives*) and other species can be explained by competition for light. High diversity of species could cause the equilibrated competition for limited resources as an overall competitive effect. Here, tree size (diameter at breast height) correlations and inter-tree distance correlations did not scale well, however they also mutual complement indicating for competitive interactions between tree individuals.

Keywords: Pair-correlation function, r-mark-correlation function, spatial point pattern analysis, tropical rain forest, Vietnam

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Conservation and Genetic Variation of Teak (*Tectona grandis* Linn. f.) in Natural Populations in Myanmar

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Teak (*Tectona grandis*) is a valuable tropical forest tree species which naturally occurs in India, Laos, Myanmar and Thailand. Ten polymorphic nuclear microsatellite markers (SSRs) and seventy-one AFLP markers (Amplified Fragment Length Polymorphisms) were used to investigate genetic variation of teak in natural populations in Myanmar for conservation and sustainable utilisation of genetic resources. Adult trees and young regeneration were sampled in selectively logged and unlogged populations in four regions, each in the northern and southern parts of Myanmar, and two plantations in Benin. A total of 1667 samples and 1573 samples were used for SSRs and AFLPs, respectively. In general, genetic diversity within teak populations was relatively high but not significantly different between management types and between regeneration and adults. Myanmar populations were less diverse than Benin populations with SSR markers and the allelic richness was significantly higher in southern than in northern populations of Myanmar. Additionally, inbreeding was significantly higher in the regeneration in unlogged than in selectively logged populations. AFLP markers showed contrasting patterns as the Myanmar populations were more diverse than those of Benin, and genetic diversity in northern populations was significantly higher than in the South of Myanmar. Furthermore, genetic diversity of adult trees was significantly higher than in the teak regeneration in unlogged populations. For both markers, cluster and structure analyses revealed two major clusters: one with northern populations and another one with southern populations of Myanmar and those of Benin. A Mantel test showed significant positive correlation between genetic and geographical distances among populations. Analyses of molecular variance (AMOVA) detected the highest genetic variation within populations. The Fst values were significantly different among all teak populations and higher between than within the regions in Myanmar. This study suggests applying different conservation strategies for northern and southern Myanmar.

Keywords: AFLPs, genetic variation, SSRs, teak

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Indigenous Knowledge for Classification and Utilisation of Wati (*Piper methysticum* Forst.) in Marind Tribe of Merauke Regency, Southern Papua

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Papua Province harbor a very rich biodiversity which is not inexhaustible to be researched and explored. Various plants act as a drug and are traditionally used by the community. Marind tribe is located in the district of Merauke in southern Papua. Based on its geographical conditions, society of Marind tribe is divided into 3 groups in terms of Marind pantai (Marind dufh), Marind rawa (Marind bob), and Marind darat (Marind degh). One of the most important traditionally used plant species is *Piper methysticum*, the so-called Wati. Wati leaves contain active substances which have a sedative effect and cause long sleeps. The pharmacological effects are known by indigenous people of the tribe since the antiquity. The species is used as alternative medicine and in beverages, and hence, it is important for social interaction between individuals and community groups. In addition, Wati growing in the region of Marind show a high diversity in morphology and the indigenous people have specific local names for each variety or cultivar. The people can recognise and classify the different forms traditionally. In order to the importance of Wati, the plant species is a nice example for ethno-botanical studies. These can be carried out based on the knowledge of the three ethnic groups in terms of morphological characterisation, utilisation, cultivation and preservation of Wati. The present study included explorative survey methods and participatory observations. The informants were selected by using a purposive sampling technique, and data were collected mainly by semi-structured and open interviews. The ongoing research shows that Wati is considered as sacred and the species is included in every ritual ceremony. Hence, Wati is strongly linked with the culture of Marind tribe.

Keywords: Indigenous knowledge, Marind tribe, Merauke, Papua, *Piper methysticum*

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Demographic Structure and Population Biology of *Albizia amara* and *Terminalia brownii* as the Dominant Tree Species in Elsareef Reserved Forest, Kordofan Region, Sudan

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The present study was conducted in Elsareef reserved forest, Kordofan region, Sudan during 2009–2011. We investigated the demographic characteristics of *Albizia amara* and *Terminalia brownii* as the dominant tree species in the forest. We also investigated the effect of illegal logging as the main threat to the species structure and population density. Data was collected from inventory work where systematic sampling method was adopted. A number of 40 sample plots ($400\,\mathrm{m}^2$) along line transects were placed. Tree species, growth form, and vitality were recorded in addition to diameter at breast height (DBH) (cm) and heights (m). The regeneration life stages, vitality, grazing and browsing damage were recorded too. Data was analysed using SPSS 18.0 and Microsoft Excel Office. Tree numbers, density, proportions, dominance and other parameters were calculated. The diameter class distribution of *Albizia amara* was enhanced but the diameter class distribution of *Terminalia brownii* was fluctuated. The causes of regeneration mortality were: competition, drought, frequent wind storms and grazing, while termites damage earlier stages of seedling and sapling. *Albizia amara* recorded the highest proportion of stem (52 %) followed by *Terminalia brownii* (29 %). However, *Terminalia brownii* scored the highest proportion of basal area (42.2 %) followed by *Albizia amara* (31.5 %) and *Sclerocarya birrea* (21.0 %). The effect of recurrent wind storms and illegal logging on the species population was not significant. The falling of trees by wind storms provided a large opportunity for collection of dry and dead trees by people, but in contrast it increased the opportunity of people for illegal logging. The study came up with recommendations which might help conserving and enhancing diversity of the species which reproduce the dynamic of the forest.

Keywords: Demographic structure, disturbance, Elsareef reserved forest, forest structure, regeneration, sustainable forest management

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Assessment of Regeneration Situation in Natural and in Plantation Parts of Elsareef Reserved Forest

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The present study was conducted in Elsareef reserved forest, Kordofan region, Sudan in 2011. We assessed the current structure of woody species regeneration and their demography in natural and plantation parts of the Elsareef reserved forest and their capability for continuity and recruitment. We also assessed the effect of silvicultural influences as well as the effects of the most recurrent natural disturbance on regeneration (population density and mortality proportion). Data was collected from inventory work where systematic sampling method was adopted. A number of 40 sample plots (400 m^2) along line transects were placed. Tree species, growth form, and vitality were recorded in addition to regeneration life stages counting and measurements. Moreover, grazing and browsing damage were recorded. Data was analysed using SPSS 18.0 and Microsoft Excel Office. Tree numbers, density, proportions, dominance and other parameters were calculated. There are 6 regeneration species in natural parts and 8 regeneration species in plantations. The total number of regeneration species in the whole forest is 10 species. Three species have grown in both parts: *Albizia amara*, *Terminalia brownii* and *Acacia senegal*. Three other species were found only in the natural part: *Boscia senegalensis*, *Acacia tortilis*, and *Acacia nilotica*. Four further species were found only in the plantation part: *Ziziphus spina-christi*, *Grewia tenax*, *Adansonia digitata* and *Tamarindus indica*. Competition, drought, frequent wind storms and grazing contributed to the highest mortality of regeneration in natural part. However, in the plantation part, the mortality of species observed referred to the soil condition adverse climate conditions. Termites caused damage at the earlier stages of seedling and sapling development. The study ended with recommendations which help the decision maker for better choice of successful silvicultural influences in the context of enhancing stability, multifunctionality and diversity of this forest.

Keywords: Demographic structure, Elsareef reserved forest, forest structure, regeneration, sustainable forest management, seedlings mortality, silvicultural influences

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Livelihoods Sustainability and REDD Implementation in Communal Lands in Northeastern Ecuador

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Almost half of the world tropical rain forests are located in the Amazon basin. Tropical rainforests are crucial for supporting, providing and regulating ecosystem services. Apart from that, they have a high cultural value, as community forests in developing countries support livelihoods and fulfil human spiritual and religious needs. This applies especially for indigenous populations that directly depend on forest resources. Despite the proven necessity to engage local inhabitants in conservation activities, little attention has been given to the manner in how indigenous and local inhabitants manage community lands in the Amazon. The "tragedy of the commons" opened the discussion about the sustainability of open-access land systems and consequently the misuse of resources. Later on, Ostrom (1990) showed some principles under which circumstances common property regimes could work. Implementation of reducing emissions from deforestation and degradation (REDD) proof again the capacity of communities to cope under different communal land arrangements.

In this presentation, an analysis of the territorial configuration and the socio-political organisation of two indigenous tribes, the Shuar and the Kichwa are presented and compared to a "campesino-mestizo" group living in the buffer zone of the Yasuní National Park, Ecuador. In addition, an evaluation of the possible impacts of REDD+ implementation is presented.

Communities living in the Yasuní are highly heterogenic and complex. Insecure land tenure, increasing population and national legal uncertainties about carbon property rights should be clarified along with the national socio- and environmental safeguards. We found high difficulties to discern the impacts of mining and oil companies in the region as well as illegal logging effects when compared to the implementation of carbon-related-businesses. However, is undoubtedly the importance to define legal framework uncertainties, mechanisms of distribution of benefits and governance of communal indigenous lands to avoid negative impacts in local livelihoods when entering in a REDD process.

Keywords: Communal lands, conservation, forest dependency, livelihood, REDD+, Ecuador Yasuní

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Food from the Forest – An Alternative to Agriculture in Crisis?

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Since "Kyoto" there is an increased awareness on international level to enhance forest conservation. Nevertheless, positive results have been poor, and deforestation in the tropics, as in Central America, is an ongoing problem. At the same time, small scale agriculture in Honduras is in crisis under the effects of climate changes, putting in risk the family production and local food source. Some rural women in the Biosphere Reserve Rio Platano took therefore a decision backward – they are harvesting food from a native forest, following the tradition of the ancient Maya culture: They are using the nut of the tree *Brosimum alicastrum* (Swartz), in preparing beverages and pastries. The nut is nearly fat free, but a good source of carbohydrates, sugars (malt), protein, potassium and calcium, and the essential amino-acid tryptophan, which is poor in the typical tropical diet, and needed to produce melatonin and serotonin in the human organism. As the women are consuming the nut and making some money while selling it, the natural forest got some additional value and the local people are committed to its protection. On the other hand, *B. alicastrum* seems to be a key species of the tropical rainforest ecosystem, being the base of the alimentation pyramid for jungle wildlife. In this study, there is made a first afford in quantifying the potential production of *B. alicastrum* of 100 ha natural humid rainforest and the percentage being consumed by wildlife, which have to be considered in a sustainable management. It also shows the potential of *B. alicastrum* to better the economics of rural women in Honduras and might help to end up with the old dilemma of food production, deforestation and climate change: not agriculture *versus* forest, but food from the forest!

Keywords: Food security, indigenous knowledge, non-timber product, rural women economy

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Assessing the Opportunity Cost of Avoided Deforestation in Central America: Case Studies in Nicaragua and Costa Rica

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This research examines the scope and equity implications of REDD through case studies located in Central America. First, a CO_2 emission baseline scenario was built considering current deforestation rates and change in carbon stock due changes in biomass. Second, feasibility and competitiveness of REDD areas were identified through estimating the opportunity cost of land use decisions and benefits from potential carbon offsets. Later, the spatial distribution of REDD among service providers was identified through overlaying net benefits, land use and land tenure using ArcGis. Analysis is done at regional level focusing on Bosawas protected area in Nicaragua, including transaction and implementation cost information from Costa Rica's PES scheme and data from enhancement of law enforcement in protected areas in both countries. Bosawas, the most extensive moist broadleaf forest in Central America, is the living space of two indigenous communities: Miskitu and Mayagna with annual deforestation rates between 0.3 % - 7.4 % in the last decade. Costa Rica has successful experiences in implementing forest conservation policies based on PES scheme. The work relies on empirical data from group discussions and interviews with local experts, considering a 30-year land use trajectory. The economic activities analysed were: maize, beans, cacao plantation, coffee plantation, beef and dairy cattle. In parallel, information about land market values was also collected as an alternative way to estimate opportunity cost. Transaction and implementation cost information were obtained through interviews with civil servants, project developers, and verifiers / certifiers company representatives. Results suggest that indigenous areas are better off to become service providers due to well-defined property rights, but opportunity cost lies above carbon off-sets and became uncompetitive areas for REDD payments (up to -303 US $ ha^{-1} yr^{-1}) due to low input crop production and reforestation projects influencing land use values; while sites located close to markets and main mean of transportation report positive net benefits up to 1300 US $ ha^{-1} yr^{-1}; where land tenure is unsecured and high deforestation rate. In addition, land market values are below estimates from cash flow approach and it may lead to underestimation of opportunity costs.

Keywords: Land tenure, opportunity cost, REDD, transaction costs, implementation costs

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Assessment of Tree Water Use for Development of Resilient Agroforestry Systems in Salinized Areas of Northern Uzbekistan

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Identifying tree species suitable for planting over shallow saline groundwater table would help in increasing the productivity of salinized croplands under conditions of irrigation water scarcity. Tree water use was examined in five-year-old plantations established on highly salinized cropping site over shallow groundwater table ranging within 0.9–2.0 m with salinity of 1–5 dSm^{-1}. Four trees per each species *i.e. Elaeagnus angustifolia* L., *Populus euphratica* Oliv. and *Ulmus pumila* L. were monitored throughout the growing season, from March till November, using Granier's Thermal Dissipation Probes. Air temperature, relative humidity, net radiation, and wind speed were simultaneously recorded by a micro-meteorological station at the research site. The active sapwood area was analysed on stem cores and stained disk samples. The diurnal sap flux density followed an obvious circadian rhythm, with distinct differences among the species. The daily average sap flux density (Fd) ranged from 0.003–1.08 ml cm^{-2}min^{-1} for *E. angustifolia*. and 0.002–0.41 ml cm^{-2}min^{-1} for *P. euphratica*, to 0.001–0.18 ml cm^{-2}min^{-1} for *U. pumila*. Panel regression showed that overall explanatory power of meteorological factors on Fd was low with r^2=0.46. The factors' relative impact differed among the species, thus indicating the importance of physiological control of Fd. The contribution of Nr was largest in explaining Fd variability in *E. angustifolia* while vapour pressure deficit was most important in the other two species and wind speed showed a negative relation with Fd of *U. pumila*. During the course of the growing season, the species order in water use was *E. angustifolia > P. euphratica > U. pumila* ranging 1.1–13.5, 0.8–8.9 and 0.9–10.2 L day^{-1}, respectively. The seasonal variations in sap flow were also species-dependent with a maximum peak observed in July and a minimal flow in March for both *E. angustifolia* and *U. pumila*. For *P. euphratica* the peak flow was recorded in May and minimal in November. Given the observed differences in water use characteristics in tree species, the species selection appears important for designing resilient tree plantations, capable of surviving over shallow saline groundwater table without additional irrigation. The most water consumptive *E. angustifolia* showed thus best suitability for planting on salinized cropping sites.

Keywords: Afforestation, *Elaeagnus angustifolia*, meteorological factors, *Populus euphratica*, sap flow, thermal dissipation probes, *Ulmus pumila*

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Seasonal Changes of Photosynthetic Activity in the Tropical Forest of the Araguaia River Floodplain, Brazil

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High variation in seasonal environmental patterns in tropical floodplain forest influences carbon storage in the biomass. We searched for factors limiting photosynthetic activities (A) and hypothesised that the species of diverse successional status differ in photosynthetic performance. The measurements were done in a South-East Amazonian forest on the Araguaia river (Bananal island) during an aquatic (flood), terrestrial dry and terrestrial wet vegetation phase. The highest A, with an average of 14.17 μmol, $8729\,m^{-2}$ and $8729\,s^{-1}$, was found on the species *Piranhea trifoliata* during the terrestrial dry phase. During the aquatic phase, A in this species was reduced by 42 %. Also, A in the evergreen species *Amaioua guianensis* declined from 10.73 μmol, $8729\,m^{-2}$ and $8729\,s^{-1}$ during the terrestrial wet phase by 23 % during an aquatic phase. Decline of A during the aquatic phase was also observed in other species. We did not identify any reduction in stomatal conductance and transpiration rate by the trees during the aquatic phase, therefore we assume that the reduction of A was caused by the anaerobic soil conditions and reduction of photosynthetic active radiation. Less reduction of A was found during the terrestrial dry phase. Stomatal limitation in form of high leaf temperature (T(leaf)) and reduction in stomatal conductance was noted. Phenological observation confirmed pronounced loss of leaves by the evergreen species *Amaioua guianensis* and the pioneer species *Vochysia divergens*. This fact resulted in higher water use efficiency in the remaining leaves. The pioneer species *Vochysia divergens* presented an elevated rate of stomatal conductance and WUE, implying a higher capacity to overcome seasonal limitations. We identified leaf temperature as the most important limiting factors during the terrestrial dry phase, with an inverse correlation between A and T(leaf). Reduction of radiation during the aquatic phase and stomatal limitation during the terrestrial dry phase were the most evident limiting factors for A in the forest of the Araguaia river floodplain.

Keywords: Carbon storage, photosynthetic activity, tropical forest

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Absorption of Photosynthetically Active Radiation by a Tropical Rainforest in Indonesia, Measurements and Modelling

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The plant ecosystem ability to absorb photosynthetically active radiation (PAR) is one of the most important research issues with respect to the modelling carbon assimilation by vegetation. In ecosystem research and especially those using remote sensing data this ability is characterised by the fraction of absorbed PAR (FAPAR) – which is specific for individual vegetation types. However, estimates of FAPAR for teh tropical rainforest are rare. The presented study investigates FAPAR in a tropical rainforest stand located in the central part of Sulawesi (Indonesia). FAPAR is estimated based on field measurements, modelling (using a 3-D radiative transfer model, SPM3D), and the FAPAR product of Moderate Resolution Imaging Spectroradiometer (MODIS). FAPAR based on field observations is calculated from hemispherical photography and measurements of incoming PAR taken above and below the canopy. The estimated mean value is 0.88. FAPAR of the study stand shows pronounced seasonal dynamics, which are captured by both the SPM3D and MODIS data: generally, the value of FAPAR is lower during wet seasons and higher during dry seasons. The comparison of modelling and remote sensing results revealed general underestimation of FAPAR by the MODIS product especially under overcast sky conditions (wet seasons). At annual scale the FAPAR simulated by the SPM3D shows the mean of 0.84, and estimated by MODIS - of 0.79. These inconsistencies could not be ascribed to contamination of the MODIS FAPAR product by clouds (the MODIS data were extensively corrected before the use), but are caused by too large seasonal amplitudes in MODIS FAPAR.

Keywords: Indonesia, radiation absorption, radiation modelling, rainforest

Fine Root Biomass and Soil Carbon Storage of Teak Plantations in Myanmar

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Fine roots of trees and under-story vegetation play an important role in the carbon and nutrient dynamics of forest soils. Therefore, quantifying changes of soil carbon and fine root biomass could be an important consideration under large-scale afforestation or reforestation. However, there is little research on the fine root biomass of reforestation area and its contribution to the carbon storage of the stand. The study was conducted with the main objective of assessing the carbon storage in fine root (<2 mm in diameter) biomass of 20-yr and 30-yr old Teak (*Tectona grandis*) plantations. The amount of live fine roots in terms of dry weight in every stand was estimated from soil cores taken to a depth of 50 cm where most of the root fragments were distributed. Tree species, diameter (1.3 m above ground level) and tree height were measured for all trees within the plot with a breast height diameter greater than 4.5 cm. This allowed accurate determination of individual tree volumes and basal areas, as well as respective stand level characteristics. The average carbon accumulation in the soils of 20-yr and 30-yr old Teak plantations were estimated 95 ton ha^{-1} and 161 ton ha^{-1}, respectively. Fine root biomass for each stand was 2050 and 3800 kg ha^{-1}, and the respective C amounts to 1215 and 2110 kg C ha^{-1} in 15-yr and 30-yr old Teak plantations, respectively. The carbon accumulation in soils is increasing with increasing stand age. However, there is no relationship between fine root biomass and the amount of carbon stored in the soils. Commonly used variables describing the stand structure also did not show any notable correlation with the fine root biomass at the stand level. Continuous studies at ecosystem level are recommended for understanding and predicting the below-ground responses to global change.

Keywords: Biomass, carbon storage, fine root, *Tectona grandis*

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Dynamic Growth of *Schizolobium parahyba* var. *amazonicum* in two Planting Models in the Eastern Brazilian Amazon

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Globally, deforestation has been occurring with great intensity, and in the Brazilian Amazon the deforested areas reached about 35 million hectares. Reforestation using fast growing species would be a commercially attractive alternative to minimise deforestation impacts, bringing environmental benefits, increasing the wood supply and reducing pressure on remaining natural forests. However, one of the major impediments to reforestation is the lack of scientific knowledge about the behavior and growth of native species. Thus, this study aimed to evaluate the dynamic growth (height and diameter at breast height - DBH) of *Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke) Barneby in two production models in the eastern Brazilian Amazon. The experiment was conducted in the municipality of Dom Eliseu, State of Para, based on the following models: mixed forest species (*S. parahyba* var. *amazonicum* and *Khaya ivorensis* A. Chev.), and an agroforestry system (AFS (*S. parahyba* var. *amazonicum* and *Musa* sp.). To 40 months of age, in the mixed system, the plants of *S. parahyba* var. *amazonicum* showed the highest height growth, with averaging 20.9 m. However, diameter growth was similar in both planting systems, with averages of 17.3 cm (mixed) and 17.9 cm (agroforestry). Relating the growth with the rainfall of the area, it was observed that irrespective of the model evaluated, there was a greater growth in height and diameter of plants during periods of higher rainfall. Regardless of the tested models (mixed species and agroforestry) the growth of *S. parahyba* var. *amazonicum* was satisfactory and this species can be recommended for restoration of altered areas. In addition, the AFS can serve as an option for the small farmers, which in addition to attending the environmental law, will diversify the family income with timber and fruit species.

Keywords: Amazonia, forestry models, land reclamation, precipitation

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Implementation of Sustainable Forest Management in two Different Forest Management Unit Models in Vietnam and Malaysia

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By the 1990s tropical forests in Southeast Asia had been exhaustively logged, mainly for economic growth and development of the countries. Over harvesting and poor forest management had led to the decline and degradation of natural forest areas. In the following years sustainable forest management (SFM) became one of major topics of the annual meetings of the Asian Senior Officials on Forestry (ASOF) at the Association of Southeast Asian Nations (ASEAN). But so far, the number of certified natural forest areas in the region is still behind the expectations. This study was based on two forest management units (FMUs) in Vietnam and Malaysia to evaluate the lessons learnt while implementing SFM concepts in natural forests for timber production under state forest enterprises (SFEs). The case study involved the Deramakot Forest Reserve (Sabah, Malaysia), - the first natural tropical forest certified in 1997; and the Dak To Forestry Company (Central Highlands, Vietnam), which was the first controlled wood certified natural forest in Vietnam, in 2011. Both FMUs were certified under the FSC (Forest Stewardship Council) certification scheme for natural forests, and initially received extensive technical support from German Society for International Cooperation (GIZ) during the initial phases with little involvement by local communities.

Literature review and discussion were used to understand forest management practices in the FMUs. Study findings indicate that forest management of the two case study models is very different. The Deramakot Forest Reserve model is very successful, with a high capability of duplication, whereas the Dak To Forestry Company model is still facing challenges from such issues as illegal logging, conflict over forest and land uses, and lack of support from the relevant stakeholders during the SFM process.

The management aspects of these two models are explained by the "top-down" management oriented appraoch with the involvement of an international technical support agency and the cetralised administration. It is recommended that a greater involvement of players from private sectors and other stakeholders is necessary in order to expedite the performance of forest management at the FMU level.

Keywords: Forest management unit, Malaysia, model, natural forest, stakeholder, state forest enterprise, sustainable forest management, timber production, Vietnam

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Soil Carbon Stocks Decrease after Conversion from Degraded Forest to Rubber Plantation - Southern Yunnan China

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Land use conversion from degraded forest patches into rubber plantations is taking place in a large area of Xishuangbanna (southern Yunnan, China), northern Laos and northern Thailand. These degraded forests consist of woodlots, village forests, and mature fallow fields. Due to the mountainous topography most of the established rubber plantations are terraced. In the present study we quantified the changes in soil carbon stocks after a conversion from degraded secondary forest to terraced rubber plantations. The study area has a size of 4200 ha and was located in Xishuangbanna. We selected plots in 11 rubber plantations ranging in age from $5-46$ years. Each rubber plot was paired with a degraded secondary forest plot. Paired rubber and forest plots were located within short distance and have similar biophysical conditions. The selected rubber plantations were established immediately after deforestation. At each plot we measured soil carbon concentration and stocks in the top 120 cm of the soil. The specific questions addressed in this study are: i) What is the amount of change in soil carbon stocks after a conversion from forest to rubber? ii) Which predictor variables considering soil characteristics, biophysical factors and management related parameters can be used to predict the changes in soil carbon stocks following this land use conversion? iii) What is the impact of terracing in rubber plantations on soil carbon stocks and soil carbon dynamics? Preliminary results show that conversion from degraded secondary forests to rubber plantations result in a significant ($p < 0.05$) decrease of soil carbon stock by 40 Mg C ha^{-1} in the top 120 cm of the soil. The strongest decrease in soil carbon stocks occurs in the first 5 years after land use conversion.

Keywords: China, deforestation, land-use conversion, rubber, soil carbon, terracing, Xishuangbanna

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Smallholder Tree Plantations in Paraguay: Comparative Assessment of Influencing Factors and Contribution to Income Generation

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Together with the global climate change debate, renewable energy is becoming a widely discussed topic. Wood based energy is the most traditional source of energy, but usually is underestimated in its contribution to the welfare of rural families. Forest resources constitute an important element in the rural economy in Paraguay, not only for subsistence but for income generation. High deforestation rates in the eastern part of the country between 1970's and 90's and hardly any reforestation in that time, significantly reduced the supply of wood. However, since a couple of decades, plantations are being established in small areas but with rising frequency. The study aim is to provide a better understanding of the socioeconomic factors influencing tree planting for energetic purposes and their contribution to income generation to small farms in eastern Paraguay. It is known that personal and socio-economic characteristics of an individual influence the respective decision making behaviour. Landowners who decide to plant trees engage themselves in an unusual form of land use practice. Participatory tools and expert interviews were conducted of smallholder tree growing initiatives. Results show that apart from land availability and income level as the main factors; the progressive attitude of farmers, social organisation level, and the perceived risk towards wood availability are also significant for successful tree growing. On the other hand, farmers with fewer resources consider that the government should promote state incentives for reforestation. Compared to agriculture or cattle breeding, tree planting requires significantly less labor for the farmer, but it also provides little financial return in the first years after planting. Other land use practices usually appear to be more attractive and profitable than forest plantations. Due to these facts, landowners only establish plantations under a certain set of circumstances or conditions like being beneficiaries for a long term extension service or a secured market for their products.

Keywords: Energy, income generation, Paraguay, tree planting initiatives

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Floristic Composition of Soil Seed Bank in Forest Plantations in the Eastern Amazon, Pará, Brazil

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Forest plantation in degraded areas of the Eastern Brazilian Amazon is considered a opportunity for land reclamation. The plantations, besides the economic benefits, can also be catalysts of natural regeneration in the understory, contributing to biodiversity conservation. The aim of this study is to characterise the floristic composition of soil seed banks present in the understory of forest plantations, to support environmental legislation regarding the maintenance of biodiversity in legal reserves in the Eastern Brazilian Amazon. The research is carried out in four rural properties with plantations of *Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke) Barneby and *Eucalyptus urograndis* at different ages. At the time of data collection, the age of the natural vegetation in the plantation's understory ranged from 6 months to 4 years. The chosen areas have a distinct land use history prior to planting. Of each property were collected composite samples of the seed bank with a wood template of 0.25 m^2. The samples were spread on polyethylene trays and incubated during 6 months in a greenhouse at EMBRAPA, Eastern Amazon, to evaluate the natural regeneration. The samples of the soil seed banks showed a total of 2,750 individuals, representing 79 species, distributed to 34 botanical families. The heterogeneity index of Shannon-Weaver was high and ranged from 2.75 to 3.02, indicating a high diversity of floristic composition of the four plantation areas. The Sorensen index ranged from 0.619 to 0.778, and indicated the existence of high floristic similarity between the pairs formed by the four areas of study. In all areas there was a higher predominance of herbaceous vegetation (above 50 %). The portion of trees, shrubs and woody vines ranged from 36 % to 49 %. The ecological succession was mainly characterised by pioneer species (66 %) and early secondary species (23 %). The main types of seed dispersion were zoochory (38 %), anemocory and barochory (both 29 %). The studied areas may be regarded as strongholds of biodiversity as they show a similar richness as secondary forests with a comparable land use history, and whose native vegetation is under development with plants age close to 3.5 to 5 years.

Keywords: Floristic composition, forest plantation, land reclamation

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Effects of Land-Use on Deforestation Dynamics in Pará State, Amazonia, Brazil

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The constant increase of deforestation in Amazonia, especially in Pará State, and the top-ranking in terms of deforestation of several counties of Pará are of considerable scientific interest. Conversion of forests to land-use typically follow similar logics, even though patterns differ regionally. To measure rates of deforestation across the Amazon region, the PRODES project was implemented that measured approximately 100 000 km^2 of forest loss. Data from this project demonstrate that the gross rates of deforestation, which amounted to 23 000 km^2 yr^{-1} between 2002–2003, are accelerating through the last five years by about 13 % per year. This study investigates the effects of different land-uses on deforestation dynamics in Pará State. We investigate the percentages of forests, deforested areas, timber production, areas planted to upland rice, beans, cassava, maize, soybean, banana, cacao, oil palm, oranges and black pepper, and the area under pasture, between the years 2000–2009, using Factorial Explorative Analysis and Principal Component Analyses, and Varimax grouping techniques. We identified the main factors associated with deforestation and their respective contributions. Our model explains 86 % of total variance, with a high correspondence between variables, and our model was able to reestablish between-county ranking and the State Deforestation Index. Deforestation was positively correlated with pastures, this being the principal cause of deforestation in our study area. Soybean cultivation was indirectly associated with deforestation via cultivation of upland rice and maize. We conclude that the principal causes underlying deforestation are timber extraction, pastures and the expansion of grain production, with strong differences between counties.

Keywords: Forest, index, multivariate analysis, productive activities, varimax

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Analysis of the Livestock Passive Forest Restoration in the Tamaulipan Thornscrub in Northeast México

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Around 29 % of earth surface is used for livestock by establishing permanent grassland or sowing to produce fodder. In Mexico the area having livestock activity is 110 million hectare equal to around 56 % of Mexican territory. Thornscrub is the most abundant and historically mostly used for livestock in desert and semi-desert zones in Mexico. The objective of the present study is to analyse the passive forest restoration after livestock overgrazing in Tamaulipan Thornscrub in the northeast of Mexico. Two study areas were selected, one having history of livestock use and 30 years of passive forest restoration, and a second area as reference. Four sampling sites of $40 \, \text{m} \times 40 \, \text{m}$ each ($1600 \, \text{m}^2$) were established in the study areas. In these sampling sites all the bushes and trees with diameter $>3 \, \text{cm}$ (considering a height of $10 \, \text{cm}$) were evaluated. Ecological indicators such as abundance, dominance, frequency, importance value index, Margalef index, and Shannon Wiener index were considered. In order to evaluate if significant difference exists in the variables for the evaluated areas the mean values of the sampling sites were calculated and an analysis of variance was performed. In the area used for livestock, two dominant species were registered (*Acacia farnesiana* and *Prosopis glandulosa*) with 97 % of absolute dominancy and the remaining 3 % divded into 10 species. Of the 3050 subjects counted 60 % belong to *Acacia farnesiana* . The diameter distribution showed that from the total of *Acacia farnesiana* subjects 57 % have between 0 to 10 cm of diameter, indicating that there is an active regeneration. The research showed that the passive restoring area presents significant difference ($p < 0.05$) compared to the reference area in all the variables (density, crown cover of trees, richness and density).

Keywords: Abundance, density, Margalef, Shannon

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Reconstructing Past Fire Regimes: Applications and Relevance to Fire Management

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Nowadays, forest fires have increased significantly around the world, in size, frequency, and intensity. Hence, anticipating future forest-fire regimes under a changing climate requires that scientists and natural resource managers understand the factors that control fire across space and time. Fire scars – proxy records of fires, formed in the growth rings of long-lived trees – provide an annually accurate window into past low-severity fire regimes. The Mexican forest experiences recurring forest fires, especially during El Niño years. In Mexico, the El Niño Southern Oscillation (ENSO) is a climate-forcing mechanism that has been shown to affect precipitation and the occurrence of fires. Linkages between ENSO and the occurrence of forest fires have been recognised at scales ranging from local to regional. La Niña winters (ENSO cool phase) in northwestern Mexico are typically hot and dry, and fires are more likely to burn during these years. In southern Mexico, however, El Niño winters (ENSO warm phase) are dry and fire-prone. However the government efforts for fire prevention are still insufficient to reduce both fire frequency and fire intensity. Nevertheless, Mexico needs to develop fire prevention strategies with high efficiency in order to avoid the loss of natural resources and to protect the reforestation efforts. As any other natural disaster, fires have always provoked important biotic and abiotic changes. However, not all ecosystems are adapted to the increasing frequency and sizes of forest fire. The objective of this presentation is to illustrate the significance and, as far as possible, to ascertain the quantitative importance of forest fires and how they can threaten reforestation efforts of Mexican agencies in charge of the natural resources. These data also offer crucial reference information on fire as a dynamic landscape process for use in ecosystem management, especially when managing for forest structure.

Keywords: Climate change, fire management, reforestation, El Niño

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Insects Associated with Exotic and Indigeneous Tree Species in Plantations in Ondo State Nigeria

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The study was carried out to examine the effect of tree species and age on both aerial and soil Arthropod species diversity and abundance. Five plantations comprising 3 age series of *Nauclea diderichii* (15, 9 and 5 years old) and two plantations of *Gmelia arborea* and *Tectona grandis* within Ondo State were selected for the study. Sample plots of 50 by 50 m were demarcated in each of the selected sites. Collection of insects was done using sweep nets and hand picking method from each of the selected plots. Soil samples were also collected from 5 points on each of the selected plots at 0–10 cm depth. A total of 43 insects were collected and identified, 170 insects from the 15 years *Nauclea* plantation, 140 from the 9 years and 120 individuals from the 5 years plantation. A mean abundance of 44 individuals of mesofauna were also encountered, 20 from the *G. arborea* plantation, 5 from the *T. grandis* plantation, and 19 from all the *N. diderichii* plantations. The result of the insect species diversity index obtained from Shannon Weiner diversity index, for the three age series of *N. diderichii* were 1.67, 1.63 and 1.62 for the 15, 9 and 5 years old plantations, respectively. While the diversity index for the *G. arborea* and *T. grandis* plantations were 1.63 and 1.68, respectively. The mean mesofauna abundance from the three different tree species were significantly different ($p \leq 0.05$), while there was no significant difference in the mean mesofauna abundance in the *Nauclea* age series ($p \geq 0.05$) and also there were no significant differences in the insect species diversity and abundance in all the sites studied.

Keywords: Diversity, index, mesofauna, plantation pest

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Floristic Composition of Soil Seed Banks in Degradad Agriculture Areas Recovered by Forest Plantations, Brazil

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For a long time the agricultural and livestock activities have been the causative agents of environmental change in the Brazilian Amazon. The intensive use of soil through slash and burn agriculture provoked significant losses in the structure, natural fertility, and diversity of micro-organisms and soil macrofauna, leading to significant losses in the productive capacity of the soil. There are several methods to recover degraded areas under these conditions. Soil seed banks and seed rains are direct means to establish ecological groups and restore flora, being fundamental to the understanding of changes in biodiversity and soil remediation. This study aimed to characterise the floristic composition of soil seed banks present in the understory of forest plantations in areas of "family farming". To this end we collected four composite samples of seed banks with a wood template of $0.25\,\mathrm{m}^2$, in the three municipalities of Bragança, Capitão Poço and Garrafão do Norte, Pará State, Brazil. The samples were spread on polyethylene trays and incubated during 6 months in a greenhouse at EMBRAPA, Eastern Amazon, to evaluate the natural regeneration. In addition, we reviewed the literature on habit, ecological groups and seed, dispersal of the species identified. In all areas there was a predominance of herbaceous species and pioneers of ecological succession. The greatest species diversity of germinated seedlings was found for Garrafão do Norte. The main types of dispersion found in the three municipalities were anemochory, barochory and zoochory.

Keywords: Floristic composition, forest plantation, recover degraded areas

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People's Perception Towards Forest Plantation Development in Owo and Supare Akoko, Ondo State Nigeria

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The study was conducted in Owo and Supare Akoko, in the northern senatorial district of Ondo State Nigeria. The research aimed to identify the perception of the people towards the plantation development and it related activities in the Government reserved area; it also assessed the level of awareness of the people towards community forestry. Primary data was collected using questionnaire survey and data was collected on the awareness and perception of the people towards the plantation development in the two communities within northern senatorial district of Ondo State. These two areas were selected due to the forest plantation development that was already going on there at the time of survey. The findings of the study revealed that there are huge numbers of people with a positive perception towards Government decision to create future wealth within the environment. However, none of them are fully devoted towards forest plantation development. An agricultural crop is the major motive of forest development with ability to maximised available land. The research also showed that not all the people were aware of the benefits of forest plantation and there was less people's participation. The study also indicated the availability of land was the major constraint for forest plantation development. The virgin land in the surrounding was decreasing due to unplanned urbanisation, indiscriminate felling and hunger for fertile land. The study has revealed that government should take immediate steps to implement some of the recommendations of forestry institutions to facilitate forest plantation development in the nearest future.

Keywords: Afforestation, educational status, forest plantation, perception, respondents, community forestry

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Enhancing Cost-Effective Watershed Management in the Brazilian Atlantic Forest by Valuing Forest Ecosystem Services Linked to Water Quality in the Guapi-Macacu Watershed

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The Guapi-Macacu watershed is located in the Brazilian state of Rio de Janeiro, has a drainage area of about $1.640\,km^2$, and drains into the Guanabara Bay northeast of the metropolitan area. The upper catchment in the Serra dos Órgãos mountain range is covered by dense old-growth forest of high biological diversity, while pastures and agricultural land dominate in the lower catchment. Apart from its outstanding biological value, the watershed provides crucial services including water supply to 2.5 million inhabitants in five municipalities. Nevertheless, forests and soils in the lower watershed are highly degraded due to the expansion of the agricultural frontier, overexploitation, and suburbanisation processes. Several pressures on this ecosystem persist. Therefore payments for ecosystem services (PES) schemes are proposed by local initiatives and supported by international organizations as a suitable instrument to deal with the trade-offs between agricultural use and watershed services in a cost-effective manner. Studying the provision costs of and the demand for watershed services can support decision making process to evaluate the scope and economic feasibility of PES and alternative management options. Water resources in the watershed are of extreme importance for agriculture and also for industries, such as water bottle companies, breweries and the biggest Brazilian petrochemical complex, COMPERJ. Our study concentrates on calculating the opportunity costs related to the provision of watershed services under varying land use systems and evaluating the feasibility of PES related aspects, such as preserving or recovering forest areas and integrating good agricultural practices. Watershed services are valued in terms of controlling nutrients (Nitrogen and Phosphorus in surface water) and sediment loads (measured in terms of turbidity and total solids). Replacement and avoided cost methods are applied focusing on the local water treatment facility to estimate demand for service maintenance and improvement. To provide empirical evidence of the link between land use and water quality indicators, we rely on water quality modelling and monitoring specifically adapted to this area. Spatial conservation opportunity cost analysis is used to study the costs of watershed services maintenance and improvement and derive implication for cost-effective management on the basis of scenario analyses. The research activities take place within the framework of the multi-disciplinary German-Brazilian cooperation project DINARIO/MP2.

Keywords: Atlantic forest, cost-effective watershed management, ecosystem services, PES, land use systems, water quality

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Principle Method to Harvest Resin from Wild Pistachio in Iran

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Mediterranean forests are characterised by a remarkable set of features that make them naturally and aesthetically attractive, on the one hand, but also quite fragile, on the other, therefore calling for careful strategies for their conservation and management. Wild pistachio (*Pistacia atlantica* Desf.), locally known as "Baneh" in Iran, is the most economically important tree species in many rural and boundary areas in the West of Iran. It is playing an important role due to its particular characteristics, in aforestation of the dry areas and Mediterranean areas in Iran. *P. atlantica* is also used as a rootstock for edible pistachio tree (*P. vera* L.). The resin of wild pistachio, called Saqez, is used for a variety of industrial and traditional uses, including food and medicine. Because the resin can be harvested non-destructively, the trees are maintained until mortality occurs from natural causes. Unfortunately, over-harvesting from wild Pistacia trees lead to degrade the habitat of this species. Rural people use traditional methods to extract the resin and with some of these methods Pistacia trees are destructed. As well as adaptation of Pistacia trees to harsh desert conditions, their longevity also make them ideal candidates for reforestation in arid zones. So the extraction is very important to achieve a sustainable development. In this study we tried to introduce a principle method to conserve the forests in Zagros Mountain and also to obtain economical profit from resin extraction of wild Pistacia trees.

Keywords: *Pistacia atlantica*, resin, Iran, Saqez

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Agroforestry

Shade Canopies and the Productivity, Sustainability and Resilience of Cacao Agroforestry Systems

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Global changes have immense impacts on human societies. For instance, the livelihoods of poor rural families and the sustainable management of their natural resources have been shown to be severely impacted by economic globalisation and climate change. To tackle these adverse effects in tropical regions, global society and national governments seek to enhance the sustainability of the rural livelihoods, generate wealth and reduce both poverty and the vulnerability of rural economies, increase the resilience and adaptive capacity of households to climate change, and promote the shift to green economies with low carbon emissions and high carbon storage.

Three million smallholders cultivate 7 million hectares of cacao (*Theobroma cacao* L.) worldwide; at least 80 % of the cacao is cultivated under a shade tree canopy. Farmers retain a large list of tree species in the plot to provide shade and shelter to sustain high cacao yields; and to produce timber, fruits, fiber and other goods for family consumption, use in the farm, or sale. Cacao agroforestry systems have been ranked as good land use alternatives to cope with climate change because their high levels of species diversity, year-round soil cover, high levels of store carbon in the soil and aboveground, and other positive attributes. Despite all these good features, shaded cacao systems are affected by global changes and it is safe to ask: how productive, sustainable and resilient these systems are today and in the presence of global changes? Can they be optimised for the simultaneous delivery of valuable goods for the household and the provision of ecosystem services for society? How to achieve this?.

In this presentation: 1) the concepts and criteria used to evaluate sustainability and resilience of socio-ecological systems are quickly reviewed for Central American cacao households; 2) a simple, qualitative model is used to explore (for various cacao farming typologies) the relationships between yields (from both cacao and shade trees), carbon storage, and shade canopy design and management. A practical methodology for the analysis, improved design and management of cacao shade canopies at any particular location is presented.

Keywords: Carbon stocks, Central America, cacao, diagnosis and design, resilience, shade canopy, sustainability, yield

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Microclimate Controls of Shade Trees in Agroforestry

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In agroforestry and park systems the crops are growing under the canopy of so called "shade trees". The growth rates and yield of crops depend strongly on energy and water fluxes between agroforestry system and atmosphere. The microclimate in agroforestry systems is strongly influenced by number (canopy density) and structural parameters of shade trees. Therefore, the shade trees can be used to reduce or mitigate the negative effect of climate variability (including climate change) on crop growth and yield. To quantify the influence of shading trees during different seasons, different meteorlogical conditions (cloudy, clear sky), as well as cumulative annual effects, the radiation and turbulent transports in agroforestry canopies were modelled on example of cacao (*Theobroma cacao*) agroforestry system in Indonesia. Three typical shade tree species - *Aleurites moluccana*, *Cocos nucifera* and *Gliricidia sepium* - were chosen for the experiment. Because of high heterogeneity of vegetation structure typical for agroforestry system a three-dimensional modelling approach has to be applied to describe the canopy transport adequately. In the present study the high resolution small scale 3D model of radiative transfer (SPM3D) (Bioclimatology Group, Göttingen University) was implemented. The wind regime was modelled by means of 3D Boundary layer Model SCAlar DIStribution (SCADIS) (Wind Energy, TU Copenhagen). The structure of different shade trees and its variations were measured directly and retrieved from hemispherical photos. The inaccessible structural parameters were estimated using allometric functions obtained from direct measurements. The results show the non-linear influence of the number, size and spatial distribution of shade trees on radiative and wind regimes in cacao agroforestry systems.

Keywords: Agroforestry, climate change, microclimate, shade trees, cacao modelling

Optimising the Measurement of Landscape Biomass Carbon in Agricultural Landscape Mosaics

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Development of quick, reliable and economical methods of predicting the amount of biomass carbon stored in the landscape is essential if smallholder farmers are to benefit from carbon markets by growing trees on their farms. While estimation of landscape carbon can be easily achieved through use of allometric models, the quality of the model depends on the empirical data used. As part of the effort in developing standard methods of estimating biomass carbon in agricultural landscapes, a study was conducted in Western Kenya in three sentinel blocks (Lower, Middle and Upper Yala) along the River Yala basin. The study used established trees with the aim to determine (i) sources of error that can be easily avoided, (ii) ways of achieving quality empirical data, and (iii) constraints accompanying biomass estimation. Seventy two trees ranging in diameter at breast height from 3–102 cm (total basal area: 10.2 m^2) were randomly selected for destructive sampling and their dendrometricmeasurements taken. The roots system, stem, branches and leaves contribute 22 %, 45 % 30 % and 3 % of the total tree biomass respectively. Belowground biomass sampled to a depth of 2 m within 2 m radius from the tree edge allowed only 77.6 % of the total root biomass to be captured. About 1.1 % of the total aboveground biomass was lost though sectioning the stem and branches into practically weighable pieces ($<$300 kg); with losses as high as 2 % recorded on large trees. Prediction error of equations did not increase substantially above a sample size of 30 trees. It is therefore recommended that methods for quantifying biomass in agricultural landscapes should always take into account the biomass of all components, ensure sufficient sampling depth and width, and that the sampling strategy covers the heterogeneity of the tree diversity in the landscape.

Keywords: Agricultural ecosystems, allometric equations, biomass, carbon, western Kenya

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Enriching Forest Plantations with Understory Crops: An Interdisciplinary Approach Towards Reforestation, Food Security and Resilient Production Systems

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Deforestation in the Central American Republic of Panama is continuing at a rate of 13,000 ha per year. Politicians and scientists therefore widely acknowledge the need for reforestation in order to restore environmental services such as the regulation of hydrological regimes, the maintenance of biodiversity, and the storage of carbon. In this context tropical timber plantations are considered as a sustainable and economically feasible way to foster reforestation of degraded lands. However, the greatest obstacle to the implementation of timber plantations for small as well as large-scale reforestation is the long time period of up to 10 years until the first returns out of wood harvesting can be expected.

The present study presents an approach to overcome this obstacle by introducing four different crop rotations into high value timber plantations of six exotic and native tree species in an agroforestry trial in Eastern Panama. The aim of the trial was to identify optimal tree-crop combinations as well as optimal tree planting distances and light regimes to allow first returns out of wood plantations during the establishment phase. Initial tree growth and mortality has been evaluated in the different agroforestry systems in comparison to tree monocultures. Socioeconomic methods were used to evaluate the suitability and feasibility of this agroforestry system using participatory interviews with local farmers and methods of investment appraisal including risk analysis.

Results show that the enrichment of forest plantations with *Cajanus cajan* even improved tree performance of some species. Combining reforestation with crop production can help to overcome the frequent criticism - observed in the interviews - of forest plantations reducing the area available for food production. These agroforestry systems can improve food security in rural areas, while the agroforestry systems tend to have higher net present values on a long time view of 25 years.

Keywords: Agroforestry, Panama, reforestation, taungya, tropical forest plantations

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Domestication Potentials of *Irvingia gabonensis*: Farm Level Tree Growth Characteristics Assessment, Fruit Phenology and Effect of Light Intensity on Seed Germination

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Throughout the tropics, there are indigenous forest tree species that produce locally important NTFPs, thus contributing to food security and increasing diversity of foods necessary to reduce monotony in rural people's diets. This study examines tree growth characteristics, fruits phenology and germination of *Irvingia gabonensis* (var. *gabonensis*) seeds under different light intensities. Ten villages with high abundance of *I. gabonensis* trees were purposefully selected from rainforest and derived savannah ecosystems of Ondo State, Nigeria. Ten trees were selected from each village, their age and silvicultural history obtained from their owners and their growth parameters measured. Fruits were harvested from each tree and their phenology investigated. Mean tree age across the villages ranged from 6 to 47 years, with trees in rainforest being older (mean: 40–47 years) than those within savannah ecosystem (mean: 6–16 years). Thus, *I. gabonensis* trees within rainforest are aging and need to be replaced. 88 % of trees in derived savannah were planted against only 2 % of those within rainforest, thus indicating higher domestication of the species in derived savannah and explaining the lower age of the trees in this ecosystem. Variation in tree growth characteristics is as follows: total height 5.1–28.8 m; dbh 16.5–125.3 cm; crown height 3.0–20.0 m; crown diameter 1.3–24.0 cm; leaf length 5.2–14.6 cm and leaf width 2.7–7.2 cm. Fruit phenotypic variation is as follows: length 4.65–7.1 cm; width 5.0–7.2 cm; weight 64.7–202.1 g; flesh weight 55.1–177.70 g; flesh depth 1.0–2.2 cm; seed length 3.0–5.0 cm; seed width 2.5–3.9 cm; seed weight 9.6–25.4 g and kernel weight 1.5–6.8 g, which reveals a wide variation in *I. gabonensis* fruit. Seed germination commenced on the 21st and ended on the 68th days after sowing. Seeds sown under 40 % and 100 % light intensities and control had mean cumulative germination of 65.5 % while those under 60 % light intensity had 61.8 % germination. The non-significant difference in seed germination under the different treatments implies that germination of *I. gabonensis* seeds is not affected by light environment.

Keywords: Domestication, fruit phenology, germination, growth characteristics, *Irvingia gabonensis*, light intensity

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Influence of Agroforestry Systems in Risk Reduction and Climate Change Adaptation in the Peruvian Andes

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Climate change as a long-term hazard is already affecting the small-scale farmers in Andean regions of Peru through extreme weather events. Weather hazards like frosts, hailstorms and droughts are affecting crops and livestock, increasing food insecurity and poverty levels.

Risk reduction and adaptation measures are one of the most urgent aspects for local small-scale farmers depending on agriculture. Although they have reduced the impacts of these hazards by adapting farming techniques, varying their crops and altering their planting season, so far not much is known about the related local knowledge, behaviour and action.

The Achamayo river basin is a typical inter-Andean valley of Peru's central highlands ranging from 4500 m asl down to 3262 m asl, where agriculture remain one of the main economic activities and traditional agricultural practices are still in use. Here, droughts, more precisely, agricultural droughts during the midsummer ("veranillos") are one of the events which affect crops most directly and thus the livelihoods of the small-scale farmers in the region. Even if the mean annual rainfall has not changed significantly, there is a loss in the yield production due to agricultural droughts, and their incidence is increasing in the last years.

By increasing the trees and forest share in the area *i.e.* through agroforestry systems, small-scale farmers can adapt their systems to prevent natural hazards (locally mitigating their negative effects) and simultaneously contribute to climate change mitigation (increasing the storage of carbon in the system), linking both adaptation and mitigation strategies.

The main objective of the research is to analyse the use of trees as a measure of adaptation to agricultural droughts in the rural areas of the tropical Andes. The main focus is put on the relation between the presence of trees in the crops (agroforestry systems) and their influence on agricultural droughts (analysing their effects in the yield) and consequently in the farmer's livelihood (with emphasis on food security).

Keywords: Adaptation, agricultural droughts, agroforestry, Andes, climate change, food security, Peru, rural livelihood

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Genetic Differentiation among Natural Populations of *Shorea contorta* and *Parashorea malaanonan* (Dipterocarpaceae) in the Philippines

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The rapid decline of the Philippine forests during the past century has resulted in highly fragmented tree populations. To conserve the remaining forest genetic diversity and to better support an effective forest restoration activities in the country, genetic differentiation among the remaining natural populations of the ecologically important and critically endangered timber species, *Shorea contorta* and *Parashorea malaanonan* (Dipterocarpaceae), was investigated using microsatellite markers developed for *Shorea* species.

Results revealed a higher mean values for populations in the northern than in the central region, in both dipterocarps, concerning on their allelic richness, effective number of alleles, and observed and expected heterozygosities. Further, population differentiation was higher in the northern (F_{ST}=0.187) than in the central region (F_{ST}=0.134) for *P. malaanonan*. An opposite trend of F_{ST} value, on the other hand, was obtained for *S. contorta* populations (northern: 0.017; central: 0.038). Analysis for inbreeding coefficient (F_{IS}) among populations within region generally showed an excess of heterozygotes for the studied dipterocarps. The groupwise differentiation of these different genetic parameters between populations from two regions in both dipterocarps, however, was not significant based from the two-sided test.

Analysis of molecular variance (AMOVA) showed significant difference between populations from northern and central region for both dipterocarps (*P. malaanonan*: 12.48 % variation, P= <0.05; *S. contorta*: 6.31 % variation, P= <0.01). This was supported by principal coordinate analysis and clustering of the populations based from the UPGMA dendrogram. Mantel test also revealed highly significant ($p < 0.0001$), in both species, after regressing Nei genetic distance against the geographic distance (P. malaanonan: r = 0.599; *S. contorta*: r = 0.511). Further, a high significant ($p < 0.001$) genetic structure among populations within region was also revealed in the studied dipterocarps (*P. malaanonan*: 3.37 % variation; *S. contorta*: 2.26 % variation). This result was supported by an analysis of a model-based Bayesian inference clustering, which was estimated from an optimal K population.

Keywords: Dipterocarpaceae, genetic differentiation, microsatellites

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Investigation of Agroforestry Practices within *Eucalyptus camaldulensis* Plantations: A Case Study of Kaduna State Forest Management Project, Buruku, Nigeria

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The environmental services that agroforestry practices can provide especially their potential contribution to the conservation of biodiversity, climate amelioration and livelihood improvement has recently attracted attention among agroforestry and conservation scientist. An investigation of agroforestry practices within *Eucalyptus camaldulensis* in Kaduna State Forest Management Project Nigeria was carried out. A total of 100 questionnaires were administered with 77 retrieved from the respondents. The questionnaire was structured to access and identify the benefit of agroforestry practices to the rural communities (forest management staffs and the core villagers). Results obtained from the study revealed that 77 % of the respondents are male while 52 % of the respondents are married. 71 % of the respondents are involved in other activities than agriculture, which serve as their source of income. 60 % of the respondents rear livestock while 58 % of the respondents benefit from non- timber forest products (NTFP). 51 % of the respondents experience pest and diseases on their farm. The Chi-square analysis of data collated among 8 variables including gender, age, size of farm land, impact of agroforestry, effect of agroforestry on soil fertility, beneficial relationship between food crops and tree crops revealed that the computed value X2 of these variables are greater than the critical value thus null hypothesis is rejected and the alternative hypothesis accepted. Therefore there is significant difference within the variables. The results of the study show that agroforestry practices serve as a means of improving the livelihood of the rural communities in the study area and also provide other in-direct benefit such as reclamation of soil fertility. It is recommended amongst other things that there should be provision of adequate knowledge about the benefits derived from improved agroforestry practices to farmers through extension services.

Keywords: Agroforestry practices, Bukuru, *Eucalyptus camaldulensis*, Kaduna, Nigeria

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Agroforestry for Resilient Agroecosystems in the Mid-Hills of Nepal

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In order to adopt sustainable land use and to improve food security and livelihood, agro-forestry systems offer an alternative to traditional farming that can be advantageous in terms of productivity, biodiversity, and ecological services provided.

16 farmers of Kaule, a Nepalese village in the Mid-Hills have changed over from traditional farm management with crop rotation systems to the integration of woody perennials on the same land management units. Poor nutrient conditions and susceptibility to erosion characterise the region's prevalent soils. The agroforestry farmers have taken different measures to enhance the soil fertility, such as the use of green manure. The Nepali-German organisation Kaule e.V. supports the adoption of agroforestry systems in Kaule. In the context of scientific documentation and evaluation of this project the study's objective is to compare soil properties and phytodiversity of: A) 15 years ago established agroforestry land, B) 2 years ago established agroforestry land, and C) conventional crop rotation land.

Soil samples (n=96) were taken at 24 terraces (8 per land type) and analysed. The fields' crops, shrubs and trees were examined by stratified random sampling. The survey included soil and vegetation parameters of field boundaries – in general the terrace risers.

Analysis of variance shows significant ($p < 0.05$, ANOVA / Kruskal-Wallis test) differences of agroforestry land (A) and conventional land (C) in terms of plant diversity, plant cover, and soil parameters. Soils of agroforestry land provide more favourable conditions for plant growth *e.g.* concerning pH, total C, total N, CEC, and exchangeable Al, Ca, and Mg. Although the transition process to agroforestry has been in progress for only 2 years in 'B', soil parameters already reflect the shift to restoring farm soil fertility. Terrace risers' soil parameters are not correlated with management. Species richness of agroforestry lands' tree and shrub layers is higher compared to conventional lands'. Transition lands' α- and β-diversity indices have reached values of agroforestry land within two years since conversion has started.

In conclusion, agroforestry in the Nepalese Mid-Hills provides ecological and economic benefits and is a viable option to develop more efficient, more resilient and sustainable land use systems.

Keywords: Agroforestry, Mid-Hills, Nepal, phytodiversity, soil fertility

Preliminary Characterisation of Common Legume Tree Species as Coffee Shade for Climate Change Readiness

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Agroforestry practices are proposed for adaptation to the increased temperatures and more irregular rainfall associated with climate change in the coffee growing areas of Mesoamerica. We propose that understanding the functional characteristics of different legume trees can contribute to the design of multi-purpose, multi-strata shade, including climate change readiness. The genera of *Inga* and *Erythrina* of the Fabaceae family are common in coffee fields due to their capacity to fix nitrogen. We studied photosynthetic parameters and biomass accumulation of young trees grown in 15-L pots of five species found as coffee shade - *Erythrina poeppigiana* (Ep), *Inga jinicuil* (Ij), *I. oerstediana* (Io), *I. punctata* (Ip) and *I. vera* (Iv) at 10, 40 and 100 % of full solar irradiance. After 125 days, Ep had accumulated the highest biomass, followed by Iv and Io. Biomass of Ep, Iv, and Ip declinaed linearly with irradiance, while for Io and Ij, biomass declined less at intermediary irradiance. Leaf area for Io and Ij increased in 40 % irradiance compared to others species, although leaf area ratio increased in all species with declining irradiance. At leaf level, the photosynthetic capacity expressed by the maximum carboxylation rate (Vcmax in μmol m^{-2} s^{-1}) and potential light-saturated electron transport rate (Jmax in μmol m^{-2} s^{-1}) were higher in Ep, Iv and Io compared to Ip and Ij, according to the highest biomass accumulation. Vcmax and Jmax reduced with declining irradiance showing an acclimation to shade related to changes in leaf traits as leaf specific area, but the rated of reduction was specie specific. Diurnal courses of photosynthesis and transpiration (T) showed highest values at 100 % full sun. Instantaneous water use efficiency (WUE An/T) was higher for 100 % irradiance for Ep, Iv, and Io compared to Ij and Ip, for WUE was higher at 40 % irradiance. These results indicate that species differences need to be further characterised to provide the basis for the design of climate-change ready multi-strata. Follow-up field studies are needed to pruning and thinning. These parameters are also essential for modelling long-term photosynthesis and productivity in these agroforestry systems.

Keywords: Agroforestry, biochemical model, light, photosynthesis, shade species, water use efficiency

Quesungual Slash and Mulch Agroforestry System: Improving Livelihoods of Smallholders in Central America

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Food insecurity and poverty are major problems in rural areas of Central America, particularly for those farmers who depend on maize-bean-livestock systems in sub-humid ecosystems. Intensive use of agricultural lands and farming in not suitable areas, and limited use of soil conservation practices, have lead to an extensive degradation of natural resources. Earlier work on hillsides of Central America has shown that both the Quesungual Slash and Mulch Agroforestry System (QSMAS) and silvopastoral systems with improved forages can enhance eco-efficiency to improve livelihoods of poor farmers by increasing agricultural productivity and profitability, and facilitating the generation of other ecosystem services.

This research compares QSMAS, in combination with improved (stress-adapted) food crops (maize and bean) and multipurpose improved forages (grasses and legumes), to the traditional crop-livestock system based on slash-and-burn agriculture and traditional pastures. Experimental plots were established in 16 farms in two regions of Nicaragua. Baseline studies on ecosystem parameters included soil quality, fertility, macrofauna, erosion, and carbon stocks. Agricultural productivity and ecosystem benefits of improved crop-livestock systems are being assessed on the experimental plots with natural forest as reference. Sociocultural and socioeconomic factors driving adoption are defined of both participating and non-participating farmers, to support the development of strategies for translating the results into practice.

Preliminary results (one year) show no significant effects of treatments on crop yields, although in one region maize productivity tended to be higher with improved varieties and improved management. Erosion is highest in the traditional (especially slash-and-burn) system, and lowest on QSMAS plots. Although in general QSMAS did not show significant differences in physical and chemical soil quality parameters when

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compared to the traditional system, abundance of macrofauna was greater suggesting improved soil conditions.

Out and up scaling activities have included several workshops and field days with farmers, technicians and researchers, directly and indirectly (through NGOs and local authorities) involved in the project. In the coming year evaluations of food crops will continue, as well as the monitoring of ecosystem parameters. In addition, grazing trials will be implemented to assess the effect of the improved sylvopastoral system on milk production.

Making Social Forestry Work: A Comparative Study of Smallholder Reforestation Projects in Paraguay

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Paraguay has one of the smallest forest plantation areas in Latin America currently estimated at 66 000 hectares. Additionally in the second half of the 20th century the dramatic deforestation rate assessed by the World Resources Institute reached 2,65 %. Those are just some of the reasons explaining the particular importance of promoting plantation activities within the country. One such initiative has been the project for management of natural ressources (PMRN) of the German Development Agency (GIZ) involving assistance for smallholders in the establishment of forest plantation plots.

This paper tries to explain the observable difference in the performance of two nearly neighbouring communities. It asks why in the same region (Department of San Pedro) and operating under the auspices of the same external project (PMRN) the results of the two case study areas (in Cuatro Vientos and Choré communities) are so divergent. After the analysis of the relevant documents and a field visit to both areas, the variation between the plantation results can be explained by the degree of self-organisation and institutional capacity, with the formalised cooperative in Cuatro Vientos as a potential "champion" and the loose producers committee in Choré as the visible "laggard". The paper discusses the initial conditions, external factors of influence and project outcomes regarding forest plantations. It broadly assesses the socio-economic and environmental impacts of plantations, producers' attitudes towards planting trees, plantation integration at the farm level, options for value added chains and microfinance and finally long-term continuation of the efforts after the project. It finally points to the importance of governance and institutional set-up in plantation forestry and provides lessons learned for making social forestry work at the grassroots local level.

Keywords: Development, Paraguay, smallholder plantations, social forestry, socio-economic impact

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Improving Smallholders' Access to Good Planting Material - Improving Input Supply Chains: A Baseline Survey

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In Kenya, forest cover has been reduced to about 2 % over the last decades, and forests are still threatened by increased population and climate change. In order to increase resilience against climate change and to conserve the remaining forests, the government of Kenya has set a national goal of 10 % tree cover in their Vision 2030. Tree planting activities are being promoted on smallholder farms, since agroforestry systems are more resilient and sustainable than monoculture systems, as well as reforestation of natural forests. The current system of input supply for tree seeds consists of a range of actors, with no specific coordination of efforts. This situation is typical for eastern and southern Africa.

The purpose of this study was to identify actors in the input supply system of planting materials and to identify the constraints and opportunities for improving tree nurseries and the distribution of quality germplasm to agroforestry systems.

Findings conclude that NGO started group nurseries face many problems rendering them unsuitable as source of germplasm for smallholders in the long run. The NGOs mainly promote indigenous species for forest restoration, with little consideration to farmers needs. There are strong indications that small scale individual nurseries are more efficient in supplying species in demand, therefore representing a vital link in the input supply system. It can also be seen that training efforts of these small scale enterprises results in higher profit.

NGOs are performing an important role in reforestation and preservation. However, it can be recommended that they change their roles as seed providers, of often low quality seeds, to offer technical training and support to small scale nurseries. National seed centres and NGOs should focus on small scale nurseries, provide training programs and establish good quality seed sources of useful exotic and indigenous species. This would make the input supply system more efficient, providing the best quality germplasm to rural farmers. Promotion and value chain interventions for agroforestry products on a larger scale will further improve the value chain from input supply to outputs, such as timber and fruits.

Keywords: Agroforestry, input supply system, seed sources, tree-planting

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Tree Diversity in Cacao Agroforestry in San Alejandro, Peruvian Amazon

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Cacao cultivation that maintains higher proportions of shade trees in a diverse structure (cacao agroforestry) is progressively being viewed as a sustainable land-use practice that complements the conservation of biodiversity. Our basic hypothesis was that cacao agroforestry systems can support relatively high tree diversity compared to primary and secondary forest. The objective of this study was to assess the impacts of forest conversion on tree communities by comparing tree species richness, diversity and composition between natural primary and secondary forest and cacao agroforestry systems. In total we collected data in 30 (25×25 m) plots on three land-use systems (20 in cacao agroforestry, 5 in secondary forest and 5 in primary forest) in San Alejandro, Peruvian Amazon. All trees were identified to species, and their height and DBH recorded. Cacao farmers were also interviewed to document their knowledge about association of cacao with trees. Our results support the hypothesis that cacao agroforestry contains relatively high tree species richness and diversity comparable to secondary forest. Although we found higher tree density in primary and secondary forest compared to cacao agroforestry. The species richness was found the highest in the primary forest. According to the species diversity indexes, the species composition of cacao agroforestry is higher than in secondary forest. Farmers have very good and extensive knowledge about advantages that trees provide for cacao, soil improvement and biodiversity conservation. However, we also found that tree species cultivated in cacao agroforestry are very different from the species found in primary forest, so there is a question if the relatively high tree diversity and richness is able to support some of the original faunal diversity found in natural forest. In this context our study forms a good scientific background for the further monitoring of ecological changes in human modified landscapes in the Amazon region.

Keywords: Cacao agroforestry, Peruvian Amazon, primary forest, secondary forest, species diversity, species richness

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Agroforestry as Resilience Tool for Ecological Degraded Agricultural Areas of Northeastern Mexico

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In northeastern Mexico predominant livestock under extensive management, coupled with low and erratic rainfall, uneven topography, results in degradation of large areas with phenomena such as soil erosion and loss of biodiversity. The objective of this research was to test agroforestry - systems in response to the problem of soil erosion and is proposed as a dynamic way to support the resilience of these ecosystems damaged through missmanagement, to conserve the ecosystems and to diversify the production in order to generate sustainable benefits for the rural population of the region. The work consisted in the restoration of a degraded area to a productive area with contour lines and reforestation in the region of Linares, Nuevo Leon, Mexico. The following forest species were planted: *Acacia berlandieri, A. rigidula*, *Leucaena leucocephala*, *Havardia pallens, Prosopis laevigata* and *Opuntia* sp. Forage grass was promoted (*Lolium perenne*) between levels. There where the agroforestry model was established erosion was controlled. The grass showed a yield of $790 \, \mathrm{kg} \, \mathrm{DM} \, \mathrm{ha}^{-1} \, \mathrm{y}^{-1}$ in the first year after establishment and of $4090 \, \mathrm{kg} \, \mathrm{DM} \, \mathrm{ha}^{-1} \, \mathrm{y}^{-1}$ from the third year on. The LAI increased from 0.025 on the degraded area to 2.75 in the agroforestry area. The content of soil organic matter in the agroforestry module increased from 0.6 % in the first year to 4.2 % after 3 years. Statistical analysis indicated that the species with the highest survival rates after three years were *Havardia pallens* and *Acacia rigidula*. The study area is more suitable for the production of forage grasses ($4090 \, \mathrm{kg} \, \mathrm{ha}^{-1}$) than for corn production ($480 \, \mathrm{kg} \, \mathrm{ha}^{-1}$). The species recommended to implement in the agroforestry system are *H. pallens* and *A. rigidula*. It was demonstrated that agroforestry systems can be implemented as a resilience tool on degraded areas.

Keywords: Agroforestry, *Havardia pallens*, leaf index, *Leucaena leucocephala*, *Prosopis laevigata*

Assessing the Conservation Value of Different Habitats for Birds in the Walnut Fruit Forests of Kyrgyzstan

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Walnut fruit forests represent both a valuable hotspot of biological diversity and have significant economic value for the livelihoods of local communities. However, the sustainable management of these forests is a complex task requiring the successful juggling of the different interests of local stakeholders, including fulfiling their economic, social and ecological demands. Here, birds were chosen as the indicator of biodiversity with which to evaluate the effects of such forest management activities. A research study was conducted in 2005 during the birds' breeding season in five different habitats (primary and secondary forests, plantation, agroforestry and brushwood) using the point sampling method. A total of 23 species were recorded. According to the various diversity indices employed, the best habitats for species richness were areas of agroforestry, while primary forests were found to be the best habitats in terms of species abundance. In contrast, the lowest bird diversity was observed in plantations due to their structural homogeneity. In addition, habitat suitability was assessed according to both horizontal and vertical structural parameters and tested using 5 selected indicator bird species. The results reveal a link between birds and vegetation, with abundance of old trees, availability of dead wood and habitat understorey density found to be the most important indicators of bird survival. Our research findings highlight that it is imperative to protect existing primary forests which are genetic diversity hotspots for endemic species such as *Dendrocopos leucopterus*. Although areas under agroforestry were primarily found to be relatively promising habitats in terms of species richness, these intensively managed ecosystems may also be useful for simultaneously fulfiling the needs of local people, if such projects are carefully planned and managed.

Keywords: Biodiversity, bird diversity, forest management, Kyrgyzstan, walnut fruit forests

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Not Only Humans Like Cacao: Conflicts with Wildlife Threaten Farmers' Livelihoods Around the Bia Conservation Area, Ghana

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Human-wildlife conflicts (HWC) are a severe threat to smallholders' livelihoods around many conservation areas in the tropics and subtropics. Among them is the Bia Conservation Area (BCA) in Ghana, where many farmers are experiencing increasing levels of crop-raiding. We determined the wildlife species involved in HWC and examined the effects of crop-raiding on the livelihood of people around the BCA. The kind and extent of damage was recorded and possible factors influencing the risk of raids were investigated. Also, prevention measures applied by farmers and their pay-offs were analysed. 100 interviews were conducted in 10 fringe communities around the BCA. The presence and relative density of different wildlife species were assessed through transect walks and spoor plot monitoring in the transition zone of the BCA. Crop-raiding took place all around the BCA but was most severe in the northern part. Elephants (*Loxodonta africana cyclotis*) were identified as the major conflict generating species, but also smaller mammals such as squirrels (*Sciuridae* spp), bushbuck (*Tragelaphus scriptus*) and cane rats (*Thryonomys swinderianus*) were found to cause damage. The relative density for squirrels was by far the highest of all species recorded in the farmland. Cacao (*Theobroma cacao*) was most frequently raided (99 %), followed by cassava (*Manihot esculenta*), yam (*Dioscorea* spp.) and plantain (*Musa* spp.). Traditional prevention measures applied by farmers were only partly effective and hardly any non-traditional methods based on chili pepper were used. One mitigation approach could be the use of buffer crops that are unpalatable for wildlife, such as ginger or chili pepper. Latter could then serve as basic material for wildlife repellent measures like chili grease fences or chili-dung bricks. However, further education of farmers on such mitigation measures is needed, as is general training on improved farming practices.

Keywords: Crop-raiding, Ghana, smallholders' livelihood, wildlife, human-wildlife conflict

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Socioeconomics

High-value markets

Can Geographical Indication Increase Household Welfare and Reduce Poverty? Evidence from Rural Northeastern Thailand

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Can a Geographical Indication (GI) which indicates that a certain product originates from a certain region with a given quality being attributable to its place of origin, become a tool to promote socio-economic livelihoods of rural communities? A GI is one kind of intellectual property right which has gained increasing interest among policy makers and in academia alike since its protection has been ensured multilaterally under the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement of the World Trade Organisation (WTO). Thung Kula Rong-Hai Thai Hom Mali Rice (TKR) being traditionally produced in the Thung Kula Rong-Hai (TKRH) area in the Northeast of Thailand is the first registered GI Jasmine rice in Thailand. The producers in the TKRH area along with other business operators of the TKR value chain have to apply for GI certification which then provides protection against any counterfeiting by parties other than the genuine producers. This case study aims at finding the potential impact of the GI certification adoption on household welfare and rural poverty. It uses data obtained from a cross-sectional household survey of 541 TKR households in two districts of the TKRH area from 2009. A non-parametric Propensity Score Matching (PSM) analysis is applied to assess the causal effect of the GI certification on farm household's welfare. The central question is whether GI certification adoption for Jasmine rice results in improved household welfare in terms of increased consumption expenditures and in a decreased propensity to fall below the poverty line. The study finds a significant and positive effect of GI certification adoption on the household welfare and poverty reduction in rural Thailand. However, a long lasting positive impact on household welfare and poverty in rural communities depends on the awareness and the rate of adoption of the TKR households to make use of their embedded right to apply for GI certification. The results stress the importance of a sustainable and well-functioning and for the producers reachable GI registration system which facilitates the registration procedure for GI certification to TKR producers.

Keywords: Geographical indication, propensity-score matching, rural household welfare, rural livelihoods, rural poverty, Thailand

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Can Contract Farming Reduce Vulnerability to Poverty among Oil Palm Smallholders in Indonesia?

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This paper uses an asset-based vulnerability approach to investigate the poverty risk of smallholder farmers in the oil palm industry in Indonesia. In particular the question is asked to what extent contractual arrangements between smallholders and large agro industry companies are an effective means to reducing vulnerability, *i.e.* the risk from falling into poverty. In order to better understand such vulnerability, four types of shocks experienced by oil palm smallholders namely price, production, health and demographic and other economic shocks were also analysed. Data were randomly collected from 245 smallholders consisting of 126 contract and 119 non-contract smallholders in the province of Jambi, Indonesia. Results show that contract smallholders tend to be more dependent on oil palm. They reported price and production shocks more frequently while non-contract smallholder experienced health, demographic, and other economic shocks more extensive. Using a probit model we find that the negative impact of price shocks can be reduced by participation in the contract scheme; however this is not the case for production shocks. We find that contract smallholders are significantly less vulnerable, however not because of contract participation but mainly because of their better asset endowments. The results of vulnerability estimates suggest that about 40 % of smallholders are expected to be non-poor but the occurrence of shocks can make them fall back into poverty. Hence our findings differ from past publications on oil palm households' well-being which only looked at static poverty and thus reported low poverty headcount ratios. Our results suggest that policy measures must focus on reducing vulnerability rather than *ex post* poverty. Consequently contact schemes need to be reviewed in order to be more effective for the poor and vulnerable.

Keywords: Contract farming, oil palm, smallholders, vulnerability to poverty

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Commercialisation of Smallholder Horticulture: A Panacea or a Deterrent to Reduction of Rural Poverty Vulnerability – An Asset-Based Approach

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Commercialisation and diversification into horticulture has often been seen as a pro-poor development strategy in Kenya. Whereas the horticultural sub-sector seems to be successful in economic terms at macro level, the extent to which these economic gains derived from commercialisation of horticulture impact on the poor at the household level in the long-run has not been clearly understood. The argument of "pro-poorness" of commercialisation of the horticultural sub-sector is often based on cross-sectional income or expenditure poverty measurements, reporting who is poor at the time of survey. These methods not only fail to show who is likely to remain poor in the future or who is moving out of poverty. The current study follows an asset-based poverty measurement approach utilizing two-wave panel data comprising of 309 vegetable producing smallholders from selected districts in eastern and Central Kenya. Results indicate that over 37 % smallholder farmers have exited from commercial vegetable production as their main livelihood activity while about 20 % have abandoned production of vegetables altogether. While per capita income among farmers who have abandoned horticulture business have increased by about 40%, per capita asset holding have reduced by about 10 %. Using logistic regression model, factors such high dependency ratio, availability of remittances, opportunities for small business enterprises and old age are seen to have contributed to shifting away from horticultural business. On the other hand, household with higher income and land endowments and have access to extension services are likely to remain in commercial horticultural farming. Policy implication focuses on creating a better investment environment to promote small rural based businesses as an alternative livelihood to vegetable production business, exploring the potential role of safety nets to allow investment in household assets, and promoting access to extension services. Further research should look at contribution of horticulture to gender differentiated groups of smallholder farmers.

Keywords: Assets, commercialisation, horticulture, Kenya, poverty, smallholders

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Welfare Effects of Coffee Certification: Some Evidence from Nicaragua

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Nicaragua is the second poorest country in Latin America with the production of coffee playing a central role in the economy. In the last years, certification of smallholder cooperatives has been increasingly promoted as an instrument to enhance smallholders' incomes and to satisfy growing worldwide demand for healthier and more socially and environmentally-friendly produced coffees. By applying econometric models to survey data from 233 coffee smallholders in Jinotega Municipality, North-central Nicaragua, this paper empirically shows the impacts of Fairtrade, Organic, and double (Organic and Fairtrade) certification standards against the counterfactual of non-certification on the income of cooperatively organised smallholders. The results show modest positive impacts of both Organic and double certification on smallholders' incomes but no significant income effects of Fairtrade certification. The findings further illustrate that Organic certification has been more effective in denting income poverty among the 'extreme poor' of the cooperatively-organised smallholder coffee farmers in Nicaragua relative to the 'moderately poor', while Fairtrade certification shows no positive impact in this regard. The paper concludes that the current impacts of certification on income poverty of coffee smallholders in Nicaragua are nascent; however, it asserts that certification can contribute to poverty reduction if it is complemented by an efficient and frictionless institutional framework and by other effective development strategies. Beyond smallholders' income, the base of all certification approaches is a strong organisational capacity on the production side, especially when they aim to improve smallholders' livelihoods. However, challenges remain. The first and probably most difficult challenge is the availability and maintenance of strong organisational and infrastructural capacities. The success of certification is often interlinked with capacities of the agricultural cooperative sector in the respective country. Second, certification needs proper monitoring. The effective and regular verification of certification requirements by accredited inspectors is still challenging, not only in remote rural areas of developing countries. Third, certification needs the 'right' concepts and standards to be applied to certain local environments, especially when aiming simultaneously at socio-economic, ecological and health concerns.

Keywords: Certification, coffee, cooperatives, impact evaluation, Nicaragua, poverty reduction

An Evaluation of Dynamism in Compliance with Global GAP Standards among Horticultural Smallholder Farmers in Kenya

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Efforts to overcome the challenges of implementing Global GAP standards for export horticulture have been hampered by the dynamism in compliance among key stakeholders viz. smallholder farmers and exporting companies. Limited knowledge exists on the dynamism of compliance and factors driving the changes. Yet, such knowledge would provide lessons to stakeholders implementing similar sets of farm standards. This research sought to fill this information gap. The main objective was to examine how different compliance mechanisms emerged since the enforcement of Global GAP standards and how they have been changing over time. The study was carried out in four districts in Eastern and Central Provinces of Kenya in 2010.

Data was gathered through key informant interviews, case studies, focus group discussions, observation and Participatory Rural Appraisal (PRA) tools. It is evident that after the initial trainings and enforcement, exporters have remained the most influential in maintaining compliance with the standards. The findings also show that farmer groups have been crucial in smallholder compliance. However, the groups were found very dynamic in terms of group dynamics, choice of contractor (exporter), compliance levels between farmers within a group and across groups, linkages with other stakeholders, farmer innovativeness to either achieve or remain Global GAP compliant, and also had varying impact on member's welfare. These changes were mainly a result of the need to cut costs, spreading of risks, leniency in contract enforcement, group mismanagement, and breaching of contracts.

The findings of this study are important to stakeholders in devising implementation strategies to achieve sustainability, improve levels of compliance and access to export markets. The findings inform policy makers and other development partners on how to position new food safety standards within the ever dynamic smallholder horticulture business in developing countries.

Keywords: Contracts, global GAP, group dynamics, smallholder horticulture

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Importance of Mobile Technology in Food and Agribusiness Value Chains: Electronically Linking Farmers with Markets

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This project focuses on assessing the requirements for electronically linking rural farmers in Ethiopia, Rwanda and Bangladesh. Rural farmers are limited in their ability to successfully market products by a lack of market knowledge. The availability of inexpensive cell phones and increased use of SMS platforms is changing the nature of market communication. The opportunities for small rural farmers to improve market price and to identify new markets is now possible.

Using "Concept Mapping" process researchers were able to determine what factors were most important in helping rural farmers access markets. Concept Mapping is a process that allows information to be collected from a variety of stakeholders and to be organised using sophisticated statistical analysis that produces a visual representation that captures common trends. The process requires a "prompt statement" that will generate a single idea to complete the thought. The "prompt statement" used was "I would be much better able to market and distribute my products if...." Statements were gathered through interviews in community settings and at formal group meetings. Participants responded to this prompt and generated between eighty and ninety statements for each of the three countries. These statements were rated by participants on two five-point scales (importance and feasibility) and then analysed using the Concept Mapping program. Participants were producers, retailers, middlemen, extension agents and agribusiness representatives.

The results of this study can be examined from three perspectives. First, there is a high degree of similarity in the features that farmers consider most desirable. Secondly, there are common issues around the type of market information that farmer's desire. Lastly, there are contextual issues; many farmers wanted to use technology as a means of organising themselves into coops, and influence policy in regard to quality and price of storage, pesticides, seeds and equipment.

The goal of this project is to offer specific recommendations that will lead to the development of cell phone platform technologies that will assist local farmers in maximising profits and accessing markets. With USAID funding this project was conducted in Rwanda, Ethiopia and Bangladesh but provides insight to issues common among all developing countries.

Keywords: Communication, farmers, market, mobile phone, technology

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Value Chain Development Interventions in Francophone Africa: A Review of Donor Approaches

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Value chain development has become a prominent tool in development assistance. Due to the concept's inclusive approach, which considers all stages of a product's transformation from conception to disposal, it has been increasingly applied in interventions targeting sustainable agricultural development. In Francophone Africa, agricultural value chain development has traditionally been shaped by the French filière – an early value chain concept that places much emphasis on state control. This study strives to measure the extent to which the filière framework continues to influence value chain interventions in the region. Particularly, it addresses the question of whether value chain development projects targeted at Francophone African countries share common characteristics and draws implications for project design from its findings. For this purpose, twenty project documents published by various international aid agencies focusing on Francophone African countries were assessed against ten predetermined criteria. The study revealed remarkable similarities – the most dominant being a high degree of government control, a strong focus on firm development and an emphasis on institutional frameworks, which were independent of the targeted commodity, recipient country and even the implementing agency. To obtain indications on whether these findings were specific to Francophone Africa, similar documents focusing on Anglophone African countries, which do not have a history of filière approaches to value chain development, were subsequently included. This comparison showed large deviations, with interventions targeted at Anglophone Africa placing a very low emphasis on the criteria of government involvement, firm development and institutional frameworks. These findings indicate that the French filière approach continues to decisively shape value chain development in Francophone Africa irrespective of the project-implementing organisation.

Additionally, striking findings were made concerning environmental and gender mainstreaming considerations within value chain development interventions, which featured lowly for both examined regions. In a time when environmental sustainability and gender equality have become conceptualised by the current development discourse these findings are surprising, indicating that a large proportion of agricultural value chain development projects might not yet have caught up with these development paradigms.

Keywords: Filière, Francophone Africa, value chain development

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Multi-Layer Distribution System of the Indonesian Fruit-Vegetable Sector: Current Challenges and Future Perspectives

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As in the case of most of developing countries, Indonesia's agricultural sector is facing challenges that require a change of agricultural management strategy. The challenges, among others, include: consumers' demand of better quality and accessibility of agricultural products, and the increasing competition from imported agricultural products ever since the free-market policy was implemented. Such a market dynamic poses a threat for players in the Indonesian agricultural supply-chain, characterised by many intermediaries and multi-levels of business transactions within the supply chain or the so called multi-layer distribution system. This situation is especially critical for perishable products such as fruits and vegetables. Realizing the importance to establish a more resilient system, this article aims to (1) identify and observe the multi-layer distribution system, especially for the Indonesian fruit-vegetable sector, and (2) propose alternative solutions for a more effective and efficient fruit-vegetable supply-chain.

The current challenges can be summarised as follows. We observed that the distribution of fruit-vegetable from farmers to end-consumers is a multi-stage operation, typically involving at least five intermediaries, namely collectors, village/local wholesalers, agents at central markets, traditional markets and retailers such as fruit-vegetable vendors, small restaurants, and small markets. Information flow is lacking, each player seems to have information only from its direct upstream and downstream clients. Information about end-consumers' preferences, for example, will likely not reach the farmers, and hence, it hinders the farmers to quickly adapt to changing demand. There are some evidences showing the inefficiency of the supply-chain.

As future perspective, we propose some options to increase the supply-chain's efficiency: (1) contract farming and direct collaboration with modern-supply-chains players as options to shorten the length of supply-chain and to be more consumer-oriented; (2) possibility to reposition the existing cooperatives' network; (3) opportunity to strengthen farmers' bargaining power by creating producer organisations or community-based enterprise; and (4) understanding the consumers' needs better and integrating consumer-oriented policies in all supply channels. Nevertheless, the improvement of distribution systems should also be accompanied by favourable political situation and more research on the consumer side to enable upstream players to better fulfil consumer demand.

Keywords: Fruit-vegetable sector, Indonesia, multi-layer distribution, supply-chain

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Comparative Advantage and Competitiveness of China's Agricultural Products in the EU Market

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China established trade relations with European Union (EU) in 1975. The bilateral trade between China and EU has increased dramatically especially since 2002. In the China-EU agricultural trade relations, China has played an increasingly more important role and China's total agricultural exports to EU and imports from EU increased significantly in the recent years. EU has become one of the largest and most important markets of China's agricultural trade. China imported 6.8 % of the total agricultural products from EU in 2010, which was China's fourth largest import market. EU has become the second largest export partner of China since 2005. The market share of China's agricultural products in EU market increased gradually especially the labor-intensive products such as animal products and horticultural products. Whether this trade relationship remains viable for both partners in terms of competitiveness remains an empirical issue in the background of world food price crisis. As well the implications of these trade relationships to resource use particularly labor and land in agricultural production in China. In order to measure the comparative advantage and competitiveness of China's agricultural products in EU market, the comparative advantage indexes, that is, revealed comparative advantage (RCA), trade competitive index (TC) and revealed competitive advantage index (CA), of China's agricultural products in EU are estimated in this paper. Results show that China's agricultural products have lost their comparative advantage in EU market compared to other sectors and other partners. Although the competitiveness of China's agricultural products in EU has become less significant, the productivity of agricultural products in China is slightly higher than the world level especially for the labor-intensive compared to the land intensive products. Hence, China could export less land intensive but export more labor intensive products such as horticultural products and animal products to EU. China should import more land-intensive products such as cereals and vegetable oilseeds from EU.

Keywords: Agricultural trade, China, comparative advantage, competitiveness, EU

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Participation of Small-Scale Farmers in an Expanding Horticultural Market: Impacts of Global Production Processes on their Livelihoods

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Small-scale farmers in rural areas in sub-Saharan Africa are often the focus for development interventions. While small-scale farmers' adaptation and resilience to climate change has drawn much attention, their linkages with and impacts through global production processes remains strikingly absent. Economic liberalisation, the decreasing confidence in the role of states as agents for development and pressure from NGOs and consumers for multinational corporations to be responsible for their impacts on society, has led to a shift away from governmental regulation of international business activities towards more voluntary self-imposed guidelines. Associated with this change is the concept of corporate responsibility that has impacts on developing country stakeholders mainly through guidelines along the supply chain, for example with measures such as codes of conduct, quality standards and labelling. There is limited research on how these initiatives impact on small-scale farmer livelihoods, on their environment and their levels of access to resources.

The paper addresses the impact on smallholder lives through a case study in Laikipia, Kenya. Here local smallholders were integrated into global markets through the establishment of export-oriented large-scale horticultural companies beginning in the 1980s. Kenya has experienced a sharp increase in high-value exports, such as fruits and vegetables, and a decrease in the importance of traditional tropical export commodities such as coffee, cacao and tea. As horticultural production is labor intensive and produced for a large share by small-scale farmers it is generally viewed to provide opportunities for poverty alleviation. Associated with the growing market for horticultural produce, however, are a growing number of quality standards that aims to meet end-consumer demands and food safety concerns. The increasing control of supermarkets over the supply chain further puts pressure on the production process. The impacts on small-scale farmers are not conclusive and it is called for more empirical evidence to address if the rise of and enhanced stringency of these standards marginalise small-scale farmers from the global market. The paper evaluates how small-scale farmers are incorporated in the global supply chain and how the increasing spread and stringency of standards and labels impact on their opportunity of participation.

Keywords: Corporate responsibility, horticultural production, Kenya, small-scale farmers

From Production to Export Markets: The Case of the Cacao Value Chain in Ghana

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For many smallholders, agriculture is their main source of income. Understanding how value chains work can derive many benefits to increase productivity and therefore farmers' income. Many different stakeholders around the world are involved in the cacao value chain, which is part of a billion-dollar chocolate industry. Cacao farming in many developing countries is the main source of income for households. West Africa is the most important cacao-producing area worldwide, accounting for 70 percent of the total production. In Ghana, small-scale farmers, with plantations of no more than 4 hectares, are responsible for most of the national production. This investigation sought to determine if the interactions of these farmers with different local and international stakeholders were improving their situation. The study took place in two main cacao producer regions in Ghana, Brong Ahafo and Western. Three hundred small scale farmers in 20 different villages were interviewed. Interviews of different key stakeholders in Ghana, such as COCOBOD and in Switzerland, Felchlin AG, Chocolats Halba and Chocosuisse were conducted. This study focused on identifying the relationships, support, benefits and/or problems between stakeholders (national and international) and small scale farmers. On the other hand, the issue of contract farming and its impact on cacao farmers in Ghana was analysed. The results indicate that small scale farmers have little or no contact with stakeholders especially with chocolate manufacturers, the lack of farming contracts is high in both regions and if farmers work under contract there is little or no information about contracting terms and conditions. Awareness of sustainable production or certifications to motivate better producer price among farmers is also missing. Finally, a participatory value chain analysis is proposed in order to improve relationships between farmers and stakeholders.

Keywords: Cacao, contract farming, Ghana

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Fair Trade and Organic Agriculture in Developing Countries – A Review

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Fair trade regimes and organic agricultural systems are two innovations that increasingly play an important role for agriculture in developing countries. While fair trade arrangements have its origin in the developing countries, organic agriculture was started in the industrialised nations and has only recently become popular in the Third World. Whereas organic certification is purely production-oriented, fair trade regimes includes labor standards and guarantee a minimum price and a pro poor price premium. In combining the two innovations; developing a pro-environment and pro poor agenda are promoted simultaneously. Both can be mutually reinforcing as fair trade often combined with organic production standards open up new market prospects. More specifically what has been the ground level impact of both these movements and how these have been perceived by the smallholder farmers has always been a topic of research. Adopting these certification schemes does not come without challenges and costs for the farmers. But these systems will only be accepted if they prove to offer better livelihood strategies.

In this paper we explore the opportunities and constraints of marketing organic products from developing countries under fair trade managements. Based on available literature, we review evidence of the magnitude of organic production and fair trade systems in developing countries. We explore theoretically and empirically how these two are likely to influence the smallholder producers. We also propose a framework for studying the impact of fair traded organically produced commodities using the case of black pepper in India. The framework will generate testable hypotheses regarding the two innovations. Results will allow assessing if organic production under fair trade regimes will discriminate against the smaller and poorer farmers. It will also contribute to design policies that can better adhere to inclusive growth in the agricultural sector in India.

Keywords: Fair trade, India, organic farming, sustainability, vulnerability

A Mechanism to Discover Hidden Markets and to Improve Information Flow Towards Food Producers: A Case of Kiambu District, Kenya

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Food insecurity in many regions in Kenya is mainly attributed to changes in rainfall patterns, lack of markets to sell agricultural produce from regions with surplus and poor infrastructure to distribute to regions facing deficits. Small scale farmers are in desperate need of markets to sell their produce at a good price. They require information on credit and input markets. This paper discusses the methodologies to improve farmers' access to these markets and enhance access to relevant information that they may find useful in making decisions. The study argues that providing a platform for farmers to interact and transact business directly with buyers, sellers, researchers and other relevant stakeholders in agribusiness would provide market for the farmers. This interaction may facilitate exchange and dissemination of update information on changes in the markets and, changes in consumer needs and taste. Many studies have shown that networking among individual or groups either in social or professional networks may help in development of the members. This paper argues that providing farmers and agricultural extension agents with access to current information and communication technologies (ICT) could be instrumental in finding new markets for the farmers and in dissemination of relevant information. By facilitating the agricultural extension agents to have access to internet, mobile phone and rural radio, hidden markets can be discovered and new information and technology can reach the farmers before they become obsolete. Many businesses have grown through advertising their products online. A national website managed by extension agents can help farmers advertise their produce so that anyone willing to buy can contact the farmer directly. Agricultural based businesses can also advertise their products in the website. Consumers can use the website to buy fresh produce directly from the farmers. Although internet is not available to most households in Kenya, agricultural extension agents can post information of buyers and sellers in village boards and in the market place. This paper discusses how ICT can be implemental in finding new markets and reducing food insecurity in Kenya

Keywords: Extension, food insecurity, ICT, Kenya

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Environmental and Quality Assessment Along the Post-Harvest Value Chain for Export-Quality *Capsicum* Products in Peru

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With declining commodity prices and the existence of niche markets for differentiated products in Europe, a window of opportunity exists for varieties of crops which are unexploited. This is the case of some varieties of chili peppers (*Capsicum* spp.) in Peru. A more diversified base of *Capsicum* products may increase incomes of farmers whose livelihood depends mainly on over-exploited varieties. Currently pests and diseases are becoming more frequent, making small farmers increasingly vulnerable to harvest losses and economic instability. Income augmentation among farmers can be addressed by securing revenues per cultivated area unit, one approach being the cultivation of varieties with an enhanced value. This poverty reduction strategy is considered to be more environmentally friendly than other strategies such as the extension of production area, which is unfeasible in many contexts (especially due to availability of land, a limiting production factor in developing countries), and less counterproductive to the environment as a result of deforestation which extension often entails. Products with enhanced value are those for which a niche market has been identified, however to reach such a market, especially in Europe, standards and consumer requirements must be fulfiled and guaranteed on the side of the exporting country. This study was aimed at assessing good agricultural practices (GAP) and good post-harvest and manufacturing practices (GMP) along the value-chain of *Capsicum* products followed by an environmental impact evaluation by means of Life Cycle Assessment in order to identify bottlenecks and shortcomings found along the value chain that hinder compliance with necessary certifications for these value-added products to be sold in EU markets. The importance of compliance of quality assurance and environmental certifications is that of being able to ultimately obtain higher prices for value-added-differentiated products and thus higher income to actors along the supply chain, among them small scale farmers.

Keywords: *Capsicum* products, export certifications, life cycle assessment (LCA), Value chain assessment

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International Market-Based Instruments and the Protection of Ecosystems in Tanzania: Potentials and Pitfalls

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Tanzania is home to some of the world's most diverse and richest ecosystems. They provide the backbone of the livelihoods of millions of Tanzanians, particularly the rural poor, and underpin the country's tourism industry. However, in the last decades, unprecedented population growth coupled with rural poverty and agricultural expansion led to a massive degradation and loss of these ecosystems.

Against this backdrop, various ecosystem protection instruments have been implemented by the Tanzanian state, international donors and NGOs. A total of 792 protected areas were created - accounting for 39 percent of the country's terrestrial area. The effectiveness of these protected areas, though, often proved limited. In the last years, international market-based instruments such as the CDM, REDD, or ecosystem certification according to standards of the CCBA or Plan Vivo, are increasingly promoted as new pathways towards environmental sustainability.

This paper analyses the potentials and pitfalls of international market-based instruments for the protection of ecosystems in Tanzania. It is based on structured interviews conducted in 2011 with decision-makers working in environmentally-concerned national state agencies, NGOs, research institutes and private companies in Arusha, Dar-es-Salaam, Morogoro, Moshi and Zanzibar.

The paper shows the skepticism of the decision-makers in Tanzania towards international 'innovative' market-based instruments for the protection of ecosystems and the discrepancy between the level of international debate and practical implementation so far. Major pitfalls are found in the increased complexities and high costs related to the implementation of these instruments. This entails the risk to perpetuate Tanzania's dependency on international donors' support and expertise.

Keywords: CDM, certification, market-based instruments, REDD, Tanzania

Impact of Certification for Tribal Coffee Growers Wellbeing: A Case Study from Araku Valley, India

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Coffee is one of the major sources of income for the tribal communities in Araku valley in a southern state of India namely Andhra Pradesh. It was introduced in order to promote the sustainable livelihood of these communities by (i) providing a continuous and assured source of income to the inhabitants of the community and (ii) by preserving the ecosystem. The farmers were organised in a cooperative called Small and Marginal Tribal Farmers Mutually Aided Cooperative Society (SAMTFMACS) in 2007. The cooperative is double certified by both organic and fairtrade certification standards and is the only cooperative in India to have received fair-trade certification. Current research assesses the decisive factors to adopt organic and fairtrade certification and its impact on tribal coffee growers' well-being in relation to poverty reduction. The empirical analysis in this paper is based on the cross-sectional data of 211 households, collected in 2011. The non-parametric propensity score matching technique is applied to address the problem of self-selection bias that is often present in a non-experimental sampling. The paper follows a 'with and without' treatment approach in which the certified farmers and the conventional farmers have been used as the treatment and the control groups, respectively. Findings suggest that the education level, agriculture as primary occupation, year and amount of coffee production, training received are the major influential factors for the adoption of certification. Further, adoption of the certification is found to have positively affected well-being of the farmers, given the increment of their total income level and per capita income.

Keywords: Certification, coffee, cooperative, poverty reduction, propensity score matching

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Farm and Farmer Characteristics that Influence Tomato Farmers' Awareness and Willingness to Adopt Mobile Phone Based Market Information Services in Ghana

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The provision of mobile phone based market information services (MIS) is an innovation that can improve marketing options, market efficiency and incomes of tomato farmers, who hitherto are easily censored out of market information as a result of the "two-level" tomato marketing system in Ghana. Following the theory of technology adoption, the success of this innovation depends on the awareness, willingness to adopt and adoption by farmers' which in turn are influence by farmer and farm level characteristics. The aim of this study was to determine these farmer and farm characteristics that influence the awareness and willingness to adopt the mobile phone based MIS. Purposive sampling techniques were used to sample 107 tomato farmers from 10 communities in the Dangme East and West districts of the Greater Accra region of Ghana. The binary probit model was used to analyse the data collected. The results showed that there is a low awareness level among farmers in that only farmers who had larger farm size (above 2 hectares), were educated and had SMS ability were significantly aware of the service. Location (urban or rural), farm size, quantity of tomatoes harvested, ability to read and write English and belonging to a farmer association had significant effects on willingness to adopt. The implication of this finding is that organisations that promote the use of mobile phone based MIS should not neglect the need to promote awareness of the existence of such services among farmers. More training should be offered in order to encourage farmers' interest and willingness to adopt the market information services.

Keywords: Ghana, market information services, mobile phone, probit model, horticulture

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The Role of Collective Action in Improving Market Performance of Smallholder Banana and Legume-Based Systems in Central Africa

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Since the 1990s, collective actions through farmers' cooperatives have increasingly come into the focus of international aid organisations as a strategy to enhance smallholders' livelihoods and improve food security in low-income countries. They recently have been recognised also as a positive force for rural development in Central Africa. Still, research-based information about the success factors is still largely missing. In an effort to fill this gap and to provide a basis for further improvements, the research presented in this contribution aims at examining the extent to which certain attributes and asset endowments of smallholder farmer groups and cooperatives facilitate collective action initiatives to adopt strategies to improve their marketing performance. It is based on empirical data collected in 2012 through farmer surveys and focus group discussions in banana and legume based systems in Rwanda and DR Congo.

The market orientation strategies considered are market-led approaches which include collective marketing, implementation of business plans, product transformation and participatory market research. These are aimed at improving income, food security and market potential of smallholder producer groups while also motivating adoption of agricultural productivity enhancing technologies. The marketing strategies have been designed and disseminated by the Consortium for the Improvement of Agriculture-Based Livelihood in Central Africa (CIALCA), in collaboration with the National Agricultural Research Institutions (NARS) and other development partners in project areas. CIALCA aims at improving livelihoods of smallholder farmers in banana-based systems of Central Africa through enhancement of agricultural productivity, household income and nutrition. Preliminary results indicate that more mature cooperatives with efficient internal institutions, functioning activities, and a strong resource base of natural, human and physical capital are more likely to improve their market performance. Gender composition affects market performance, which tends to be higher in male-dominated cooperatives. Linkages or collaborations with external service providers ranging from private sector, government and non-governmental organisations have the potential to improve market performance of farmer cooperatives.

Keywords: Farmer cooperatives, market orientation strategies, social capital

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Innovation adoption and agricultural productivity

Cultivar Selection for Farm Profitability and Risk Management: Case of Rainfed Maize in India

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Drought is one of the major abiotic constraints for maize production in India, where about 80% of maize is still grown under rainfed conditions. Lack of irrigation restricts the use of production inputs on farm, further limiting the crop productivity. The present study examines the rainfed maize production systems of India, to identify the impacts of cultivar selection as an adaptive strategy to combat drought stresses. The farm-level maize production details were collected during 2010 and 2011 from three districts of Rajasthan, Bihar and Karnataka states of India, making a total sample of 340 maize cultivating households. The data showed diverse cultivation systems of maize across the selected districts, mainly with respect to the season of cultivation, cropping pattern followed, and input-use. Most of the sampled farmers recognized open pollinated varieties (OPVs, including improved composite and local landraces) as more congenial for growing under such risk-prone, rainfed conditions, compared to the commercial hybrids.

Varietal adoption is an important coping strategy for managing drought risk, and the hybrid and OPVs production systems co-existed only in *Kharif* (rainy season). Therefore, we limited our examination to the sub-group of 308 sample farmers who cultivate maize in this season, largely without irrigation. Production system characterization was undertaken to delineate the impacts of farmer practices, including varietal adoption, and on production risks. The production and profitability risks were estimated employing mean-variance (Just-Pope type) functions, which showed that hybrids perform *at par* or better than the OPVs in reducing abiotic risk, even in the most drought-prone rainfed system of Rajasthan. The paper also identifies the relevance of consumption utility differences across the cultivars in determining their rate of on farm adoption. A low consumption preference was cited as one of the major reasons for the non-adoption of hybrid maize in the traditional production systems. The study shows that the research and development activities on hybrid development should focus on developing not only the drought tolerant maize hybrids, but also on consumption quality traits, which could be helpful in enhancing food and nutritional security of maize producing households living in the rainfed environment.

Keywords: Drought, hybrid seed adoption, mean-variance production function

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Impacts of Natural Resource Management Technologies on Agricultural Yield, Income, and Poverty: The System of Rice Intensification in Timor Leste

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Natural resource management (NRM) technologies, such as the system of rice intensification (SRI), have been proposed to tackle agricultural challenges such as decreasing productivity growth and environmental degradation. Yet, the benefits of NRM technologies for farmers are often debated. Impacts seem to be context-specific, which is especially relevant in the small farm sector with its large degree of agroecological and socioeconomic heterogeneity. This was not always considered in previous research. We analyse the impacts of SRI adoption on rice yield and household income among smallholder farmers in Timor Leste. Heterogeneity is accounted for in an endogenous switching regression framework. Comparing mean yield and income levels, we find no significant differences between SRI adopters and non-adopters. This is due to negative selection bias; SRI seems to be adopted more on plots and by farmers with less than average yields. Controlling for this bias reveals significant yield and income gains. Poor and non-poor households benefit from SRI adoption; small and specialised farms benefit more than larger farms. The results also suggest that SRI may not be beneficial when compared to conventional rice grown under favourable conditions and with best management practices. This reveals that the impacts are very context-specific, depending on micro-level agroecological and socioeconomic conditions. Such heterogeneity in impacts can also be expected for other NRM technologies, which often depend on the farmers' capacity to adapt general principles to local conditions. We find that successful adoption is crucially based on good information flows and effective extension services. Innovative technology transfer models, such as farmer-to-farmer extension as well as participatory learning and knowledge sharing, may support more widespread and successful adoption of NRM technologies.

Keywords: Endogenous switching regression, impact assessment, system of rice intensification, Timor Leste

Farm Size and Productivity: Empirical Evidence from Rural Vietnam

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The inverse relationship between farm size and productivity is a major hypothesis of agricultural development which is particularly relevant for the land reform debates in developing countries. In the course of Vietnam's economic reforms, agricultural production has attained high growth rates. However, land market is still in its infancy and the allocation of agricultural land to the most productive farms does not take place to the necessary extent. The land-man ratio is a constraint for the development of efficient farm sizes. In this paper, we submit an empirical test for the inverse relationship between farm size and land productivity in three provinces in Vietnam. Additionally, we investigate to what extent farm size affects labor productivity in agriculture.

The study hypothesises that as farm size increases land productivity decreases but labor productivity increases. This hypothesis is tested by using data on some 2200 rural households in three provinces of Vietnam, namely Ha Tinh, Thua Thien Hue, and Dak Lak in 2008 collected under the DFG project "Impact of Shocks in the Vulnerability to Poverty: Consequences for Development of Emerging Southeast Asian Economies". There are two models used in this analysis: a fixed-effects model with village dummies and a random effects model.

Results confirm the negative relationship between land productivity and farm size. This finding still holds when village-related factors such as soil quality, irrigation facilities, and prices are ruled out in the fixed-effects model. Another finding is the existence of decreasing returns to scale. This fact is explained by the low level of mechanisation in agricultural production in these provinces. Moreover, the study finds an inefficient allocation of land, labor and other inputs which is ascribed to the abundance of family labor in small farms and the imperfections of the land, labor, and credit markets. Higher crop yields of small farms are merely obtained by means of using production inputs excessively. Finally, the results show that larger landholdings increase labor productivity. The outcomes of the study call for further reforms in land market and the provision of more off-farm labor opportunities to facilitate the development of larger farms.

Keywords: Farm size, labor productivity, land market, land productivity, land reform, returns to scale, Vietnam

Resilience of Pacific Agricultural Systems against Crisis

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Though populations in Pacific Island Countries (PICs) are growing at a rate of up to 3 % per annum, agricultural productivity is relatively low or stagnant. Farming communities rely on traditional production practices with low levels of intensification, posing considerable risks in terms of food security and income generation in the long term. Increasing deforestation, vulnerability to natural hazards and changing weather patterns due to Climate Change (CC) pose additional risks. Improvement in agricultural productivity, distribution and marketing of locally produced food at affordable prices is needed.

This can only be achieved through sustainable intensification and by building resilience of the agricultural systems in the Pacific Island Countries with a focus on improving smallholder production systems and local marketing infrastructure. The development and adoption of technologies such as tolerant crops, integrated soil fertility management systems, increased crop and livestock diversity to include the use of indigenous genetic resources and improved seed systems and management of natural resources can contribute to achieving sustainability. PICs also need to invest more in science and technology to track climatic changes and loss of biodiversity, forests and fisheries as well as to undertake the research and development needed to achieve transformative changes.

Hence, PICs need to develop strategic long term programmes which are collaborative, cross-sectoral and multipronged in targeting bottlenecks in the overall innovative agricultural systems (including crops, livestock, forestry and fisheries). Research, development and innovation in PICs for resilient agricultural systems include:

a) Improving the human capacity in key areas of natural hazards and CC mitigation and adaptation;

b) Improving the preparedness of smallholder farming communities to the effects of CC;

c) Improving the integration of national information systems which are linked into regional and international systems;

d) Improving the enabling policy and institutional environment at national and regional level.

Keywords: Agricultural productivity, climate change, development, innovation, Pacific Island Countries, vulnerability

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What Happened to Bt Cotton?
Evidence from Shandong Province, China

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Bt cotton has been widely declared a success story of a cotton pest management technology that has solved major pest problems in cotton in China. Benefits resulting from Bt cotton adoption are stated to be a significant reduction of pesticide use as well as labor input and hence cost savings for farmers and decrease of environmental pollution and human health effects.

However, recent evidence from a long-term, in-depth case study of some 150 farmers in five villages in Shandong province provides some evidence that the past benefit assessments could have been overestimated. Using panel data of village and farm characteristics as well as on cotton production collected through household survey and season-long monitoring in 2002, 2005 and 2012 allow a long term assessment of the technology. Using descriptive statistics and econometric analysis of the panel data set allows a more realistic assessment of the benefits, costs and constraints of this technology under farmer conditions in China. For example, results show that the profitability of the technology has been hampered by the need for more chemical control of secondary pests and farmers are uncertain about the quality of Bt cotton seeds due to a severe lack of quality control mechanisms in place. Costs have gone up due to an increase in cotton seed prices while at the same time cotton lint faced a downward trend. Finally, agricultural policy in China is changing and the government is not subsidising rice and corn production which lowers the competitiveness of cotton production among farmers. While in 2005 all 150 farmers in the panel planted cotton, in 2012 this number has dropped to just over 50 farmers. From a methodological point of view, this study allows to quantify benefits in a cropping systems context, which are lower than estimates of previous studies.

Keywords: Biotechnology, Bt cotton, China, economic analysis, impact assessment

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Understanding the Dynamics of Agricultural Technology Adoption: Integrated Soil Fertility Management in South Kivu, DR Congo

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The adoption of new agricultural technologies by smallholder farmers is still a pertinent question for academics and policy-makers. Relatively little is known about technology adoption in the poorest countries and about the adoption of composite technology packages. In this paper we analyse the adoption of Integrated Soil Fertility Management (ISFM) practices by smallholder farmers in South Kivu, DR Congo, after the introduction of these techniques by the Consortium for Improving Agricultural-based Livelihoods in Central Africa (CIALCA). ISFM is a complex technology including the simultaneous use of improved germplasm, judicious chemical fertiliser application and organic matter management.

We use original data from a farm-household survey among 450 households, conducted in the period February - June 2011 in two different territories in South-Kivu. We specifically model consecutive steps in farmers' adoption decisions as factors might differently affect the tryout of a new technology and the sustained adoption of it. We model technology adoption as a three step process including awareness, tryout and sustained adoption. By specifying awareness as the first step in the adoption process, we explicitly account for selection bias caused by non-exposure. In addition, we explicitly model the adoption of different components of ISFM. We use a combination of probit and Heckman selection models.

We find that awareness rates are higher for improved germplasm (84 %) and organic matter management (73 %) compared to chemical fertiliser (57 %). Tryout rates range between 57 % and 8 % for different components but adoption rates are quite low (36 % to 4 %). Membership of farmers' associations and CIALCA presence in the village increase the likelihood of farmers to be aware, test and adopt ISFM technologies. Farm size has no major impact, but farmers renting a larger share of their plots have a higher likelihood of testing and adopting chemical fertiliser and improved germplasm. Land fertility is found to decrease the application of organic matter management and increase the adoption of chemical fertiliser. Access to off-farm income, livestock and non-land asset ownership significantly increase the likelihood of adoption of all components (with the largest effect for chemical fertiliser), which points to the importance of cash constraints.

Keywords: Adoption, agricultural technology, fertiliser, improved germplasm, integrated soil fertility management, organic matter management

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A Qualitative Approach to Understand the Potential of Weather Indexed Crop Insurance to Help Ethiopian Farmers Cope with Risks

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The ineffectiveness and problems of traditional mechanisms for households to adapt to and cope with climate variability creates a need for alternatives, especially with the expected increase in the frequency and severity of extreme climatic events. This study explores the potential of weather indexed crop insurance (WICI) to help farmers cope with weather-related risks in two villages in central Ethiopia where WICI for drought was available. To understand weather-related risks, existing coping mechanisms, and opinions of and experiences with WICI, a qualitative approach was employed. Focus group discussions with smallholders in three villages as well as semi-structured interviews with key stakeholders were conducted. The main analysis is based on focus group discussions held separately with policyholders and non-policyholders in two villages where WICI was available. Two additional focus group discussions which took place in a village where multi-peril insurance was available offer interesting comparisons. Transcripts from the focus group discussions were analysed with a computer software program, Atlas.ti. The analysis highlights the failure of WICI to enable smallholders to cope with major weather-related risks as policies insured against drought only, whereas farmers reported suffering from other natural disasters as well. Moreover, the demonstrated and self-reported lack of understanding about WICI among policyholders not only reduces the sustainability and adoption of WICI, but also decreases the potential of WICI to enable households to take more production risks such as increased fertiliser use. Based on the findings, we recommend increasing smallholder involvement in the design of WICI policies and offering more effective training about WICI to potential policyholders. This study demonstrates that a "one size fits all" approach to WICI may not be appropriate in villages where farmers live with diverse weather-related risks. Therefore, insurance companies should consider providing a variety of WICI products within villages. This would allow smallholders to insure against natural disasters they consider most significant based on their production system.

Keywords: Coping mechanisms, Ethiopia, natural disasters, risk, weather indexed crop insurance

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The Informal Market of Edible Crickets and Spiders in Cambodia. Potentials of a Traditional Food Source

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The contribution outlines the current market of edible crickets and one species of edible tarantula in Cambodia and how this supports the livelihoods of Cambodians.

Eating insects as part of the diet (entomophagy) is common among rural and urban people in South East Asia. In Cambodia, most people regularly consume a variety of insects and spiders as part of their diet, and an informal market for such a food source has developed throughout the country. This market contributes an additional source of income to rural/urban livelihoods, due to an increasing demand in recent years.

In this study a market assessment was conducted in 6 provinces, including the capital Phnom Penh, as well as a review of the current institutional framework regarding policies and responsible stakeholders. Both qualitative and quantitative research methods were applied, including questionnaire surveys, focus group discussions and key stakeholder interviews. The data was collected in the period January-May 2012. The study is part of the WINFOOD project, a collaboration between University of Copenhagen and the Department of Post-Harvest Technologies and Qualitative Control, Fisheries Administration, Cambodia.

The findings show that crickets have the potential for a larger domestic market, as well as export to the neighbouring countries of Cambodia, through domestication and scaled up collection practices. On the other hand, edible tarantulas are facing the challenge of overexploitation due to increased market demand, which puts pressure on the natural population of the tarantulas and consequently, the livelihoods of collectors.

Among the national government and international agencies the awareness of the potentials and constraints of the edible insect sector is limited. This is a field which is gaining more international recognition as an alternative source of food and livestock feed and therefore it is recommended that the Cambodian government and other stakeholders begin investigating the potentials and limitations of the edible insect market. Edible insects in Cambodia can contribute to resilience of agricultural systems to supply food and feed, but it has yet to find its place within academic disciplines and natural resource governance structures in order to be sustainably utilised.

Keywords: Alternative food sources, Cambodia, entomophagy, livelihood strategies, value chain analysis

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Constraints to Integrating Non-Food Biofuel Feedstock in Smallholder Farms in Kenya

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Agricultural farming is a predominant enterprise in developing countries and mainly Africa. This is attributed to land availability, abundant labor from its vast population, favourable climatic conditions and food demand among other factors. Most of the rural households depend on subsistence farming to meet their food requirements with minimal commercialisation which mainly target the export market. There is thus need for caution on introduction of another enterprise in the smallholder farms so as not to distort the vulnerable food production enterprise. There is however evidence that most farms are not optimally being utilised. Hence increasing on the portfolio of the farm enterprises on the household level need not necessarily hinder or reduce their food production capabilities. One such additional enterprise could be non-food biofuel feedstock farming which has a dual potential of generating income and as a source of energy in the households. In Kenya, potential biofuel production areas have been zoned taking cognizance of the food production requirements, climatic conditions and biodiversity requirements in the midst of the energy demand and supply situations prevailing in the country. There is however ample evidence that the taking up of biofuel feedstock farming by the smallholder farmers is slow even though the government and a number of non-governmental organisations are deeply involved in its promotion. The study thus seeks to identify the factors within the smallholder farms that hinder the adoption of the Jatropha and Croton biofuel feedstock. A survey was conducted in three agro-ecological zones being Laikipia, Nyeri and Lamu, of which a representative random sample of 273 farms was selected for the study with 136 having biofuel crops in their farms and 137 being the control group. The study used a logistic regression econometric model sorted by crop type to take care of the uniqueness of each crop in terms of their agro-ecological requirements. The factors that influence the integration of Croton in the smallholder farms are household size and proximity to the urban centre. Gender of the household head, land size and access to off-farm farm income were the main determinants of farmers' decision to adopt Jathropa.

Keywords: Biodiesel, biofuel, feedstock, integration, *Croton megalocarpus*, *Jatropha curcas*

Is There a Future for Agriculture in Rural Villages in Northeast Thailand?

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The importance of agriculture in rural villages in emerging market economies like Thailand is declining. As a result of rural-urban migration rural livelihoods are diversifying and the rural population tends to rely on remittances from migrant household members as a main source of household income. At the same time they use their agricultural resource base only as a safety net. As a result, agriculture is neglected by many village households, although there is potential for agricultural entrepreneurship in the course of rising prices for agricultural commodities as for example rubber.

Drawing upon a unique set of household panel data from three provinces in Northeast Thailand, collected from some 2,000 households between 2007 and 2010, this paper investigates investment in agriculture by rural households. A double hurdle model is used to account for zero inflated data as well as for possible differences in the determinants for the decision to invest and the amount of investment.

Results show that only one third of the households have made investments in agriculture and most of these are on a small scale of not more than 400$. Non-investors in agriculture tend to be potentially marginalised households with female or older household heads. Factors that positively affect the probability of investment in agriculture are farm size, household wealth and income. Diversification in wage and self-employment as well as shock experiences discourage investments. The investment volume is influenced by farm size, household wealth, education of the HH head, savings, additional off-farm income and the number of household members working in agriculture.

Our findings suggest that most rural households in Northeast Thailand neglect agriculture. Farm investments are only made by a few wealthy households with the consequence that the already existing inequality in wealth is likely to increase further, which could lead to social problems and the impairment of village development in the long run.

Keywords: Double hurdle model, farm investments, rural development, rural households, Thailand

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Determinants of Irrigated Cotton Farming among Smallholders in Bura Irrigation Scheme, Kenya

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Under the Kenyan Government's policy in Vision 2030 for addressing poverty, cotton production has been identified as a key sub-sector for economic development for the drier areas of the country. The Bura Irrigation project was set up by the government in 1977; the project functioned fairly well, producing cotton and maize from 1982 to 1990 with an area of 2,500 hectares being irrigated. For the next fifteen years, there was little or no crop harvest due to lack of adequate irrigation water. In 2009, the project was revived through an Economic Stimulus Programme and irrigated cotton was reintroduced in 2010 by the Cotton Development Authority in partnership with the National Irrigation Board, Equity Bank and Ginners among other stakeholders. In 2011 a survey was carried out to determine the levels of adoption of irrigated cotton production in the scheme. Questionnaires were administered to 100 randomly selected farmers. All households used inorganic fertilisers as part of their soil fertility management strategies. Based on a logit analysis, access to credit, market for seed cotton, availability of labor, years of farming, off-farm income, contact with extension officers, pest management and timely provision of irrigation water significantly and positively affected adoption for irrigated cotton farming. The results from this survey suggest that the strategy for improving the adoption of irrigated cotton farming will differ depending on infrastructure and the socio-economic niches of farmers in a given area. This study proposes enhancing these strategies with Bt-cotton farming, commercial cotton seed production and integrated crop management.

Keywords: Bt cotton, economic stimulus programme, integrated crop management, irrigated cotton

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Climate Variability and Agriculture in Western Kenya: Farmers' Perceptions and Coping Strategies

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Agriculture practices in the tropics are vulnerable to climate change. Higher temperatures reduce crop yields while encouraging weed and pest proliferation. Changes in precipitation patterns increase crop failures in the short-run and production declines in the long-run. In 2005, nearly half of the economically active population in Africa (2.5 billion people) relied on agriculture for livelihood. In Kenya, the challenge facing the arid and semi arid lands (ASALs) ecosystems is how to enhance community resilience whose livelihoods depend on climate-sensitive resources. In response to this, a baseline study was undertaken in Western Kenya along a gradient across agro-ecological zones from the Upper Midland Zone (UM1), Lower Midland Sugarcane Zone (LM1), Marginal Sugarcane Zone (LM2), Lower Midland Cotton Zone (LM3) up to the Marginal Cotton Zone (LM4). The study sites were in Kakamega, Vihiga, Siaya, Bondo and Rarieda districts, respectively. Using a structured questionnaire, a total of 160 households were interviewed. In addition 2 focus group discussions were done in each district.

The results showed that 90 % of farmers had observed a shift in the onset of seasons in the last 10 years. The farmers in UM1 and LM1 reported the merging of the long and short rainy season. There was an emergence of the short rainy season in the LM3 which was previously not the case since they only had one long rainy season per year. Other changes attributed to climate variability included increased incidences of existing and / the emergence of new weeds, pests and diseases for crops, increased prevalence of livestock and human diseases.

To face the climate variability, farmers employed several coping strategies such as: changing of crops and / varieties grown (*e.g.*, abandon local late maturing crop varieties and adopting new and improved early-maturing varieties), rearing local animal breeds that are tolerant to diseases, and seeking veterinary and human medical attention rather than depending on traditional remedies.

Keywords: Africa, agro-ecological zone, arid, climate change, resilience, semi-arid

Crop Production and Livelihood Strategies in Solio Village 3, Nyeri District, Kenya

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This Sustainable Land Use and Natural Resource Management (SLUSE) research project investigates the reconstruction of agricultural livelihoods in a young resettlement community known as Village 3 in a semi-arid area in the central highlands of Kenya. A majority of the villagers are formerly displaced people who were granted land as part of a resettlement scheme initiated by the Kenyan Government in 2007, after some twenty years of living as squatters. In order to better understand the constraints and needs of the resettled community as they begin to construct their new agriculture based livelihoods, the paper explores the importance of crop production compared to other livelihood activities, and the factors influencing farmers' decision-making. A combination of qualitative and quantitative methods drawing from both social and natural science disciplines were employed to establish the livelihood activities the villagers are engaged in and how they regard the contribution of these activities to their livelihood strategies. Furthermore the study explored the existing crop cultivation practices and the role of culture, knowledge, property rights, climate, soil fertility, water availability, and access to markets, credit and inputs on the famers' choice of crop production system. The results from the questionnaire survey, several interviews and a number of PRAs show that agriculture is the most important activity in Solio Village 3, although livestock, casual labor and small businesses are also prominent. Farmers are faced with constraints to their crop production, most notably the difficult climatic conditions, lack of financial capital, and lack of knowledge about the most suitable crops to grow. These factors influence their choice of crop production system, and they now focus on drought resistant crops such as beans, although they still try to cultivate traditional crops like maize. Most farmers are engaged in at least one other livelihood activity than agricultural production, a diversification strategy aimed at increasing their livelihood security.

Keywords: Crop production, livelihood strategies, resettlement

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Land Use in Agriculture: Econometric Modelling of the Land Allocation within the Northern Benin Farms

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Agriculture is an important activity for many people in tropical West Africa. Among the factors involved in agricultural production, land is considered as one of the main factors that influences widely the outputs. Furthermore, land-cover and land-use changes might affect livelihoods as well as food security in rural areas. Therefore one of the most important issues to be decided on by farmers is how to allocate the available land among a given numbers of crops. This article aims at understanding the driving forces that determine the decision making on land allocation on West African farms, giving evidence of farms in the Northern Benin. Using an individual inquiry questionnaire, primary data were collected from a sample of 210 farmers randomly selected in two villages. Agricultural lands are mainly allocated to cereal, legumes and cash crops. The seemingly unrelated regression of land sizes allocated to these three categories of crops revealed that socio-economic and demographic characteristics, institutional arrangements on land and access to production factors (labor and capital for instance) explained 33 % to 58 % of the variations observed in land allocation. The findings highlight at different levels of significance - 1 %, 5 %, and 10 % - that the main determinants of land use are the location (village), the household head characteristics (sex, side activity, group membership, experience in agriculture), the household size, the number of household members working in agriculture, the salaried workers use, the household's capital, and the access to credit. Consequently agricultural policy has to focus on enhancing household's capital. This could be done by facilitating the access to credit. In this line, requirements and conditions for accessing credit should be reviewed. Moreover, support and advice from extension service need to be enhanced in order to improve farmers' skills and promotion of farmers associations.

Keywords: Agriculture, allocation, determinants, land use design, northern Benin

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Driving Factors of Land Use Changes in Chieng Khoi Catchment, Yen Chau District, Son La Province, Northwest Vietnam

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In Northwest Vietnam, land use has been intensified over the last years. Additionally, shortening rainy events and increasing of intensive rains happens more frequently. This has negative impacts on crop productivity due to large amounts of nutrients lost by soil erosion, limitation of fertiliser use and market fluctuation. This study was carried out in order to identify the main factors influencing land use change in Chieng Khoi Catchment, Yen Chau district, Son La province, Northwest Vietnam. The research methods were field ground truth survey with key informants for land use history, household interviews and group discussions for identifying factors of land use changes in this area. 42 ground truthing points with key informants were collected, and 40 households were randomly selected for interview in April 2012. The results reveal that since the year 2000, land use intensified towards commercial production. Population pressure and policy implications are the main factors for land use changes. Local farmers are viewing high risks from soil erosion and land degradation, unfavourable climate, and unstable food security. Farmers introduced landcover changes mainly for commercial purposes. However, the benefits from a governmental project with forest plantation are still limited, which disappoints the farmers. Local farmers recognised the high risk related to the cultivation of cassava and maize, but they see no better opportunity to secure their livelihood. Local perception also changed the way of living. Thus, land use change is heading towards a rather unstable direction, while government policy and supports are lacking, which could control this. Urgent measures are needed to control the negative impacts of the driving factors and to enable a sustainable development in Chieng Khoi Catchment.

Keywords: Chieng Khoi Catchment, driving factors, land use change, Northwest Vietnam

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Community Adaptation Strategies for Increasing Resilience of Homegardens – Case Study from Southern Burkina Faso

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Agriculture remains the backbone for the economies of many countries and plays a critical role in feeding the world's most vulnerable people. Rapid population growth, loss of soil fertility, among others, have already impacted negatively on food production. Additionally, climate change has compounded the problem. In order to develop a resilient production system, farmers need to reorganise and find adaptation strategies. An exploratory research was conducted to study homegardens and farmer adaptation strategies in Burkina Faso. The Bieha district was purposively selected for the study. The initial Rapid Rural Appraisal was complemented by a household survey. Tools of data collection included; personal observation, key informant interview, and focus group discussion. For the survey, eighty households were selected based on systematic sampling. Data was collected by individual interviews at household level, and for statistical calculations, the households were subsequently categorised as small, medium and commercial based on the size of their homegarden. All respondents mentioned droughts, unpredictable rainfall patterns, floods, fluctuating market prices and bushfires as their most common crises. 100 % of respondents have been affected by droughts/unpredictable rainfalls, 65 % by floods and 20 % by bush fires. Respondents agreed that building strong social systems and institutions, diversification of income and livelihood sources as well as the adoption of better natural resources management practices would ensure more resilient production. There was a significant positive correlation between number of income sources and household total income. Similarly, a significant positive correlation was found between number of crop species grown and income generated. The households who belonged to cooperatives had higher incomes from sales of their homegarden products than others who sold individually. In conclusion, it is clear from the study that farming systems need to be adapted so as to ensure that they remain resilient in the face of crises. The outcome of this research has shown that local people are themselves aware of the threats that they face but would need support by way of capacity building so that their adaptation strategies can be well and appropriately developed.

Keywords: Adaptation, crises, diversification, homegarden, livelihood, resilience

Productivity and Technical Efficiency of Small-Scale Sorghum Production in Different Agro-Ecological Zones of Gadrif State, Sudan

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Gadarif State, the granary of Sudan, produces the bulk of the Sudanese main food grain: sorghum. Unfortunately, sorghum productivity, which is highly related to the conditions of the rainy season, revealed a fluctuating phenomenon with a declining trend over time. A stochastic frontier production function using Maximum Likelihood Estimation technique was used to obtain farm specific technical efficiencies, their determinants and causes of inefficiency for the small-scale rain-fed sorghum producers in three agro-ecological zones of Gadarif State, Sudan: low (400–500 mm), moderate (500–600 mm) and high annual rainfall (>600 mm). Both primary and secondary data were used, although primary data was the main source. A multistage stratified random sampling technique was used to collect data from 200 respondents by means of a questionnaire during 2009/2010. Results revealed that farmers' efficiency increased with the increasing level of rainfall and almost reached the frontier under high rainfall conditions, although, in all agro-ecological zones sorghum yields were relatively very poor (680 kg ha^{-1}), particularly if known that this study was conducted during good rainy season as perceived by farmers. Technical efficiencies were substantially and significantly affected by availability of machinery at right time, seed rate, availability of labor and finance. Factors causing inefficiency were highly related to education, Striga-weed infestation (the major threat of sorghum production in the state), and technological improvements in terms of sorghum variety (Striga and drought resistance and/or tolerance), machinery types, recommended agricultural packages (by Agricultural Research Corporation, Sudan). We argue that the introduction of water harvesting techniques in the low and moderate rainfall zone, farmers' field schools to change farmers beliefs, attitude and direction to accept the recommended packages, and technological improvements are essential to improve both sorghum efficiency and productivity.

Keywords: Rain-fed agriculture, Sorghum productivity, Striga infestation, technical inefficiency

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Sustainable Development of Bangladesh Agriculture: Examples for Strategies to Adapt to a Changing Environment

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Geo-morphological conditions shaped by interfaces of two contrasting environments - the Himalayas to the north and the Bay of Bengal to the south - make Bangladesh one of the most vulnerable countries to climate change. Flash floods, cyclones, storm surges in the south and water scarcity with droughts in the northern regions are frequent. The rise of average air temperature already affects growth of winter vegetables and wheat. Reduced and erratic precipitation limits rain-fed cropping and reduces groundwater recharge, consequently counteracting further development of tubewell irrigation for rice production. Frequent unpredicted floods submerge crops. Besides storm surges, sea level rise causes salt water intrusion further reducing arable land, fresh water availability and biodiversity in the southern regions. Environmental changes have aggravated already stressful low productive farming of crops, animal husbandry and fish culture. These manifold stressors to agriculture and rural development, which add on to population growth and urbanisation, are very pronounced in Bangladesh. Indeed, Bangladesh can act as a model country to develop climate adaptation strategies, which can be applied elsewhere.

To create potential research demands, three examples of adaptation practices in smallholder farming systems are proposed. The first example elucidates the contribution of private sector led irrigation water market to dry season Boro rice production, which improved national food security. Here, future challenges lie in improving water and nutrient use efficiency, counteracting soil salinity and finding alternative engine fuel. The second example illustrates soil fertility management, which increases soil health through improved soil organic matter management and balanced fertilisation to enhance resilience of cropping systems (*e.g.* against soil salinity). Thirdly, homestead gardening is at the core of adaptation strategies as it provides household nutrition from diverse field crops, fruits and vegetables as well as timber and non-timber forest products. The homestead production systems do also supplement family income and significantly buffer food price fluctuations. This diversity however is threatened by climate change variables. Future research therefore will focus on investigating the effect of transformation processes on biodiversity and sustainability of smallholder agriculture.

Keywords: Biodiversity, climate adaptation strategies, homegardens, irrigation, nutrient use efficiency, smallholder farming, soil salinity

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Efficiency Analysis of Coffee Cultivation: The Case of Smallholder Farming in the Coffee Sector of Nicaragua

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Coffee, one of the main contributors to agricultural GDP in Nicaragua, is the dominating cash crop within smallholder farming systems of the central and northern highland departments. In recent years certain activities have been undertaken by development agencies and policy makers to strengthen smallholders' production capacities in order to improve their livelihoods. However, still today the majority of Nicaraguan smallholder coffee producers is suffering from poverty, making them highly vulnerable to extreme shocks. Shortages in financial as well as managerial capacities put their efforts in production at risk, enforcing inefficiency in the use of scarce resources.

To cope with risks linked to climate change and to volatile agricultural commodity markets, smallholder farmers are forced to manage scarce resources in their portfolio the most efficient way. This research especially focuses on efficiency and inefficiency of smallholder farming in the coffee sector of Nicaragua. To this end we analysed a sample of 135 coffee cultivating households distributed in 4 different coffee producing departments. The data is a sub-set of a bigger survey developed within the Coffee Under Pressure Project of the International Center for Tropical Agriculture (CIAT) including 3,500 coffee cultivating farmers in Nicaragua. The selected households have been separated into two groups, namely traditional and organic certified farmers. The collected data contain socio-economic as well as farm level specific production input quantities and prices. A stochastic frontier analysis is undertaken to analyse technical as well as cost efficiency.

The mean technical efficiency of traditional farmers is estimated to be 52.7 %, while organic producers show an efficiency of 56.7 %. Similar results were found in the case of cost efficiency. Surprisingly traditional farmers showed lower average costs while producing higher outputs than organic farmers. The applied inefficiency model found the variable age to be significant, with inefficiency increasing as older the household head is older, and vice versa.

Keywords: Cost efficiency, smallholder coffee production, stochastic frontier analysis, technical efficiency

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Economic Efficiency of Cocoyam Production among Smallholder Farmers in Southeastern Nigeria

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The study determined the economic efficiency of cocoyam production among smallholder farmers in southeastern Nigeria, with particular focus on Imo State. Motivation for the choice of the study area emanated from the fact that Imo State contributes heavily to cocoyam production in the country and thus assists Nigeria to sustain its global status as the world's largest producer of cocoyam. The research was guided by the following specific objectives: to describe the socio-economic attributes of the cocoyam farmers in Imo State; to determine the economic efficiency of cocoyam production; to estimate the socio-economic determinants of economic efficiency of cocoyam production; to estimate the production elasticity and return to scale of the enterprise; to identify constraints to cocoyam production and make policy recommendations based on research findings. Multistage sampling technique was used to select 1000 smallholder cocoyam farmers across the agricultural zones of the state from which data were elicited using structured and pre-tested questionnaires. Profit function of the Cobb-Douglas stochastic frontier model was used to estimate economic efficiency, elasticity and return to scale. The estimated farm level economic efficiency ranged from 0.351 to 0.985 with a mean of 0.625, implying a wide gap between the economic efficiency of the best and worst producers. To close the efficiency gap, the average producer requires a cost saving of 38.1 % to attain the status of the best efficient farmer in the area. The study suggests as a remedial measure the intensification of farmer education and extension of specific technologies to the cocoyam farmers to further boost their economic efficiency.

Keywords: Cocoyam, Nigeria, smallholder farmers, stochastic fontier model

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Adapting or Coping? Analysis of Pastoralists' Responses to Climatic Stressors in Kenya's Drylands

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The livestock-based livelihoods in the vast drylands of Africa are among the most vulnerable systems to climatic-related risks due to their over-dependence on natural resources that are subject to bio-physical variability. This has been exacerbated by weakening of pastoral risk management strategies and inadequate supportive policies. For centuries, however, pastoralists have demonstrated tremendous ability to cope with climate variability, often employing sophisticated and continually evolving processes and practices to take advantage of new opportunities. That notwithstanding, the present concern is that the adaptive capacity of pastoralist communities may not be sufficiently robust to respond to the shocks associated with the contemporary climatic and environmental dynamics.

The traditional adaptive strategies are being undermined by increased population pressure leading to conversion of grazing lands to other uses, thereby restricting pastoral mobility. This is aggravated by increasing climatic anomalies (*e.g.*, frequent and severe droughts and floods), limited livestock marketing opportunities, changing land tenure and unclear property right regimes. Other constraints include rising socio-political conflicts and breakdown of traditional social and resource governance institutions. These factors work in concert to weaken pastoral resilience against otherwise 'normal' climatic variability as shown by large scale livestock losses during droughts and subsequent impoverishment of pastoral households.

Over the last two decades, the climate change challenge has elicited several studies in Kenya's drylands, most of them focusing on the impacts of climate variability on pastoral livelihoods and existing risk management mechanisms. However, little attention has been paid to the sustainability of the existing coping strategies. Questions that arise amid these efforts are: 1) Are pastoralists adapting or just coping with the changes (are the responses reactive or proactive)? 2) Are the current coping strategies capable of enhancing or undermining adaptation in the future? 3) What can be done to strengthen the existing coping strategies and ensure that they form the basis for future adaptation?

The paper examines existing pastoral responses to climatic and environmental risks, their sustainability, and discusses how their capacity can be enhanced to ensure effectiveness, and compatibility with pastoralism and future adaptation strategies in Kenya's pastoral areas.

Keywords: Climatic variability, coping strategies, Kenya, pastoral resilience

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Adoption Potential of Conservation Agriculture in Sub-Saharan Africa

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In a continent facing a fast increasing population, smallholder farming in Africa is exposed to double challenge: 1) to increase food production and, 2) to preserve natural resources. While conventional tillage-based agriculture has been held accountable for soil degradation, Conservation Agriculture (CA) based on minimal or no-tillage is increasingly seen as a promising alternative for highly productive and sustainable farming. Despite its potential, CA adoption rates in Africa, compared with other continents, have remained extremely low. While literature on adoption contraints is abundant, comprehensive, holistic frameworks and tools for explaining or predicting adoption are still lacking. In particular, such frameworks and tools could help in assessing systematically under which ecological, socio-economic and institutional conditions CA is best suited for smallholder farming in Africa and for its scaling up. The objective of this contribution therefore is to demonstrate how a newly developed Qualitative expert-based Assessment Tool (QAToCA) was applied in case studies across Malawi, Burkina Faso, and Zimbabwe; 1) to determine the Relative Adoption Potential (RAP) of CA, 2) to assess the institutional, agro-ecological, socio-economic and cultural influences on the RAP of CA, and 3) to determine the site-specific hindering and supporting factors to the RAP of CA for the different case studies. Results show that for the two south African case studies, Malawi has a high RAP for CA while Zimbabwe has a much lower potential. On the other hand the two case studies in south western and northern Burkina Faso both showed a relatively high adoption potential of CA. Major differences in adoption potential are explained by economic market incentives, prevailing institutional arrangements as well as some biophysical incentives.

Keywords: Adoption potential, Burkina Faso, conservation agriculture, Malawi, Zimbabwe

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Environmental Efficiency and Resilience of Conservation Tillage in Cereal Ecosystems: The Case of Eastern Indo-Gangetic Plain in Bangladesh

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Despite increasing cereal production in Asia, capital intensive technologies of the green revolution era have accounted for stagnant productivity of major crops and depletion of natural environment in cereal-ecosystems, thus reducing its ability to resist damage or recover (resilience). Along with other factors, degradation of the natural resource base resulting from inappropriate land and input use is widely documented in Asia as one of the root-causes of this yield stagnation and resilience loss. Hence, the global agricultural research and development focus is being gradually shifted to conservation tillage in cereal systems with an increased interest in developing agricultural technologies that are resource conserving, environmentally sustainable while ensuring financial profit to the farmers. In Bangladesh, the average productivity of the major cereal crops, rice and wheat, remains significantly low compared to neighbouring countries in South Asia. Low productivity, resilience loss together with resource constraints confines Bangladesh's capacity to feed its 150 mio people from 8.2 mio ha of cultivable land. Bangladesh is one of the poorest countries in the world, and ranks low on almost all measures of economic development, thus leaving the population extremely vulnerable to natural disasters and climate events. This paper attempts to explore the environmental efficiency and resilience of four agricultural practices, namely power tiller operated seeder, bed planting, strip planting and conventional tillage using efficiency variables mainly the primary sources of greenhouse gases while trying to understand farmers' adaptive capacity against climatic events. Taking each farm as a Decision Management Unit (DMU), a nonparametric method of Data Envelopment Analysis for the estimation of production frontiers was employed, where productive efficiency of DMUs is empirically measured. The Frontier Efficiency Analysis in 'R' of unpublished primary data collected during two years of adoption (2008 and 2012) among different technology adopters (N=284) in four districts of the eastern Indo-Gangetic Plain in Bangladesh showed that, farms practising conservation tillage emitted 43 % less CO_2 and could save 40 % of fossil fuel per hectare compared to the conventional practitioners.

Keywords: Bangladesh, conservation tillage, eastern Indo-Gangetic Plain, environmental efficiency, resilience

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Yield Gap Analysis of Cotton in two Major Production Regions of China

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Cotton is globally the most important agricultural trade commodity, with China being the number one producer and consumer of cotton fiber. Its production offers high income possibilities in rural China, however often at the expense of severe natural resource degradation. The North China Plain (NCP) in the East and the Xinjiang Province in the Northwest account for more than 50 % of national cotton production. Comparing the two regions shows that yield levels per hectare in the NCP are only half of the average yields in Xinjiang, with both regions lacking far behind the potential yields. Closing the yield gap would improve resource use efficiency significantly, and give a strong contribution to a more sustainable production of cotton in China. Therefore the present paper tries to analyse the causes for the yield gaps, and elaborate the potentials for closing the gaps in the two regions.

Two main reasons for the differences in yields were identified: management and climate. The NCP features much smaller production units compared to Xinjiang, which leads to a higher occurrence of poor management and a much lower technological level. This becomes evident comparing the level of mechanisation, with drip-fertigation and flood-irrigation being the prevailing irrigation method in Xinjiang and the NCP, respectively. The climatic conditions for cotton production are even more unfavourable in the NCP compared to Xinjiang, with high night temperatures, very high relative humidity and frequent heavy rainfalls from flowering to bud-opening stage. This leads to an increased disease pressure, increased shedding of squares, flowers and buds, increased respiration, unsuccessful pollination and degraded fiber quality, which explains the low yield levels in the NCP. Xinjiang on the other side, being blessed with favourable climatic conditions for cotton production, cannot tap its full yield potential due to seasonal water shortage and high salinity levels of agricultural soils. Due to the climatic constraints, an increase in technological level in the NCP has only limited potential to increase cotton yields significantly. Thus shifting cotton production from the NCP to Xinjiang is recommended to achieve higher yield levels, and thus resource use efficiency on national level.

Keywords: China, cotton, yield gap

Bridging the Researcher-People Knowledge Gap in Biodiversity Conservation: The Case of Nech Sar National Park, Ethiopia

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This study aims to analyse knowledge perceptions and gaps between researchers and local communities in Nech Sar National Park, Ethiopia, and to suggest ways of integrating knowledge systems into practices. The study is based on findings generated by key informant interviews, focus group discussions, and interviews with 60 sample households in Nech Sar National Park between May 2010 and March 2011 and interviews of key informants among wildlife conservation experts and officers. Many studies concerned with biodiversity in Africa show a rapid degradation of the diversity of genes, species or ecosystems. Extensive systems of protected areas (PAs) aim to maintain biodiversity by using different conservation concepts. However, PAs also created manifold conflicts with local people who use species and ecosystems for their livelihoods. Local people describe changes of biodiversity by using trends of flagship species, such as grasses, trees and larger animals. For grasses, they pinpoint to those preferred for cattle grazing in the priority list. For tree species, they focus on those providing shade for meetings, those which can be used as a source of traditional medicines to treat animal and human diseases, or invasive species that take-up grassland plains used for cattle grazing. For larger animals, they use either those that attack their cattle or those that graze and browse together with cattle as indicators of the population trends. Researchers often identify local people's non-sustainable resource utilization as a cause for degradation of natural resources. The local people living inside Nech Sar National Park, however, associate the degradation with the prohibition of traditional land management practices, such as burning for renewing grass growth for their cattle and transhumance, by the park administration. These diverse perceptions call for action to bridge the knowledge and communication gap between researchers, park managers and local people. Improved knowledge exchange can be generated through more participatory and transdisciplinary research. This serves as an important step towards the development of innovative management approaches for Nech Sar Natonal Park that effectively integrate local peoples' livelihood needs and the conservation of biodiversity and natural resources.

Keywords: Biodiversity, Ethiopia, indigenous knowledge, protected areas

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Tomato Production in Ethiopia: Constraints and Opportunities

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Tomato is a popular and widely grown vegetable crop in Ethiopia, ranking 8th in terms of annual national production. It is consumed in every household in different modes, but in certain areas, such as Walo, Hararge, Shawa, Jimma and Wallaga, it is also an important co-staple food. Primary data were collected from 400 randomly selected smallholder producers who were equally distributed among five different study zones where tomato was a co-staple. Surveys and Focus Group Discussions (FGDs) were held with growers and staff of the Ministry of Agriculture during 2011. Qualitative and quantitative data were gathered by employing a structured questionnaire. Before launching the survey, the questionnaire was pre-tested and was improved accordingly. Primary data collected were used to describe the actual tomato production management practices and to quantify the distribution of crop area and production in relation to agro-ecological conditions in the different administrative zones (North Walo, East Hararge, East Shawa, Jimma and East Wallaga) and growing seasons. Yield constraints were identified based on the survey including the 400 smallholder producers. The FGDs were used for triangulation. Constraints appeared to include lack of resources such as irrigation water, nutrients and high-quality seed, but also weather conditions including drought and cold. Crop production management varied significantly across study zones because of differences in agro-climatic conditions, access to resources and culture. Average fruit yields ranged from 6.5 to 24.0 Mg ha^{-1} and were different for the five survey zones. According to the survey and FGDs results about 32–40 % of the growers used irrigation. Supplementary irrigation was required in most of the production regions to sustain food security and commercially viable tomato production. There were also several major weeds, insect pests and diseases including late blight and Fusarium wilt reducing the yield. Possibilities for yield improvement are discussed and recommendations are made to further improve tomato yield in the different growing zones.

Keywords: Biocides, diseases, Ethiopia, improved seed, irrigation water, nutrients, pests, tomato

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Factors Affecting the Adoption of Organic Pepper Farming in India

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India is well-known for the production of spices and was ranked first with around 3.1 million metric tons of spices in 2004. India´s share in the world spice market is 48 % in quantity and 43 % in value. Thus, Indian economy is influenced by the spice sector, which has the potential for growing more than 25 cash crops.

Pepper is originally from the Malabar Coast, Kerala, India. Kerala produces more than 90 % of pepper, which is an important source of livelihood for more than 80 % of people living in this state. Pepper in this region is grown traditionally as a backyard crop. Frequent occurrence of diseases, depletion of soil fertility, and a small land holding size are severe constraints to pepper production. In addition, the farm gate price of pepper from 1999 to 2000 was Rs 215 kg^{-1} y^{-1} but it decreased to Rs 74 kg^{-1} y^{-1} from 2003 to 2004. The domestic prices are highly dependent on international pepper prices and are hence fluctuating. All these factors have made pepper production unremunerative. Adoption of organic farming is an alternative approach to address these problems and benefit the small farmers in a sustainable and eco-friendly way.

This research attempts to find out the factors affecting organic farming adoption by small scale pepper farmers in Kerala. Here, information is collected from a cross-sectional data of 200 small scale pepper farmers, 100 conventional and 100 organic. In this study, logit analysis is used to examine the factors affecting adoption in terms of community set-up, socio economic characteristics and perception. The results will help understand the driving factors behind organic pepper production in India. This will enable developing policies more suitable for developing small scale organic agriculture in India.

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Socio-Economic Determinants of Milk Production in Bangladesh: An Empirical Evidence on Water Use Against Water Crisis

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Water is the most critical natural resources acknowledged in all over the world. Since in large parts of the world, including Bangladesh, it is getting difficult to meet the growing demand by mobilising more water, the discourse has turned its focus to demand effective water management. But efficient water management in milk production is constrained by farm specific factors (*e.g.* socio-economic) and external factors (*e.g.* infrastructure for water procurement). Since infrastructure problems are a matter of public body, we were specifically interested to see whether there is any effect of farm specific factors on milk production and water use. Therefore, this study empirically tested the influence of socio-economic factors on milk production and water use in dairy production systems in Bangladesh. The cross sectional data set collected from 220 sample dairy farms covering three regions and three dairy production systems was submitted to two-stage regression analysis. In the first stage, a general linear regression model was used to explore the factors that influence milk production and water use intensity (as defined by low, medium and high intensity), in the second stage, water use intensity was regressed by using multinomial logit regression model to identify underlying socio-economic determinants in water use intensity. The results indicated that age of farmer, experience and training significantly influence milk production. As level of water use intensity increases from low to high, milk production increases by 60 %, which indicates the need to use more water in dairy farms. Therefore, it is of great interest to investigate which factors determine the water use intensity. The mulginomial-logit regression model revealed that a high level of water use intensity in relation to a low level was significantly and positively influenced by farm size and ownership of the farm, while age and experience of the farmers significantly influenced medium level of water use intensity compared to low level. it is concluded that increasing farm size (*i.e.* utilising economies of scale) and gaining experience would particularly be helpful to improve the management of water resources in view of high water scarcity in Bangladesh.

Keywords: Bangladesh, milk production, socio-economic factors, water shortage, water use intensity

Changes in Traditional Cultivation and Use of Maguey (*Agave* spp.) and Nopal (*Opuntia* spp.) in the Upper Mezquital Valley of Mexico: Relevance for Sustainable Livelihoods

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A large share of the inhabitants of the Upper Mezquital Valley (Mexico) belongs to the Ñähñu indigenous group. In this semi-arid and highly marginalised region, livelihood strategies have for centuries been closely intertwined with maguey (*Agave* spp.) and nopal (*Opuntia* spp.) cultivation, turning these natural resources into intrinsic to the population's cultural identity. However, traditional resource-use patterns have been increasingly disrupted due to the displacement of traditional and locally produced items by industrial products. The absence of local markets in combination with growing structural inequalities has led the inhabitants of the region to search for alternative livelihood strategies. By applying the sustainable livelihoods approach, this study explores the changes of traditional maguey and nopal cultivation and use during the last two decades in the Ñähñu community of San Andrés Daboxtha, as well as the drivers and impacts of these changes, as perceived by community members.

Field research revealed a growing neglect of maguey and nopal cultivation since the early 1990s, resulting in the further deterioration of the resource base through the strong decline of maguey and nopal stocks. This neglect was explained, among others, through migration to the United States and the associated flow of remittances that turned traditional resource-use patterns into seemingly obsolete livelihood strategies. In contrast, one cooperative producing maguey syrup has enabled its mainly female members to maintain and enhance their livelihood resource base through the creation of a slowly growing market and the continuous access to reforestation programs.

Increasingly difficult conditions in the United States have recently led large numbers of migrants to return to the Upper Mezquital and try to add value to the raw materials available in the region. Formerly neglected agricultural practices have thereby served as safety net for these migrants to return to. The reversal of migratory flows bears both opportunities and challenges; overexploitation of maguey was represented a major concern. Departing from the outlined findings, we discuss the promotion of agroecological practices as a strategy to contribute to the sustainable use of maguey and nopal as means of securing local livelihoods.

Keywords: Agroecology, biological resilience, cultural resilience, indigenous, Mexico, migration

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Environmental and Economic Effects of Manure Management in Turkey

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Increase in livestock production and consumption in Turkey has resulted in serious environment and health risks in form of increased air pollution, water pollution, and ground water contamination in many areas. The inefficient manure management is also causing economic losses. Additionally not much data is available regarding the manure management options available to farmers and their agricultural systems. The presented paper is the result of a study conducted to analyse the current situation and discuss the possible further options not only technically but also economically.

Turkey is a large, middle-income country with a growing population of 73.7 million and a rapidly developing economy. The consumption of livestock products, *i.e.* meat and milk, has increased manifold and the trend is expected to grow upwards. The rising demand has given an impulse for the investors to invest in the large livestock farms but environmental and health risks of the manure management are not yet treated sufficiently.

To obtain basic information field visitswere undertaken. Secondary data were used such as from KTBL, LfL Bayern, various agriculture chambers in EU, and GIZ project reports. For the calculations machinery costs were analysed in detail. A situation analysis examines the current manure management practices and the infrastructure available for it. Based on the findings two aspects of manure management are worked out in detail: manure storage and its field application/transport. The costs differ considerably between the various options for the Turkish livestock farmers.The slurry application costs for various combinations having a standard farm-field distance of $2\,\text{km}$ vary from $4.19\,\text{€/m}^3$ to $4.80\,\text{€/m}^3$.

The analysis suggests that the introductions of new and improved manure management practices through better storage structures and application machines or equipment can not only be economically viable but also have a positive effect of the environment. The qualitative benefits, such as reduction in environmental stress and pollution, have not been evaluated during this study.

Keywords: Biogas, environment, cost analyses, transport costs

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Rural development

The Influence of Socio-Economic Characteristics and Social Networks on Smallholders' Risk Preferences in Vietnam

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Risk is an integral part of decision making, especially in smallholder agriculture in developing countries. Nevertheless, influencing factors of risk preferences are poorly understood. This study contributes to closing knowledge gaps on how socio-economic characteristics, various indicators of social capital including social networks, and shock-induced losses influence risk preferences and how these influences may differ across five different methods to elicit risk preferences. We analyse influencing factors of smallholders' risk preferences in a random sample of 300 households which is representative of Yen Chau district, Son La Province, an upland area of northwestern Vietnam. The five methods are a non-hypothetical lottery called the multiple price list technique and four hypothetical methods. Ordinary Least Squares (OLS), tobit, and probit regression models identify influencing factors of risk preferences separately for each elicitation method. To the best of our knowledge, there exists no study which has explicitly tested for an influence of various indicators of social capital on risk preferences or which has collected risk preferences using such a wide range of techniques within-sample.

We find that most respondents are risk averse, with a high percentage being classified as very risk averse. In most OLS and tobit models, female gender, older age, lower education, lower network-based trust with extended family members, larger household impacts of idiosyncratic shocks, and poorer connections to local authorities are statistically significant in increasing risk aversion. Nevertheless, the low explanatory power of the models is a clear sign that unobservable or hard-to-observe factors, such as genetics and prior experiences, are likely to be of greater importance in determining risk preferences. The result that most respondents are (very) risk averse indicates that they may be unwilling to make investments that could increase households' productive capacity because of the associated (perceived) risks. Thus, policymakers and extension agents should recommend that smallholders invest step-wise in new income-earning activities or technologies. We also recommend that safety nets, such as agricultural insurance, should be targeted to the most risk averse individuals to help smallholders better adapt to natural disasters and other risks.

Keywords: Lottery choice task decision, risk preferences, social networks, Vietnam

Constructing Resilient Livelihoods in Burkina Faso: Finding the Right Balance between Persistence and Adaptation

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Research on resilience in farming systems often focuses on encouraging diversification, so that risks are spread across a wider portfolio of activities. However, the financial literature has long warned that diversification is only beneficial if activities within the portfolio are not interdependent (low covariance), otherwise – akin to a row of dominos spaced too closely together – shocks affecting one component can quickly reverberate through the whole system. The long-term study of ecosystems has similarly documented the detrimental effect of high interdependence on the capacity of ecosystems to recover after hurricanes and other natural disasters.

This Ph.D. research applied these principles to livelihood systems in the arid Sahel, examining the processes fostering resilience and allowing households to ensure their food security year-round. With over 2.5 billion people living in drylands worldwide, it is important to understand how sustainable livelihoods are constructed and maintained in such a risk-prone environment. To model the adaptive trajectory of livelihoods, resilience was observed at the relational scale of the household over a whole agricultural cycle, from harvest to harvest (2009–2010). Results revealed that risk-taking behaviour of interviewees varied over the cycle, alternating between periods of persistence (continuing the same livelihood activities) and adaptation (pursuing new livelihood activities), refuting the commonly-held notion of 'linear' adaptation.

Three indicators of resilience were computed, capturing strategies which were diverse but exhibited low interdependence and could easily be adapted by intensifying current activities or accessing new ones. This study shows how resilience theory applied to livelihoods may provide a more holistic approach to ensuring food provision in risk-prone environments. The identified indicators can be used as a diagnostic tool, quantifying current level of resilience and guiding policy interventions to foster resilience.

Keywords: Adaptation, diversification, food, resilience, Sahel, risk aversion

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Trade-Offs Between Biodiversity Protection and Poverty Alleviation Using Payment for Ecosystem Services at the Pasture-Forest Frontier in South Ecuador

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Ecuador is very rich in biodiversity but has the highest annual deforestation rate in South America with much land being converted to pastures. The presentation investigates the effects of contrasting instument options including Payments for Ecosystem Services (PES) that all foster a forest conversion ban in mountainous southern Ecuador. Biodiversity effects are expressed as cost-efficiency of conservation, and poverty alleviation effects as improvements of the GINI coefficient of farm household incomes. The tested conservation instruments differ with respect to being either mandatory or voluntary, and if all farmers are compensated by the same 'flat' payment rate per hectare or if the compensation equals individual opportunity costs calculated from survey data. Additionally, dedicated 'pro-poor' PES were investigated restricting payments to the poorest households. Empirical opportunity cost data stem from a sample of 130 local farming households living at the northern edge of the UNESCO Biosphere Reserve "Podocarpus-El Cóndor" in southern Ecuador. In all cases, a fixed budget of 25,000 USD yr^{-1} is distributed. The amount equals the typical annual per ha payments of the Ecuadorian national Socio Bosque programme times forest area of the 130 households. The average opportunity costs is 156 USD ha^{-1} yr^{-1}. A voluntary PES paying just farmer's opportunity costs can cover 305 ha (36 % of total forest area of the farms); the GINI coefficient does nor change. A mandatory approach covering a all farms in proportion to forest size and paying a flat 156 USD ha^{-1} yr^{-1} compensation only secures 136 ha. With most payments dispensed to the relatively least poor farmers, the GINI coefficient rises slightly to 0.488. Voluntary approaches with 156 USD ha^{-1} yr^{-1} improve the GINI coefficient to 0.477. If payments are restricted to the 60 % poorest farmers at flat compensation rates between 150 and 300 USD ha^{-1} yr^{-1}, only 168 to 84 ha forest are covered but the GINI coefficient improves to 0.470–0.462. While mandatory approaches always perform worst, we conclude that severe trade-offs between cost efficiency and poverty alleviation are likely to impact PES application in the study area - and in other regions characterised by a majority of intensively used smallholder farms.

Keywords: Biodiversity conservation, economic incentives, environmenral justice

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A Transaction-Cost Framework for Analysing Institutional Arrangements for Providing Animal Health Services in Developing Countries

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In the developing countries, the current policy environment is fragile and ineffective in guiding animal health services delivery. Most of the existing institutional arrangements are developed as responses to the crisis but not based on systematic and analytical theoretical frameworks. Analytical frameworks that guide the policy formulation for providing animal health services are needed in order to address growing animal disease risks in a sustainable manner. Existing analytical frameworks for analysing institutional arrangements for providing animal health services are based on market failure attributes with diminutive attention to governance attributes of animal health services and contextual factors that are unique to animal production system. Therefore, we present a framework of analysing institutional arrangements for providing animal health services based on market failures, governance issues and contextual factors. Williamson's discriminating alignment hypothesis is applied to assess cost effectiveness of the institutional arrangements and to generate testable hypothesises. Based on market failures attribute, governance attributes and contextual factors, we generate the following hypotheses:

H1: The community animal health worker system is transaction cost minimising under conditions of low economies of scale, transaction intensity, and low measurability in marginal areas.

H2: The para veterinary system is transaction cost minimising under conditions of low economies of scale, transaction intensity, and low measurability in productive areas.

H3: The government service delivery system is transaction costs minimising under externalities, free rider problem, and high economies of scale, asset specificity, and high measurability.

H4: An integrated livestock service delivery system is transaction cost minimising when a mix of attributes of hypotheses H1, H2 and H3 exists.

H5: The private veterinarian system cannot provide any real livestock service in marginal areas.

H6: Even in productive areas, the private veterinary system will not be cost effective in providing services.

Empirical methods for testing these hypotheses will be presented, along with conclusions.

Keywords: Animal health services, governance attributes, institutional arrangements, market failures

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Willingness to Pay for Irrigation Water from Groundwater in Spot Water Market by Self Selectivity: An Example from Iran

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Understanding the economic value of water can inform decision makers of the full social benefits and costs of water use, which is of particular importance in agriculture with its huge and often heavily subsidised water use. In the few available irrigation water markets, the price that is paid for an extra unit of irrigation water reflects the willingness to pay (WTP) of farmers but is blurred by the impact of other factors. Analysing this WTP and its determinants hence gives us the chance to find the 'right' value of water. One specific methodological challenge, however, arises from the observation that participation in water markets is usually not randomly distributed across the population of all water users. In consequence, self-selectivity issues arise for the analysis of WTP for irrigation water, which are often ignored in the existing water valuation literature. This study attempts to show that self-selectivity is indeed an issue in our case study of the spot water market in the Rafsanjan aquifer in southeastern Iran. The main source of irrigation water is groundwater. A two-stage random sampling was carried out in a field study from November 2008 - February 2009. In this survey, information was collected on different aspects of groundwater, irrigation, production and cost of the pistachio production, and socioeconomic characteristics of the farmers. The factors affecting the WTP have been analysed by the Heckman sample selection model with emphasis on the effects of the farmers' decisions to participate in the spot water market. The price which is paid by the farmers is used as the dependent variable. Results show that the self-selectivity parameter in the Heckman model is significant at an estimate of -0.73. This indicates that the average WTP of all farmers in the Rafsanjan aquifer is actually much less than the WTP of those who participated in the spot water market. The significant and effective variables in the Heckman model are mainly related to technical characteristics. The study suggests that the promotion of the groundwater market could be a way to get a clear picture of the groundwater scarcity in depleting aquifers such as Rafsanjan.

Keywords: Groundwater, Heckman sample selection model, irrigation water, pistachio, Rafsanjan, self selectivity

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The Role of Risk in Conservation Auctions for Outcome-Based Payments for Environmental Services and the Cost-Effectiveness Implications: Experiments in Kenya

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While most PES programmes tie payments to defined land use practices ("action-based PES"), PES schemes in which payments are made conditional on conservation outcome ("outcome-based PES") are argued to have many advantages as opposed to indirect approaches. On the other hand, an outcome-based contract exposes farmers to additional uncertainty, which implies different impacts on the cost-effectiveness. Further, although the auction theory assumes risk neutrality among bidders, farmers are generally considered to be risk averse, which might further deepen the divergence of impacts on cost-effectiveness under those two PES mechanisms.

The overall objective of this study was to assess whether "outcome uncertainty" adversely affects the cost-effectiveness of conservation auctions for outcome-based PES (as compared to the auction for action-based PES), and on the contrary whether "input uncertainty" improves the cost-effectiveness of conservation auctions.

Field experiments were conducted with farmers in Western Kenya and the findings highlight the trade-off conservation agencies are facing. Whereas outcome-based conservation contracts are argued to improve the ecological performance, the empirical results of this study show that "outcome uncertainty" indeed adversely affects the contract costs of conservation auctions. Thus, the supposed higher quality in the implementation of conservation contracts might be traded off with higher costs and lower quantity of allocated contracts.

On the contrary, the study shows that participants with uncertain farm income are much more willing to participate in a PES programme and accordingly decrease their bids in the conservation auction. However, the cost-effectiveness potential of this "input-uncertainty" decreases with repetition of the auction for conservation contracts and might entirely disappear in the long run.

Keywords: Conservation auction, cost-effectiveness, outcome-based, payments for environmental services, uncertainty

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Understanding of Intention Regarding Water Conservation in Face of Drought: The Case of Iranian Agricultural Professionals

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Iran is a semi-arid country which faced with frequent drought and water shortage. Recently some efforts have been made to implement water conservation among water users, particularly farmers. However, despite the increasing importance of water conservation across the world, very little is known about the psychosocial variables that predict whether or not people will conserve water. The present study uses an extended model of the theory of planned behaviour (TPB), which includes additional variables of moral norm, self-identity, and the risk perception to predict the intentions regarding water conservation in a random sample of agricultural professionals (n=80) in a survey conducted in Iran. Findings revealed that the subjective norm and perceived behavioural control had positive and significant correlation with water conservational intention. But attitude was not significantly related to intention. Findings also showed that the extended model is an improvement over the TPB for predicting intention and activities regarding water conservation. Multiple regression analysis showed that moral norm, perceived behavioural control, and risk perception can predict 68 % of variances in water conservation intentions, while in the original model social norm and perceived behavioural control can predict 49 % of those variances. Therefore, those professionals who had a greater commitment to water conservation activates also had a greater intention to engage in such activities; moreover, the significance of perceived behaviour control revealed that professionals did not have complete volition in their water conservation activities. Based on the research findings some applicable recommendations will be presented toward agricultural professionals' water conservational intention and behaviour improvement in the presentation.

Keywords: Agriculture professionals, Iran, moral norm, self-identity, theory of planned behaviour, water conservation

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Analysis of Motivational Factors Affecting Credit Demand among Small-Scale Farmers in Western Province, Kenya

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Western Province is an agricultural region that enjoys good rainfall and farmers practice mixed farming. For many farmers, there exists opportunities for accessing farm credit offered by lenders. However, they have been reported to fear accessing credit from banks. The study assessed what factors contribute towards the fear to seek institutional credit, despite the easement of its availability by lenders. We found that demand for credit did not match its supply by government (KES. 3.5 Billion for youth and women), banks (KES. 24 Billion from Equity) and micro-finance institutions. Looking at the influence of socio-economic characteristics and the farming environment on demand for credit, it was hypothesised that the motivational factors to seek information on credit and subsequent application do not inhibit small-scale farmers from seeking credit. The study did not consider the lenders' organisational weaknesses and political-economy issues that constrain or engender demand for credit. Multi-stage random sampling was used to arrive at a sample of 224 respondents. Primary data was collected using interviews and observations on farm ecological conditions. The research revealed that farmers spend only 1.6 hours per season planning for the farm, 0.3 hours planning for the market and 5 hours working on the farm. This reflected low management capacity. Factors significantly motivating the intention to seek credit were those which improved the farmers' perception of self-ability and control such as youth, asset ownership, risk loving attitude and high expectations of increased farm output and investment. The subjective norms arising out of interaction with neighbours who have borrowed and model farmers significantly enhanced inclination towards acquiring credit. The action of applying for formal credit was strongly encouraged by an increase in asset ownership. We recommend that in order to improve the farmers' capacity to utilise available credit there is need to train them in entrepreneurship and savings and give them small loans to finance products with ready markets or link with markets through vertical integration and franchising. This would enhance access to better prices to improve cash flow, thereby easing loan repayments.

Keywords: Credit demand, Heckman two stage, managament capacity, motivational factors

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Implementing Sets of Institutions Using Economic Experiments: A Case with Diverse Stakeholders in Sikunga, Namibia

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Ecosystems are complex and so are relations between stakeholders of different ecosystem services (ESS). To help a diverse group of stakeholders manage an ecosystem sustainably, a certificate-based payment for ecosystem services (PES) is useful. Manifold PES-schemes have been tested using experimental economics. Apart from empirical findings, studies as side note often concluded that economic experiments are a useful tool for educating participants on their situation and possible solutions. On a more basic level, it can even help shape the picture of the situation, so that stakeholders can level with each other. Still, economic experiments are primarily used as a tool for data collection and not taken seriously as tool for informing and educating, both stakeholders and researchers. In contrast to previous studies, our analysis aims at testing experimental economics as a tool for education and qualitative analysis. Using experiments for educational purposes is particularly useful for ESS management under a certificate-based ecosystem management scheme. A problematic ecosystem management setting often comprises a group of diverse local stakeholders and a set of resources many of which are common pool resources produced by one ecosystem. The region we chose for our experiments is the Sikunga conservancy, which is part of the Caprivi strip in Namibia. Its community just recently implemented self-management and is a candidate for a certificate-based PES. Although the ecosystem in Sikunga fulfils many services, we concentrate on three main ESS in the experiments: biodiversity, carbon mitigation and agriculture. Accordingly the participants in the economic experiments are local stakeholders of these services: farmers, tourism entrepreneurs, fire-wood-collecting households, administrators, and political as well as institutional leaders. Because of the experiments, local stakeholders were successfully brought to new insights into challenges connected to the management of their ecosystem. While proposing possible solutions, locals as well as us outside researchers gained insights into matters of governing and other qualitative information otherwise hardly attainable. Though it was not the goal of our experiments, we can also report that experiments for educational purposes do not lose their validity as data collection tool, although trade-offs between data quantity and experiment depth have to be made.

Keywords: Management of ecosystems, Namibia, PES, qualitative analysis

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Assessing the Effects of Credit Access on the Profitability of Farms in Rural Sudan: An Empirical Study from North Kordofan State

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Although serious attention has been given to support the process of development in developing countries, poor people in rural areas remain largely marginalised. In Sudan as an example, several factors are contributing to that. Poor people in rural Sudan have limited access to credit, information, and agricultural inputs. In addition, they are forced to irrationally allocate their available resources due to inefficient policy processes. This study focuses on the access to credit as a problem that persists in North Kordofan State, where several NGOs and governmental institutions implemented packages of microfinance service. The provision of microfinance to the small farmers was a major strategy employed by central bank of Sudan and other institutions to increase farmers' productivity and reduce poverty. Accordingly, this paper aims at investigating the factors affecting credit constraints conditions for credit users and non-users. In addition, it tries to determine the factors influencing the profit to farmers from agriculture. The study relies on a survey conducted in 2009 in North Kordofan State, using structured questionnaire. It surveyed 200 farm households, which were selected through a multi-stage random sampling technique.

Descriptive statistical tools and Heckman selection model (two-step estimates) were applied to analyse the data. Results show that, farm profits for all categories in the study area were SDG 1768 (100 Sudanese pound ≈ 18 €). The credit users were better off with a profit of SDG 2022 compared to SDG 1513 for non-users. The results of the probit model show that value of assets, savings and annual incomes are significant variables determining the credit constrained conditions. In addition, the results of Heckman model show the significance of several factors. These include household size, savings, labor used, land owned, distance of MFIs, off-farm income and extension services. Methodologically, the study found that using of OLS, for testing the parameters produces a bias in sample data. Therefore, the study uses of the Heckman selection model to correct the expected biasness. The study suggests that in order for the farm profits to be improved, first the agricultural investment should be improved, particularly the adoption of efficient and sustainable technology.

Keywords: Credit, farm profitability, gross margin, Heckman model, poverty, selection bias

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Rural-Urban Migration in Vietnam: Do Households and Migrants Get Better Off?

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Vietnam, considered to have undergone rapid economic and social development, has experienced an exponential increase in the movement of people from rural to urban area. Migration is one of the reasonable strategies to reduce poverty in place of origins and supply labor for industrialisation in urban areas. This paper investigates the interaction of migrants and their rural households in three provinces in the central region of Vietnam. It addresses three questions. (1) What motivates rural households to send their household members to urban areas? (2) Do migrants become better off in the destination area? (3) What is the effect of migration on rural household's income? The analysis is based on panel data of 2,200 households from rural areas in Central Vietnam covering the period 2007–2010, and on migrant survey data of 299 migrants traced in and around Ho Chi Minh City in 2010. The empirical evidence from a probit model shows that migration is an adaptation strategy for households that are exposed to social shocks. Else, migration is more likely to be observed among households with higher human and social capital endowments and among households that are financially better off. Through constructing the employment quality index, the study found that migrants perceive themselves to be better off at the place of destination. The results from difference in difference specifications with propensity score matching techniques suggest that migration has positive income growth effects and that these effects are more pronounced in provinces with fewer job opportunities. While migration thus aggravates income disparities within villages, it may reduce those between provinces.

Keywords: Difference in difference, employment quality index, impact assessment, migration, propensity score matching, remittance

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Value Chains and the Forward and Backward Linkages of Agriculture in Guatemala

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Agriculture is still the most important sector in rural areas of almost all developing countries. Additionally, through forward and backward linkages, the agricultural sector generates employment and value added indirectly in other sectors like industry and commerce. One important question is which value chains have the highest multipliers and potential to stimulate economic growth and create jobs. Especially if there is, as in Guatemala, a highly dualistic farm structure: 92 % of all farmers possess only 22 % of total cultivated land, whereas the oil palm, sugar cane and banana plantations concentrate on large landholdings and are expanding at the expense of small farms. There are no reliable data about income and job generation (or losses) of this process, but they are essential for regional and national development planning.

The present study examines 28 value chains in the main agricultural regions of Guatemala. The methodology uses input-output-tables to show the most important variables of the value chains like output, value added and employment. Unlike other studies which utilise official social accounting matrices to quantify the forward and backward linkages of agriculture, we used a bottom-up-approach starting from agricultural production, following the value chains back and forth from the local to the national level.

Results show that nearly half (47 %) of total value added is produced in agriculture, 34 % in industry, and 18 % in commerce. This means that for one dollar created in agriculture, another dollar is generated in the forward and backward sectors. One third of this value added is attributable to peasant agriculture, and more than half of all the jobs generated in the value chains can be traced back to small scale agriculture. The sugar cane and palm oil industry do not create much wealth for the regions where they are grown. Therefore, agricultural policy should support peasant agriculture not only for social, but also for economic reasons.

Keywords: Forward and backward linkages, input-output analysis, peasant agriculture, value chains

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Application of the DPSIR Model to Analyse Ecosystem Service Drivers of Agricultural Human-Environment Systems

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Integrating environment and human systems, ecosystem services have been drawing an increasing concern from environmental researchers and managers. One research focus regarding ecosystem services is the dynamics and the drivers, since this issue can well reveal the impacts of social and economic systems on natural systems. However, due to the insufficiency of quantitative analysis of the interrelationships between ecosystem service changes and social-economic drivers, the exact reasons for ecosystem service dynamics are usually still unclear. The Driver-Pressure-State-Impact-Response (DPSIR) model is a promising tool to identify the interactions between the components of human-environment systems and describe the cause-effect processes. It has potentials to quantitatively analyse how ecosystem services change under the drivers of human systems.

Our research aims at identifying the drivers of ecological integrity/ecosystem services and human well-being in agricultural human-environment systems and demonstrating how these drivers play their roles. We proposed a framework coupling DPSIR, ecological integrity/ecosystem services as well as human well-being and put forward the DPSIR indicators for the case area: Jiangsu, China. Then we revealed the factors significantly impacting ecological integrity, ecosystem services and human well-being of the research area through correlation analysis, which took the 13 prefecture-level cities of Jiangsu as the sample. The results show that urbanisation, industrialisation and economic development are the predominant positive drivers of the regional biodiversity, food provisioning service and rural residents' living standards at the prefecture-level city scale. Additionally, the knowledge, technology and finance inputs for agriculture also have generally positive impact on these aspects. This phenomenon is probably due to the high intensity land use for regional economic development and human habitation, which can save land for more natural vegetation. Contrarily, the expanding of farming land and the increasing of agricultural economy are two important negative driving forces of biodiversity, ecosystem food provisioning capacity and the well-being of the rural populations. Our study provides a promising approach based on the DPSIR model to quantitatively capture the drivers of ecosystem services and human well-being for agricultural human-environment systems at the regional scale.

Keywords: DPSIR, driving force, dynamics, ecosystem services, human-environmental, quantify

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Typical Farms in the Bio-Energy Value Chain: A Village Case Study in Tanzania

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Traditional biomass, particularly firewood, plays a significant role in rural household energy consumption. However, high rate of deforestation and continuous loss of biodiversity in most of the developing countries has been linked to over exploitation of forest resource and continuous dependence of rural habitant on biomass. As postulated by the literature, excessive biomass consumption can be reduced through biofuel production.This paper therefore seeks to determine the present and future participation of a typical household farm in the bioenergy value chain by addressing these questions: (1) What are the main factors influencing the household energy consumption? (2) Which of household groups cultivate more of Jatropha plant?

The primary data used in this analysis are drawn from a surveyed cross sectional data set of Tandai village households located in Morogoro region of Tanzania in 2010. Income categories' statistical t-test results of the surveyed households shows variation in some of the households' socio-economic factors and their per capita firewood consumption. The rich households consumed more of firewood than the poor households. More so, they were found to have more land and more household members compared to the poor households. The result of a multivariate regression analysis further proved the significant effect of wealth and household size on household total energy consumption. The alternative sustainable prospective energy source Jatropha plant has been found to be more cultivated on the rich households' plots than by poor households. Chi-sqare-test results show a higher percentage of hired labor for the rich households compared to the poor ones.

Keywords: Bioenergy, firewood, Jatropha, wealth

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Return Migrants and Employment in Rural China

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Through the national economic reform, China has achieved great progress toward economic growth and full employment since the 1970s. However, with rapid urbanisation and increasing income gap between rural and urban areas, more and more farm labor left the agricultural sector and shifted to off-farm sectors.

It is stated by the national statistical office that in 1952 approximately 84 % of China's workers were engaged in agriculture; in 1997 the figure had declined to 41 %. It is estimated that by 2030 farm employment may account for only 10 % of the total. Many scholars argue that the huge reduction in farm employment is to endanger China's food security. With increasing population, natural disasters, and decreasing arable land, the large withdrawal of labor from agriculture has become a significant factor leading to food crisis in China.

Since the global financial crisis in 2008, a large number of migrant workers lost their jobs in urban centres, they had to go back to their rural home villages. These returnees have different employment status after return. Based on the data from a field survey conducted in 2011, we find that many return migrants have given up their original agricultural work and entered non-agricultural employment, while many of them were unemployed.

This paper explores why return migrants chose non-farm work or unemployment, and what the major determinants of their employment status are. By this the study puts forward some policy recommendations to ensure food supply by promoting full employment in rural China.

Keywords: Employment, return migrants, rural development

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Determinants of Household Participation in Land Rental Markets in Rural China: Evidence from Henan Province

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Economic reforms in rural China have led to the emergence of land and labor markets. The development of rural land rental markets can improve agricultural productivity and equity by facilitating transfers of land to more productive farmers and facilitating the participation in the non-farm economy of less productive farmers. In recent years the incidence of land rental activities has increased rapidly. There are large differences of households' participation in land renting activities, both between regions and within regions. The purpose of this study is to analyse the factors affecting households' participation in land rental markets in one of the big agricultural provinces in China, namely Henan Province. Data from 464 households in three counties are used to analyse the participation in land rental markets. Multinomial logit model and tobit model are used to identify the determinants for households' land rental participation and rental size. The results show that households' land endowment and off-farm employment are the main incentives for households' land rental participation. However, this participation decision is constrained by household's labor resource endowment and the opportunity cost of off farm employment. Institutional factors, such as the reallocation times in the village and village-level indicators of land-transfer rights have significant impacts on households' land rental participation, while the expectation of the next reallocation and land contracts do not play a significant role in land renting activity. Among all of the households' characteristics variables, only household heads' age has a significant influence on the participation in land rental market. The main recommendations of this study are polices to secure the land tenure and reduce transaction cost of land transfer; this will stimulate the development of rural land rental markets. Appropriate measures in providing more off-farm work opportunities will increase the potential supply of land.

Keywords: China, land rental markets, off-farm employment, tenure security

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Vocational Training to Facilitate Rural Urban Migration in China: A Nonparametric Analysis

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The rapid industrialisation and urbanisation has driven gigantic numbers of rural laborers in China moving off-farm and into urban areas. However, the poor education they have received and low skills they possess have seriously hampered their way into urban employment and poses huge challenges to China's social stability and sustainable development. In order to solve this problem, the government implemented the "Sunshine Project" in 2004 which aims to provide non-agricultural skill training for rural migrants before they leave their rural home areas. This paper focuses on the training situation and its efficiency for China's rural migrants after the implementation of this project. The results indicate that the formal training programme focuses on the long term effects. The trainees receive both theoretical education and practical training, they can get certificates nationally recognised, which facilitate their job hunting. On the contrary, the informal training programs are very market-oriented and basically address the short term or instant effect. Both the formal and the informal training are important and they are complementary. The supply of rural migrants' training programmes increased after the implementation of the "Sunshine Project". Based on provincial panel data, the paper analyses the TFP (total factor productivity) change in China's rural migrants training during 2004–2009 through a nonparametric Malmquist index approach. Twenty-nine provinces' training input and output data were selected from China Labor Statistical Yearbook 2005–2010. The results indicate that the TFP of China's rural migrants training increased from 2004 to 2009 primarily due to technical progress; the TFP of China's rural migrants training varied among regions. Recommendations of this study are as follows: in addition to continue investment in the migrants' pre-job training, government should also create policies to stimulate employers to invest in the migrants' on-job training, thereby establishing a more flexible investment sharing mechanism.

Keywords: China, Malmquist index, rural migrants, vocational training

Analysis of Livelihoods and Income Generation among Rural Dwellers in Southeastern Nigeria

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A livelihood strategy encompasses not only activities that generate income but many other kinds of choices, including cultural and social that come together to make up the primary occupation of a household. This study therefore examined livelihoods and income generation for poverty alleviation among rural dwellers in Southeastern Nigeria with specific interest in Abia State, Nigeria. Beyond the broad objective, the study sought specifically to identify and analyse livelihood strategies in the study area; estimated the income distribution; determine the poverty line, gap and incidence as well the profitability of the strategies, and determinants of the profitability in the livelihood strategy with highest participation.

A total of 240 households were selected across the agricultural zones using multi-stage sampling technique from which data and information were elicited. Analytically, the study employed cluster analysis in the identification and analysis of livelihood strategies while the estimation of income distribution applied Gini coefficient. Also, poverty indicators were used to measure poverty incidence and gap while the stochastic frontier model was employed in analysing the determinants of the profitability in the livelihood strategy with highest participation. The study identified 8 primary livelihood activities with crop production emerging as the most dominant. Income distribution showed high level of inequality (Gini index = 0.987) with per capita income falling below the operational national minimum wage. The poverty gap and incidence gave a scary picture of worsening poverty situation, judging from the poverty indicators (head count index = 0.567; poverty gap = 0.568). Civil-public service emerged as the most profitable among the identified primary livelihood activities but recorded a very slim proportional participation. As the only livelihood activity with overwhelming household participation, crop production was found to be influenced negatively by equipment and consumption costs while its profitability was determined by education, household size and remittances. On the strength of the findings, the study suggests adoption of a form of livelihood diversification which will incorporate crop production as an integral constituent and intensification of extension delivery systems.

Keywords: Income inequality, livelihoods, poverty alleviation, Gini coefficient

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Banking on Variety – Systems Diversity in Small Scale Farming Systems in Sub-Saharan Africa

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Samll scale farming systems in sub-Saharan Africa are not only production systems of agricultural products. They are primarily livelihood systems within a living community, reflecting the social and natural environments as well as the thoughts and ideas of their individuals. Those livelihood systems, the farm households, are cultural, environmental and economic systems at the same time. That still counts for the majority of the population in sub-Saharan Africa, living in rural and sub-urban areas.

Livelihood systems develop and adjust themselves to their environments for centuries. While some technological changes are absorbed easily, others could be observed being neglected or were just taken over for a short period of time. Looking at the system's properties, it can be observed that those options with a significant positive or no effect on the diversity of the system are those being accepted easily. The diversity of the system must be the primary measure, in order to maintain the capacity for resilience against potential crises.

This study is based on 100 randomly selected rural households in Northern Malawi. Data analysis demonstrates that the diversity in activities of the farming household is continually maintained in order to tackle risky and uncertain situations, while maintaining the livelihood for their household members. The presented study postulates that farm households achieve an optimum diversity in order to address the needs of subsistence, income and security, depending on the specific environments. I argue that "banking on variety" is just that strategy for small scale farming systems in sub-Saharan Africa to maintain the resilience against potential crises.

Keywords: Diversity, household, livelihood system, Malawi, smallholder farming system

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Financial Vulnerability and Indebtedness of Poor Households in Thailand and Vietnam

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The lack of finance is a major reason for poverty. Also a typical feature of the poor, especially the rural poor, is that their income highly fluctuates often as a result of shocks. This volatile nature of the poor households' cash-flow underlines the need for good financial management which the poor are often not well equipped to do. In emerging market economies the delivery of financial services has advanced, albeit with larges differences in access. Some programs may also have led to over-supply of credit and may be responsible for unproductive investment which may have resulted in levels of indebtedness exceeding the repayment capacity of rural households. In general, excessive debt accumulation coupled with household liquidity constraints could weaken the social and economic well-being of households and result in financial distress.

This study seeks to examine household indebtedness in rural Thailand and Vietnam with a particular focus on the indebted households whose consumption level is near the poverty line. The main objectives of the study are (1) to evaluate the extent of indebtedness of households and (2) assess the changes in the level of household indebtedness over time, (3) to analyse the factors that make certain households accumulate excessive debt, and (4) to develop the concept of financial vulnerability. Results are presented in three steps. First, descriptive analysis will be carried out to assess the extent and pattern of households' indebtedness. Second, multivariate analysis will be performed to determine factors that influence households' level of indebtedness and make households more financially vulnerable. Third, longitudinal analysis will be used to examine which factors and characteristics of households influence transition of household indebtedness across time and between two countries. Results will provide policy makers and other stakeholders an insight into the financial situations of the poor suggesting appropriate measures to reduce financial vulnerability.

Keywords: Financial vulnerability, household indebtedness, poverty, Thailand, Vietnam

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Decency of Women's Working Conditions in Peri-Urban Dairy Production Systems in the District Faisalabad, Pakistan

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Equitable working conditions and fair payment for female workers are often insufficient. To analyse the decency of women's working conditions in dairy production systems in Pakistan, a study was conducted applying qualitative and quantitative research tools. Female workers (n=73) were asked about their on-farm activities in a semi-structured face to face interview. In addition participatory research tools were applied in group-discussions to determine problems the women are facing. The research was carried out from September to December 2011.

The workload of female family members is enormous: it is the task of women to take care of the household, the children and the livestock. Not only the high number of working hours which can take up to 15 hours, but also high physical workload like the transport of heavy material on their heads, might be considered as inappropriate. Main tasks of women are to prepare dungcakes (86.1 %), to feed the buffaloes (86.1 %), to clean the animal sheds (91.7 %), to milk the buffaloes (65.3 %) as well as doing housework and other work.

More than two thirds (69.8 %) of the interviewees related the hard work to negative impacts on their body condition. For example, 57.5 % of the interviewed women regularly suffer from temperature stress. In most cases where working women owned one or a few buffaloes (n=47), their work was performed as "unpaid family labor" while the milk was mainly produced for subsistence, informal sale to neighbours or a milkman (dhody). Female farm laborers also participated in the interviews (n=26). These women are facing similar health problems, but additionally complained about inadequate payment. Most of them (61.5 %) are not getting paid in a monetary terms: Commonly the labor (88.5 %) is compensated with non-monetary goods like dungcakes, milk, feed or food.

The combined results of the qualitative and quantitative research approaches indicate that the working conditions for female workers in peri-urban dairy production units of Faisalabad are partly not decent.

Keywords: Decent work, dungcake, women, working condition

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The Role of Islamic Micro-Finance Institutions on Poverty Alleviation and Environmental Awareness in Indonesia

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Micro finance institutions have expanded in Indonesia as well as in large parts of the world. The expansion of micro finance programs has been reviewed as an effective means of empowering poor people, smallholder farmers and entrepreneurs relying on the agriculture sector. At the same time, the Islamic micro finance institutions (IMFI) have well developed to support financial schemes, particularly in rural communities during planting periods. However, the nexus between Islamic micro finance, poverty reduction and environmental awareness has remained largely unexplored.

This study examines the role of Islamic micro finance on poverty alleviation and environmental awareness in Indonesia. The data analysis is based on randomly collected primary level data from three different areas, including: lowland, coastal and mountain areas (180 respondents) using standardized questionnaires, focus group discussions and multistage approaches. In advance, an in-depth literature analysis of the role of Islamic micro-finance to eradicate poverty and increase the environmental awareness has been utilised. The preliminary findings a) give strong evidence that Islamic micro finance has positive effects on improving the welfare of the recipients compared to the control group (90 respondents); 93.3 % of 90 entrepreneur respondents said that their welfare improved after adopting Islamic financial schemes. b) Despite these positive impacts, Islamic micro finance does not affect significantly the environmental awareness although it has contributed positively to the well-being of the poor in general. c) It is captured that litter straggles along the coast and local people do not care about the hygienic quality of their food due to lack of social training on environmental issues. 66 % of 90 (IMFI) entrepreneur respondents did not receive such training on ecological sustainability from the institutions. Nevertheless, Islamic micro finance institutions are concerned about environmental issues but they do not have a mandate to enforce the environmental awareness and the behavior. This would be the task of the local, regional and national governments. The potential role of Islamic micro finance systems in poverty reduction and environmental training should be investigated at larger scale.

Keywords: East Java, environmental awareness, Indonesia, Islamic micro finance, poverty alleviation

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Natural Resources Governance in Northern Kenya: Implication of Institutional Changes on Environmental Management

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Community Based Natural Resources Management (CBNRM) has gained some popularity in the recent past as a panacea for resource governance in many parts of Sub-Sahara Africa, including the arid and semi arid environment of northern Kenya. In most of the places, community groups were created by external environmental conservation agents to address resource degradation. In these cases, customary laws and management practices based on traditional institutions and in-depth knowledge of the environment have been replaced by rules and regulations developed by the environmental management groups. Alienation of traditional resource governance institutions is partly said to be due to poor understanding of how they operate, including decision making and rules enforcement. We studied the implication of these changes among the Borana and Rendille pastoralist communities in northern Kenya. We conducted semi-structured interviews with the members of environmental management groups, elders who were the custodians of the customary laws for resources management, and also held focused group discussions with key informants. In both pastoral communities, contemporary community based approaches to environmental conservation are effective only in areas where active monitoring and guarding of environment by community scouts was present. Elders who were the custodians of traditional institutions are not consulted for important decisions such as development of new land use plans and access to the grazing resources. Furthermore, we observed that traditional institutions had an elaborate system for making environmental management decisions and their enforcement. It is evident that contemporary approaches to participatory environmental management touted as successful model need to be reconsidered in light of problems pointed out. We recommend that a more accommodative model that adequately caters for the roles of traditional institutions, resource use regimes, production strategies and knowledge of local communities be adopted in the arid and semi- arid environment of northern Kenya to enhanced genuine participation.

Keywords: Community participation, indigenous institution, natural resource management, Northern Kenya

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Livelihood and Resource Use Situation of Mangrove Forest Dependent Rice Farmers in Yanbye Township, Myanmar

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Wunbaike Reserve mangrove forest and the nearby mangrove ecosystem have been degraded within a few decades mainly due to agricultural encroachment, conversion of mangrove forest for shrimp farming, and uncontrolled fuel wood collection related to the increasing population pressure in the region. At the same time, mangrove related farming contributes decisively to local food security and to the stability of local livelihoods. Under these conditions there is a need for socially, economically and ecologically sustainable mangrove management in the region. The present study analyses, in the framework of a case study, the livelihood and resource use situation of farm households which are engaged in rice production in the mangrove forests. For that purpose 173 rice farmers in Yanbye Township were interviewed in 2011/12.

The results show that the main forest products extracted by the rice farmer households are fuel wood (by 100 %), wood for fences (by 89 %), fish (by 93 %), shrimp (by 81 %), crab (by 86 %) and vegetables (by 52 %). Besides less than half of the households collected nipa palm as roofing material (28 %), and forest honey (15 %). 98 % of farmers used these products essentially for subsistence purposes. Fish and fish related products as well as crab are the commercial products. On average 80–98 % of the total household income is contributed by rice production in cash and in kind. This demonstrates that for the farm households, rice production might have a strong priority against the preservation of the mangrove forests which applies even more as alternative sources of income are missing and the local population's educational level is low. The public value of the mangrove forests until now has not been assessed, and therefore public interest in preserving it has not been highlighted, with the consequence that it is not high on the political agenda. Our research intends to provide policy input by contributing clarifications with regard to the social value of the mangrove forests, *i.e.* their opportunity costs in case of degradation and loss.

Keywords: Local livelihood, mangrove ecosystem, resource use situation

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Knowledge, learning and extension

Visual Problem Appraisal
Using Filmed Narratives for Learning and Mediated Participation

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The film-based learning strategy of Visual Problem Appraisal (VPA), which is used to enhance the analysis of complex issues and facilitate a plan of action. It is used in workshops dealing with problem analysis and policy design, and involves the participants 'meeting' stakeholders through the latter's filmed narratives. Workshop participants consult stakeholders through watching them on films. A VPA set consists of a series of filmed interviews (between 20 and 30) complemented with two documentaries. These films provide particular perspectives on the contextual reality of the stakeholders. Within a set workshop format of 'scoping', 'stakeholder consultation' and 'action', the participants 'interview' the stakeholders, which gives them a chance to explore the complex and conflictive arena of the issue at stake. The participants soon come to realise that stakeholder consultation is not about finding out one final truth, but about experiencing personal versions and diverse framings of reality. Stakeholders who interviewed and filmed in the VPA production articulate their motives to document their life story and allow exposure by a wider audience as willingness to communicate and share their experiences and views. A major motive is described as mediated participation. Interviewees realise that their filmed narratives may provide access to policy-making processes they are otherwise excluded from.

The first VPA set, 'Rice from the Guyana's' (Witteveen, 2007; reprinted from 1996) focused on international agribusiness and rural development issues in the Guyana's. A second VPA set, 'Kerala's coast' (Witteveen, 2003), was produced in Kerala, India and focused on integrated coastal zone management. A third VPA set, filmed in Ghana, Tanzania and Zambia, focused on HIV/AIDS and rural development in Sub-Saharan Africa (Witteveen, Lie and Thachapuzha, 2008) and a fourth set on rural livelihoods in KwaZulu-Natal, South Africa will be released in 2012.

Keywords: Filmed narratives, learning, mediated participation, social change, visual problem appraisal

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Assessing Sustainable Technology Options to Increase the Resilience of the Poorest and Most Vulnerable

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When a crisis strikes, it is often the poorest and most vulnerable people who suffer most, particularly in South and Southeast Asia where the majority of the world's poor reside. Victims often lack solutions to diversify into sustainable production activities that increase their resilience to shocks and lead to a higher but sustainable productivity level. Knowledge on appropriate technology options exists but is mostly contained in separate "knowledge silos". To make the knowledge available within the region would require increased South-South dialogue and intraregional learning that could spur technology adoption contributing to improved food security and nutrition. But technologies will only be adopted in a sustainable manner if they are suitable and adaptable to farmers' local conditions.

Hence, an analytic framework was developed to identify agricultural innovations that are sustainable, productivity enhancing and suitable for the poorest and most vulnerable parts of the population. The framework contains a set of tools to collect and evaluate information on appropriate innovations based on relevant indicators. In particular, it has sections on environmental, social, and economic sustainability but also on important properties of the innovation itself.

Preliminary information on already available agricultural innovations was collected among project associates from ten countries in South and Southeast Asia, as well as the national and international agricultural research communities. Promising innovations were selected in a group process involving all associates and experts of the respective innovations were identified. A questionnaire was then sent to all experts to collect detailed information and data about the technologies or best practices. Multi criteria decision making was used to involve project associates in constructing a composite technology indicator to compare the available innovations.

All sustainable technologies will be accessible in the online data base of SATNET Asia, the "Network for Knowledge Transfer on Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia". The data base will contain fact sheets, descriptions of typical enabling environments, extension material and recommendations for dissemination strategies as well as links to regional experts and will enable relevant stakeholders and multipliers from research and extension services to find appropriate technology options.

Keywords: Best practice, evaluation, innovation, multi criteria decision making

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Joint Learning to Enhance Innovation Systems in African Agriculture

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Recognition is growing that strong and dynamic innovation systems are essential for adaptation to the rapid changes being experienced by smallholder farmers, including growing population pressure on limited natural resources and climate change. Yet relatively little is documented about how innovation processes unfold in smallholder agriculture. Most researchers, development practitioners and policymakers implicitly or explicitly work with a linear model of transfer of "innovations" from research via extension to farmers for adoption. This seldom reflects how innovation actually happens. Recent studies have revealed that effective innovation takes place within heterogeneous networks of researchers, farmers, private entrepreneurs, NGOs, government and other stakeholders who interact over time in a non-linear, iterative and non-predictable fashion to solve a pressing problem, adapt to new conditions or take advantage of new opportunities. The outcome of such interactions usually consists of a mix of technical, organisational and institutional innovations developed and refined "on the go" – often quite different from what the initiators envisaged.

The EU-funded project JOLISAA (Joint Learning in Innovation Systems in African Agriculture) is assessing recent or ongoing cases of innovation in smallholder agriculture in Benin, Kenya and South Africa, as a basis for identifying lessons about the conditions that favour or impede innovation processes. From their inventory of diverse cases, JOLISAA partners have selected some lessons-rich-cases for deeper analysis. Together with the actors involved in these cases, a collaborative assessment is made of how the innovation process unfolded, the roles and contributions of the different actors and the nature of linkages between them. Special attention is given to the contributions of smallholders to the process. The collaborative assessment is meant to provide lessons not only for the people directly involved in the cases but also more generally for policymakers, researchers and development practitioners, about how to support effective innovation processes that strengthen the knowledge, creativity and linkages of the smallholders themselves. This should render them more resilient to rapid and even sudden changes. The paper presents highlights and challenges related to the methodology as well as initial lessons drawn from the inventory and assessment of innovation cases.

Keywords: Agricultural innovation systems, local knowledge, smallholders

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Participatory Monitoring and Evaluation as a Learning Tool: The Case of Agro-Pastoralists Testing Livestock Production Options to Enhance their Livelihood

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Increasing climate variability affects crop and livestock production and therefore the livelihood of resource-dependent communities such as agro-pastoralists producing in drought-prone areas of Gaza province in southern Mozambique. Adaptation involves a process of learning and development. Learning by experience follows cycles of action–reflection where new knowledge is created and can be enhanced by introducing a structured monitoring and evaluation activity. Learning as a process of iterative reflection includes single-loop (correcting errors form routines), double-loop (innovations to find new solutions), and triple-loop learning (designing new governance norms and protocols).

This research examines how a participatory monitoring and evaluation system (PM&E) stimulated learning in two community based organisations (CBO) that tested a number of livestock production options for their suitability as livelihood strategies. Since most of CBO members are illiterate, a PM&E was developed that could be handled by them. Semi-structured interviews (n=21) and focus groups (n=6) with CBO members were conducted to assess the type of learning occurring (single-, double- and triple-loop learning) after the development and implementation of a PM&E, and its role in enhancing livelihood strategies. The results reveal that the PM&E system permitted the group members to learn from: (1) the community-based activities, as their outcome became more visible and could be easily communicated, allowing the identification of possible improvement options (second-loop learning); (2) the implementation of the PM&E process, which enhanced and fortified members' skills to plan, implement, and follow a PM&E system (single-loop learning); and to learn about (3) the relevance of collective action (single-loop learning) and a change in the CBO governance to plan and implement collective action (triple-loop learning); (4) the importance of transparency and accountability (single-loop learning) in collective action initiatives. The PM&E system promoted learning among and empowerment of the CBO members, which in turn created opportunities for consensus building, collective decision-making and action. It introduced a motivational aspect that acted as a positive feedback, and supported moving from single to double and triple-loop learning, which facilitates the implementation of innovative approaches, and showed to be effective when dealing with uncertainty.

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Impact-Oriented Evaluation for Improvement of Extension Services in Vietnam

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The ability to adjust extension programs to farmers' needs is clearly linked with resilience of the agricultural system. Extensionists in Vietnam are aware of serious limitations in this field. One particular problem is the absence of a useable methodology to improve their services to farmers under serious personal and financial constraints.

A co-operative project between junior lecturers of Hanoi University of Agriculture and Humboldt-Universität zu Berlin has been carried out in order to develop a model for a rapid and impact-oriented appraisal of extension programs to be applied by the National Agricultural Extension Centre in Hanoi.

As a main element, the logical framework approach has been adapted to be used for ongoing programme evaluation. The result is an iterative process of situational analysis, development of a goal system which shows impact pathways for the respective extension programs' activities, intelligent choices on the priority aspects to be analysed, definition and selection of indicators, and rapid appraisals.

After a first hypothetical loop, in March 2012 three extension programmes have been evaluated with the following results:

- The systems' clear orientation towards best farmers is a main constraint. While "collaborative" and "demonstration" farmers who both have formal relationship to the extension system expressed their satisfaction with the trainings, "normal" farmers who typically are the poorer ones are not even addressed by the extension programs and even do not receive input supply such as new varieties or special fodder.
- The main challenges for the vertical knowledge flow between extensionists and farmers are the low number of extensionists on commune and village level, and their heavy workload;
- Horizontal knowledge transfer between farmers is quite effective especially due to informal meetings;
- Farmers' capabilities are different – while the better educated farmers were able to attend and understand the content the extension activities, especially the poorer farmers demanded more practical training and learning by doing;

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- Need assessment and monitoring turned out to be rather informal, sporadic and unsystematic.

The contribution will further discuss consequences for both, application within the system and further development of the methodology.

Keywords: Extension, impact-oriented evaluation, logical framework, Vietnam

Towards Resilience? The Evolution of the Agricultural Knowledge System in Vietnam's Mekong Delta

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Innovative changes of agricultural and rural development of a region, in a knowledge-rich globalised world, are growingly directed, if not determined, by vigorous transformations of its local knowledge system whose functions are to bridge and nourish global and local knowledge interaction and new knowledge creation. This paper adopts a dual issue-based and actor-oriented approach to explore the evolution of the agricultural knowledge system of the Mekong Delta (MD), the largest and highly productive region of agricultural production in Vietnam. Data used in this analysis were collected and selected from one-year field-research in the MD in April 2010–2011. From our issue-based analysis, the region has been confronted chronic post-Green-Revolution challenges of a long pursuit of agricultural modernisation charaterised by top-down planning, water control system improvement, high yield-led intensive production and growth-based progress. As an alternative, over the past decades, sustainable principles and practices have been introduced. At the implementing level, however, the transfer of such new knowledge, because of its more complicated nature, even with foreign concepts is facing difficulties in overcoming epistemological, technical and cultural barriers. Moreover, ever-increasing negative repercussions of the so-called climate change effects such as salinisation or drought as well as dam and dyke-controlled water resources over- or mis-exploitation at inter-provincial and cross-border scales are posing a threat to any sustainable development efforts, with marginalised communities as the most vulnerable groups. Such old and emerging challenges require localised and instrumental knowledge and innovation from novel seed varieties, farming techniques to systemic management of natural resources and pro-poor rural development. Our actor analysis has demonstrated new role-taking of plural stakeholders in knowledge diffusion and generation for agricultural and rural development spanning public, private and civil society arenas, especially the involvement of farmer groups who have less been recognised.

It is argued in this paper from the case of the MD that the resilience of the region's agricultural system to new development challenges more than ever before is greatly dependent upon the resilience of the transformational knowledge system on which it is based, and thus *a fortiori*, to which extent professionals and farming communities co-produce knowledge in partnership.

Keywords: Agricultural knowledge system, resilience, Vietnam's Mekong Delta

Assessing the Impact of Social Learning and Social Capital for the Adoption of Soil Conservation Innovations: A Case Study in Northern Ethiopia

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The adoption of soil conservation innovations demands the development of understanding among the different actors to promote the collective process needed for soil conservation practices. In this regard, social learning and social capital play key roles. However, studies on the impact of social learning and social capital for soil conservation show mixed results. While some studies show positive outcomes of social learning and social capital for soil conservation, others show negative effects. This paper explores the impact of social learning and social capital on the adoption of stone terraces in Ethiopia. Data were collected via semi-structured interviews, group discussions, and in workshops. Moreover, the review of pertinent project documents and literature complements the analysis. The findings show that social learning results for the emergence of social capital elements such as the development of positive interactions among the actors, broader understanding of soil conservation, trust development and mutual understanding. It also opens opportunity to recognize the important role of indigenous and scientific knowledge for the adoption of soil conservation measures. The emergence of the above mentioned outcomes had encouraged the adoption of stone terraces. In contrast, the positive outcomes of social learning were non-existent on non-adopters of stone terraces. The non-adoption can partly be explained by the insufficient participation of non-adopters in learning platforms. Hence, our case study shows that soil conservation policies should invest on the creation or strengthening of social capital through social learning.

Keywords: Social learning, social capital, soil conservation, Ethiopia

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The Impact of Social Networks on Dairy Technology Adoption in North-West Ethiopia

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Social structure, especially in the form of social networks, affects the adoption of agricultural technologies. In light of an increasing focus on new demand-driven agricultural extension approaches that leverage social networks as an opportunity, too little is known about (a) which network characteristics matter? and (b) how do specific network characteristics matter? This paper investigates the impact of social networks in relation to smallholder dairy production technology adoption in Ethiopia. Structured household interviews were conducted on randomly selected 304 smallholder dairy farmers. Combined social network analysis and economic approaches is used to analyse dairy production adoption that incorporates social learning. Results reveal that smallholders acquire knowledge about improved dairy practices mainly from the public extension system (extension network), and to a lesser extent through their close associates (peer networks). The market networks are not a significant predictor of dairy adoption; supporting the finding that innovation is supply-driven by extension rather than market-driven by product demand articulated by traders. Likewise, community networks have no direct effects, suggesting that community-based associations (for example, cooperatives, self-help groups, etc.) are less likely to technology adoption decisions in this particular case. These findings suggest that the potential contributions of other social networks, particularly communication networks and market networks that can significantly affect adoption, often remain untapped. Given the adoption of agricultural production technologies as an essential means of boosting productivity, increase production and improving incomes of smallholder households, these results indicate that technology-promoters may have to change their approach and focus on the innovative use of all kinds of social networks as an important determinant. In addition, this finding shades light to design suitable strategies that leverage social networks to promote more rapid adoption of agricultural technologies by smallholders.

Keywords: Adoption, dairy, Ethiopia, innovation, social networks

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Strengthening Local Adaptive Capacity: The Key to Resilience in the Face of Climate Change

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Climate change poses countless challenges for smallholders, yet the initiatives of these smallholders to respond to change offer entry points to sustainable processes of climate-change adaptation. Partners in PROLINNOVA – a global network for Promoting Local Innovation in agriculture and natural resource management – studied how crop farmers and pastoralists responded creatively to change. For example, pastoralists in Ethiopia observed longer and more frequent drought, but also population growth, less access to grazing and water because of irrigation schemes and national parks, and increased conflict. Their responses include cutting and carrying fodder from national parks, making private and community below-ground cisterns to store water and diversifying their herds to include more goats and camels that can withstand dry periods better than can cattle. Local adaptation in Niger included making more use of donkeys than in the past and collecting hay from communal land to use as dry-season fodder. Such local innovations serve as entry points for farmer-led joint research – a process in which scientists and extensionists join with farmers to further develop the local ideas, integrating local and scientific knowledge. This approach to research and development focuses on the positive – on farmers' innovativeness; it builds mutual respect among all partners in joint research; it stimulates farmers to value their own knowledge and skills; it provides solutions that are less costly and more site-appropriate than many introduced technologies; it enhances the confidence of farmers and gives them greater control over their own development. Above all, it builds the adaptive capacities of rural communities to deal with change. Local people involved in this process are better able to analyse their situation, learn to pool their energies and knowledge, and become better linked with other actors with whom they can continue to take adaptive action to address emerging problems. They thus become more resilient to shocks and stresses in a constantly changing environment.

Keywords: Climate-change adaptation, Ethiopia, indigenous knowledge, interactive research, local innovation, Nepal, Niger, resilience, smallholders

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Institutionalising Participatory Innovation Development in Agricultural Extension: Case Study of Tahtay Maychew, Ethiopia

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Since 2005, the Prolinnova-Ethiopia multistakeholder platform has promoted participatory approaches in agricultural research and development and worked towards institutionalisation of participatory innovation development (PID) in governmental and non-governmental organisations, community-based organisations and institutions of higher education in Ethiopia. A study of the experience of Tahtay Maychew District Office of Agriculture, a partner of Prolinnova-Ethiopia in Tigray Region in northern Ethiopia, revealed that innovations developed by local farmers are being actively promoted by extension agents and subject-matter specialists in the Office of Agriculture. Moreover, this activity is becoming part of their daily routine in extension work, even though the Tigray Regional Bureau of Agriculture does not directly support the approach with structural, financial and human resources. The progress towards institutionalising PID within the extension service at district level was facilitated by the fact that the NGO coordinating the Prolinnova-Ethiopia platform in Tigray Region encouraged the Office of Agriculture to assume full responsibility to implement the activities of identifying local innovation and promoting farmer-led experimentation processes in a way that fitted into the regular extension activities. The study found that the major challenges faced by Prolinnova partners in Tigray Region for better institutionalisation of this approach are: i) the relatively weak collaboration among platform partners other than the Office of Agriculture and the coordinating NGO; and ii) the platform's lack of a clear strategy for institutionalising PID. More active collaboration and linkages are needed at all levels within the region, instead of leaving all the responsibility only with the district-level extension agents. A change in attitude towards the potential of PID as an approach to extension is still needed among decision-makers at higher levels in the Tigray Bureau of Agriculture if sustainable institutionalisation of PID is to be achieved.

Keywords: Ethiopia, multi-stakeholder, participatory innovation development, Prolinnova

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Innovative Approaches of Knowledge Management and Capacity Development for Market Oriented Agricultural Development in Ethiopia

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The delivery of extension services in the contemporary environment of developing countries requires innovative and inter-related approaches of knowledge management, skills development and partner linkages. Improving Productivity and Market Success (IPMS) of Ethiopian farmers project has been testing different tools and processes that give emphasis on market demand, knowledge sharing, capacity development and public-private partnership for improving the extension service delivery in 10 pilot districts of four regional states of the country. This paper explains the IPMS approaches, methods and processes used for effective knowledge management, skills development and partner linkages activities during implementation of value chain based development intervention. The lessons learned provide valuable information for scaling up to other areas with similar potential for market-oriented agricultural development.

The IPMS project followed systematic and step-wise approaches of knowledge management and capacity development by support of various ICT and non ICT tools that facilitated multidirectional knowledge flows, empowerment of practitioners and linkage creation to improve productivity, profitability and sustainability of market oriented agricultural development. Major tools and processes that brought the intervention to fruition include; establishment of agricultural knowledge centres for up to date and relevant information resource delivery, enhancement of programme delivery and technical skills through participatory training; establishing partnership with various stakeholders and institutions at all levels; and developing a web based platform, Ethiopian agriculture portal www.eap.gov.et, for availing agricultural resources relevant to Ethiopian agriculture. A lesson from IPMS on implementing the above components include; the need for an overall understanding of knowledge as a critical 'input' to agricultural development being internalised among programme implementers at all levels; importance in building capacity of actors, not only in being implementers but also in forging linkages, identifying needs and managing partnership processes; and the importance of having all actors on the same page of development agenda.

Keywords: Capacity development, Knowledge management, market oriented agriculture

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Indigenous Knowledge and Adaptation Strategies of Pastoralists to Climate Variability in Northern Kenya

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The Fourth Assessment Report of the Intergovernmental Panel on Climate Change indicates that the anticipated warming in sub-Saharan Africa is expected to be greater than the global average. Consequently, in-depth pastoralists' indigenous knowledge (IK) of complex agro-ecological dynamics is critical in detecting availability and appropriate management of rangeland resources. The current study aimed at describing the IK and adaptation strategies that have been practised by the Rendille pastoralists in Marsabit County of northern Kenya over time. Data were obtained through formal personal and key informant interviews and focused group discussion. MS Access software was used for database management while the General Linear Model Procedure of SAS was used for quantitative analyses. A chi-square analysis was performed where deemed essential to establish the association between different attributes studied. The information gathered from qualitative approach were categorised through identification of various thematic areas on IK and adaptation strategies, and organised into coherent categories for inferences. Pastoralists in the study area used various IK indicators from flora, fauna, climate variables, astrology and general environment in drought monitoring. Although the indicators were not compared with seasonal forecasts issued by the formal institutions, it is evident that this rich knowledge is yet to be fully harnessed and optimally combined with modern science. The pastoralists have developed a basket of reactionary adaptation strategies to maintain their animal genetic resources in the rangelands. It is concluded that creation of livelihood conditions that enable the pastoralists to respond to climate changes by addressing the linkages between poverty and vulnerability is critical for successful adaptation strategies in the rangelands.

Keywords: Adaptation, climate, indigenous knowledge, Kenya, pastoralists

The Impact of Religiosity on Economic Success in Rural South Africa

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Recent literature argues that development research should take into account social and cultural factors such as religion. Religiosity, it is often argued, affects economic performance in two ways. On the one hand, it has an intrinsic effect causing individuals to be hard-working and frugal. On the other hand, religiosity has a social effect and is a source of social capital. As such religiosity constitutes a resource that yields economic returns. It serves as an instrument of risk-mitigation, reduces transaction costs, and enables collective action. In some cases churches even provide economic infrastructure such as savings groups and small business support. This social capital function of religiosity is particularly relevant in rural areas of developing countries where adversity is high and at the same time institutional structures are weak. There it contributes to improving livelihoods and their sustainability. Against this background the objective of this paper is to assess the economic impact of religiosity in the specific context of rural South Africa. For this purpose a survey of 207 households was conducted in Fetakgomo Municipality in the Limpopo Province. Fetakgomo is entirely rural and – like South Africa as a whole – has a high religious diversity, particularly within the Christian religion. Data was collected on income, religiosity, and socio-economic characteristics of the households. Household income includes formal and informal labor income, social grants as well as the implicit profits from subsistence agriculture. Based on non-linear regression models it could be shown that membership in certain denominations has a significant positive effect on household income while correcting for main income determinants such as age, education, and household size. The practice of traditional African religion has a significant positive effect as well.

Keywords: Household welfare, religion, social capital, South Africa

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Scientific and Local Knowledge on Climate Change in Tropical West Africa: Do Farmers' Perceptions Fit the Measured Changes?

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The perceptions of climate change shape farmers' adaptation decisions. However, there is a huge debate on whether farmers' perceptions of climate change are relevant, true and realistic for further adaptation analysis. This paper aims at comparing the climatic variability - scientific knowledge referring to rainfall and temperature variabilities - and the farmers' perceptions - local knowledge - of climate change. Secondary data such as daily rainfall series from 1952 to 2010 and temperature series from 1950 to 2008 were collected, respectively from the rainfall station of Toffo and the synoptic station of Bohicon. Primary data on farmers' socio-demographic characteristics and perceptions of climate change were collected by a sample of 184 household heads randomly selected in the Municipality of Toffo in the Republic of Benin. On the one hand, the secondary data reveal that the cumulate average rainfall over the sub-periods 1952–1969, 1970–1989, and 1990–2010 were 1111.7 mm year^{-1}, 1014.1 mm year^{-1}, and 1183.5 mm year^{-1}, respectively. Besides this trend, the number of rainy days has declined and the wet seasons' length has shortened. After 1978, the minimum and average temperature increased about 0.8°C and 0.7°C, respectively. Subsequently, there is a significant difference ($p < 0.01\%$) between the averages temperature recorded between 1950–1978 and 1979–2008. From the primary data on the other hand, it came out that changes in rainfall and temperature patterns were respectively perceived by 93.5 % and 97.8 % of the respondents. As a general trend, the respondents perceived that rainfall quantity decreased as well as the number of rainy days and the length of the wet seasons. For 80 % of the respondents temperature has increased. Most of the respondents situated the beginning of the perceived changes between 1985 and 1995. Considering rainfall, therewere two main points: one between 1975 and 1985, and the second one between 1985 and 1992. As a result of the study, the changes perceived by the respondents corroborate very well the scientific results. The decrease in rainfall noticed by the respondents was only related to the decreased number of rainy days and the shortening of the wet seasons.

Keywords: Benin, climate change, climate variability, farmers' perceptions

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The Right to Adequate Food within the School Feeding Program for Quilombola Communities in Amapá, Brazil

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The Federal funds of the National School Feeding Program in Brazil are transferred to the State or Municipal Education Departments and in some instances directly to the Schools and are used for the procurement of food stuffs. Its objective is to contribute to meeting the nutritional needs of students and healthy eating habits. In 1988, the federal constitution recognised quilombola traditional territories rights and the right to adequate food in the public schools for all students. Quilombola are afro-descendants who live mostly in rural areas and considered to be one of the most insecure social groups. Since 2005, schools in quilombolas areas in the State of Amapá have received double per capita to provide better food for this group to improve their food and nutrition security situation. The revised School Feeding Program law signed in 2009 reaffirmed the right to adequate food for all students in public schools. In 2010, the Federal Constitution amended to explicitly recognised adequate food as a Human Right. The objectives were to analyse the realisation of the right to adequate food within the school feeding programme for quilombola in practice in the State of Amapá and to identify whether the programme functions in accordance with the existing national and international legislation. This is a qualitative exploratory research to describe the perception of quilombolas students and their families about the school feeding program, from a human rights perspective, through participant observation, written essays and in-depth interviews with public officers, right holders and stakeholders in charge of recourse mechanisms. Students don´t eat the meal at school when it is not good or enjoyable. Students and families don't complain when the school doesn´t offer food neither when the food is not good. Rights holders don´t know about their rights, neither about recourse mechanism. Even Brazil recognised the right to food in national legislation, the State is not meet its obligation to respect, protect and fulfil the right to adequate food within the school feeding programme for quilombola.

Keywords: Human right to adequate food, Quilombola, school feeding

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Farmer Learning in Rotational Farmer Groups: Case Studies from the Rwenzori Region, Western Uganda

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The present abstract sums up the work from a MSc thesis written at the Institute of Food and Resource Economics under the Agricultural Development programme at the Faculty of Life Sciences, University of Copenhagen, Denmark. It deals with farmer learning in farmer field schools focusing on agroecological methods, in which members rotate between each other's farms.

Using members farm's as a field of interaction and source of experience supporting member's learning processes is a rethinking of the traditional Farmer Field School concept. Taking departure in learning about agroecological methods in the so-called Farmer Family Learning Groups in the Rwenzori Region, Western Uganda, this study examines the social dynamics of learning and individual members learning processes. The methods are qualitative interviews on individual and group level, using the tool 'learning history' as a tool for capturing farmer learning processes. The framework for analysis primarily base on Kolb's experiential learning process and Nonaka & Takeuchi classification of knowledge. The (tentative) findings are that: in order for farmers to benefit from rotation between members, social capital determining the social dynamics of rotation has to develop in the group; farmers have different learning styles and thus benefit differently from different learning situations; farmer's learning styles appear to be influenced by factors such as social status, pride and educational opportunities. The recommendations are for rotation to go hand in hand with efforts to build social capital.

Keywords: Adoption, agroecological practices, farmer field schools, farmer groups, group interactions, learning processes

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Food security and adaptation

Increasing Resilience to Climate Change and Economic Shocks in Small Scale Agriculture in Zambia

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In this empirical research work, the question was explored on how Zambian small scale agriculture can develop and thereby increase its resilience to climate change and economic shocks. Based on a resilience concept, which encompasses the categories buffer capacity, adaptive capacity and organisation and also considers economic criteria, data from expert interviews and farmer's focus group discussions were analysed according to these categories. By doing so, six measures were identified as particularly suitable in order to increase both in one: resilience to climatic change and resilience to economic shocks. These are: Further crop diversification, expansion of conservation agriculture, expansion of animal draught power, punctual intensification of irrigation, introduction of an e-voucher-system and revitalisation of a warehouse-system. How these measures impact on resilience and how they can be established on the local up to the political level was elaborated in multi-level-charts together with Zambian experts and policy makers. Aside of this more applied oriented result, the data analysis also relieved the more academic result that effective adaptation measures towards climate change are mostly also effective towards economic shocks and these two categories largely foster each other. In the paper, three of the identified measures are further outlined, *i.e.* the e-voucher system, which enables small scale farmers to buy the inputs they need in a more flexible way, conservation agriculture, which improves the buffer capacity of soils and boosts yields at the same time, and crop diversification, which lowers production risks against the background of increasing price and climate variability. While incentives are necessary on each level and from both the government and the private sector, farmers' adaptive and organisational capacities have to be strengthened in a parallel process in order to strengthen their ability to apply the suggested measures successfully. Last but not least, the results suggest that the measures have to be implemented as a bundle. Standalone measures are not strong enough to buffer shocks sufficiently and they cannot develop synergies. Only in a bundle, spill over effects can be achieved and the full benefit can develop.

Keywords: Adaptation to climate change, adaptive capacity, agricultural policies, buffer capacity, economic shocks, multi level charts, organisational capacity, resilience, small scale agriculture, Zambia

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Price Variability and Consumption Patterns: Implications to Food Security Using Panel Data from Rural Ethiopia

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The earning from agricultural production has been historically low and unpredictable for Ethiopian small holders. This pressure from prices has somewhat shaped the consumption patterns of households in rural Ethiopia thereby reflecting their strategy to overcome food insecurity. However, achieving food security has been a growing challenge in recent times particularly since 2006 due to macroeconomic imbalances and inflationary pressures fanned by rising global commodity prices of food and fuel. Hence, an understanding of food consumption patterns and parameters is fundamental to predicting the effects of policy changes on households with different characteristics. This paper examines the impacts of different factors including changes in prices, income and demographic variables in influencing the consumption behaviour of households in their rational move to attain food security.

Quadratic Almost Ideal Demand System (QUAIDS) is used since it provides a unified framework for analysing the combined effects in a systematic way. The QUAIDS augmented with selected village and household characteristics is estimated to derive the elasticities and the outlay equivalent ratios.

The research also attempts to evaluate changes in consumption patterns of households across villages and clusters formed based on major agro-ecological zones and sub-zones in the country. Moreover, sufficient treatment will be given to look at households' consumption behaviour overtime and understand how it reflects (relates to) their status of food security. A longitudinal rich data set from the Ethiopian Rural Household Survey (ERHS) is the primary data source for this study. The ERHS is conducted by the Department of Economics (Addis Ababa University) in collaboration with International Food Policy Research Institute (IFPRI) and Center for the Study of African Economies (CSAE- University of Oxford). The panel data set includes 15 peasant associations and a total of 1477 rural households surveyed for four rounds in five years interval since 1994. Finally, based on the results, the research will draw policy implications that will be used by both policy makers and other researchers targeting on food security of rural households in Ethiopia.

Keywords: Food demand, food security, rural Ethiopia

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Explaining Farmers' Drought Management Behaviour in Southern Iran

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Rural households' income in developing countries is highly uncertain in face of the enormous risks such as drought-induced shocks. Drought damages can be widespread and cause significant economic losses, particularly in agriculture. It has led, also, serious short and long-term impacts on the households' well-being. For example, in Iran, fifty villages in Kerman province were evacuated due to lack of water in 2000 and more than one million head of livestock perished throughout the country.

As such, it is important to analyse the management strategies to lessen the effects of drought. The question that needs to be addressed in the agricultural sector is that how farmers perceive and manage drought. Insight into the farmers' perceptions and drought management can be the missing link between the increase of sustainable productions and the reduction of vulnerability. It also provides a knowledge base for developing public policy measures which ultimately aim to increase a desirable drought management among farmers. This paper reports on a study to elicit the factors explaining drought management practices in southern Iran. For this purpose we have applied a social-psychological model, the theory of planned behaviour, to identify the psychosocial factors that influence Iranian farmer's decision-making process to engage in drought management practices. The focus of the data analysis was on exploring the influence of drought management determinants *i.e.* attitudes, perceived behavioural control, and social norms, as theorized by the planned behaviour theory, on the farmers' drought management practices

We chose our sample of farmers who suffered from drought (n=100) through a multi-stage stratified random sampling method in Boushehr Province, southern Iran. Findings revealed that the theory can explain intention and behaviour regarding drought management. Multiple regression analysis showed that the factors such as awareness regarding drought, drought effects and perceived behaviour control regarding drought management could predict 33 percent of variances in drought management intention, while intention regarding drought management, awareness regarding drought, drought effects, and subjective norms and irrigated lands could predict 65 percent of variances in drought management behaviour. We formulated suggestions for a better drought adaptation.

Keywords: Drought, drought management, farmers, southern Iran, theory of planned behaviour

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Can Urban Agriculture Land Use Planning Maintain the Resilience of Dar es Salaam's Food System?

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Rapid and unplanned urbanisation threatens future sustainable development in cities like Dar es Salaam, Tanzania, with a growing population of 4.39 per cent annually. Due to the pressure to rapidly modernise, existing activities and physical aspects of the urban space that contribute to the resiliency of the urban environment, like urban agriculture, are often ignored. Urban food production, or urban agriculture, in Dar es Salaam contributes substantially to the informal labor market and economy, as well as to human and environmental health. Despite all of these positive attributes, the increasing value of land within the city maintains the paradigm that agriculture is not an important urban land use. Nevertheless, not all stakeholders believe this to be true; the inherent value of urban food production has been recognised and the process of conserving agricultural land on the periphery of the city is underway. This study concerns the current legitimisation of urban agriculture within the Dar es Salaam Master Plan 2012–2032. It investigates the interactions of key stakeholders at the local and national government level, as well as the advantages and disadvantages of creating urban agriculture zones and its impact on urban farmers. Data collection was carried out during February to August 2010 and January to April 2012 and collected through an action research methodology. Information concerning the legitimisation process was obtained mainly though semi-structured interviews with key stakeholders, strategic planning and visioning sessions, workshops and site visits. It was found that although the conservation of land around the periphery of the city could buffer the impact of urbanisation on the Dar es Salaam food system, many of the existing open space urban farmers in the medium density areas of the city might not benefit from this process. This is due to the fact that the implementation and coordination of such 'urban agriculture zones' has taken into consideration those who currently occupy the zoned space. In conclusion, producing food within the city limits contributes to economic, social and environmental resiliency, but local and national governmental processes can often marginalise an already resilient activity, such as open space farming within the city.

Keywords: Food systems, global south, legitimisation, sustainability, sustainable development, urban agriculture, urban resiliency, urbanisation

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Impacts of Rising Food Price on Household Welfare and Incidence of Food Insecurity in Kenya

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In line with the world food price crisis, Kenya has witnessed food price increases in the recent past. This study attempts to evaluate the welfare and food security impacts of food price increases between 2005 and 2009 in Kenya. Estimates from a quadratic food demand system and a net benefit ratio are used to evaluate the welfare impacts while an ex-ante estimation of food poverty incidence using Foster Greer and Thorbecke (FGT) measures is employed. Scenarios allowing for perfect and imperfect price transmission between agricultural producers and food consumers are simulated. This is to reveal whether, in presence of rising food price crisis, agriculture offered a cushion, and if so to which income group of households. As well, it reveals the role of the market in transmitting prices efficiently and effectively. Results reveals that, with uniform price transmission (consumer to farm gate), the negative impact of food price increase was reduced by about 83 % (43 % to 7 %) for rural and 16 % (44 % to 37 %) for urban households. the lowest income decile benefits if price increases are uniformly transmitted and one would need to take away equivalent of 27 % of the pre-crisis food expenditure from the lowest rural income quintile. Food insecurity increased (decreased) most (6 %) for urban (rural) poor households. Welfare and food insecurity impacts were more severe for urban poor households and these would be better off with cash than in-kind transfers. Improving agricultural productivity, subsidies and price supports for vegetables and maize, improving price transmission and up-scaling and proper geographical targeting of the safety net programs are some of the viable options.

Keywords: Food insecurity, food price increases, Kenya, welfare

Applicability and Spillover Effects of ICRISAT Technologies – Enhancing Benefits to the Global Farming Community

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Sustained, well-targeted, and effectively used investments in agricultural R&D improved productivity worldwide and thereby contributed to food security. In this context, research spillover effects refer to situations in which a technology that is developed for a specific target region or product is also applicable to other locations or products that are not targeted during the research process.

This study examines the impacts of ICRISAT groundnut breeding research with particular attention on the most critical production constraints facing smallholder farmers in sub-Saharan Africa and Asia. Based on a review of literature and expert elicitation among groundnut experts, it is hypothesised that new technologies addressing the most binding productivity constraints ranked in order of importance (*i.e.* 1. drought, 2. leaf spots and 3. rosette virus) will produce a significant level of direct and spillover impacts as the new technologies developed generates new knowledge which could be adapted far beyond the locations or regions where ICRISAT research is originally targeted. The approach builds on the international trade model using the principle of economic surplus and applies recently developed tools in GIS and spatial analysis of inter-country and inter-regional research applicability of new technologies across a range of ago-climatically homogeneous research domains and thereby estimates the research spillover benefits of crop breeding research globally.

Utilizing these information will lead to further spread of new varieties that were developed to fit better in the current farming system or aim at improving this. Furthermore, the increased uptake of groundnut technologies will improve soil fertility as well as nutrition of the rural population based on a diversified diet and the nitrogen fixation abilities of legume crops.

Keywords: Agricultural research, impact, spillover effects, targeting

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Microfinance for Ecosystem-Based Adaptation to Climate Change (MEbA)

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The impacts from climate change and extreme weather events relate to not only on the changes and extremes themselves, but also on exposure and vulnerability they produce. Adaptation and adaptive capacity are therefore key concerns in climate change actions. The Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance addresses in its work the financial dimension of climate change mitigation and adaptation. The project 'Microfinance for Ecosystem-based Adaptation to Climate Change' (MEbA) works to elaborate innovative financial instruments and mechanisms that will support vulnerable local communities, small land holders, farmers and other rural actors in the Northern Tropical Andes of Peru and Colombia in adapting to climate change.

The underlying concept of MEbA is to encourage Microfinance Institutions (MFIs) to invest in the resilience of ecosystems upon which these communities depend in order to secure and maintain their livelihoods. MEbA will try to connect two worlds of thinking and acting that are normally rather separate; the world of finance and the world ecosystem-based strategies.

MEbA proponents and MFIs will partner in the respective regions to include adaptation-related measures in their portfolio of financial services and products. Possible measures include sustainable land and water management, disaster risk reduction and establishment of diverse (and more resilient) agroforestry systems. In order to achieve these aims, vulnerabilities of targeted ecosystems and climate risks, the dependence of local populations on the health of these ecosystems for their wellbeing and relevant MFI portfolios will need to be identified and assessed.

Another essential concept of MEbA is that risk management and adaptation to climate change should be integrated into the MFI investment portfolios to reduce exposure and vulnerability in rural communities while at the same time increasing climate resilience. Increasing resilience and reducing vulnerability to climate change will also contribute to mitigation.

The presentation will facilitate a discussion about the crucial role of investments and funding in climate change mitigation and adaptation in both rural communities and MFIs. The resulting discussions will help to fine-tune the project activities and to incorporate relevant experiences of conference participants.

Keywords: Adaptation, agriculture, agroforestry, Andes, climate change, climate finance, climate risks, Colombia, disaster risk reduction, ecosystem-based, financial instruments, financial mechanism, microfinance, mitigation, Peru, resilience of ecosystems, smart

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Nutritional Adequacy in Africa: The Bases for Planning Sustainable and Diverse Food Supply

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The relative increase in regional and global cereal production can be paralleled by the decline in legume and vegetable production affecting the micronutrient supply. This can coincide with the emergence of simplified diets, lack of dietary diversity, the nutrition transition phenomenon and the coexistent of hunger, malnutrition, obesity and obesity related systemic diseases. It has therefore become necessary to test the adequacy of the diets of some selected countries in Africa in order to find out the state of the matter and hint the direction for change.

The continent is virtually divided into four regions from which two representative countries are arbitrarily selected. FAOSTAT and WHO regional food consumption patterns were used as the source of information on food types, qualities and levels of consumption. Data are entered to the Nutrisurvey tools in order to test the adequacy.

In Egypt, Ethiopia, Cameroon and Ghana food ingredients from plant origin make more than 80 % of the diet. In Algeria, Kenya and Zimbabwe this fraction account for about 70 % of the diet and in South Africa it lies at levels as low as 61 %. Cereals are the major sources of food energy in North, East and South Africa, whereas in West Africa roots and tubers are equally important. The average energy value of the daily diets is 2749 kcal. In North Africa and Ghana the daily diets contain 3346 and 3522 kcal respectively, whereas in East Africa the energy content is 2077 kcal, in Ethiopia it goes as low as 1900 kcal.

All of the countries have proved to be calcium deficient. All except Algeria, Egypt and Ghana, are additionally deficient in folic acid. Ethiopia, Kenya and Zimbabwe are also deficient in Fe, K, and vitamin C. Vitamin A, E and some vitamin Bs are lacking in Ethiopian diets. The problem is probably attributable to the low intake of the total diet. S. African diet is apparently adequate in Fe but deficient in folic acid and vitamin C.

Keywords: Africa, food quality, food types, level of consumption, nutritional adequacy

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Assessing Adaptation to Climate Change: Environmental and Socioeconomic Changes in the Andes of Bolivia

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Bolivia contributes only 0.04 % carbon dioxide emission of the world, yet smallholders are particularly vulnerable to changing social and environmental conditions. These changes have led to an increase in food insecurity and losses in production due to drought, frost, disease, and pests. This article outlines the understanding of adaptation to climate change and its impact on environmental and socioeconomic changes that are affecting the livelihoods in communities of the Andean region. We use a case study of Charazany valley in The Apolobamba National Park; northwest of La Paz – Bolivia. Mainly qualitative methods were used to collect and analyse data following the framework for participatory vulnerability assessments. Primary data was collected at the community level applying different participatory research methods. According to the Bolivian National Institute of Statistics (INE 2010), the occurrence of extreme weather events are increasing since 2002, particularly drought, frost, hailstorms, landslides and fire. Equal observation has been made by local communities which highlight them as the principle reasons for their losses in production. Community members are forced to search for new off-farm alternatives beyond agriculture for subsistence, like working in construction, mining, and manufacturing (INE 2004). This means a significant impact on the structure of the families and their respective role in the agriculture activities. Nevertheless there is a correspondingly large array of possible adaptation options that families are implementing. Most of them are related to ancient traditional techniques in agriculture; as example the use of local bioindicators to forecast the weather, variation in time and space of plantations, conservation *in situ* of indigenous crop varieties. Intensification of land use, diversification of irrigation system and water storage practices and the use of artificial products are some techniques adopted as conventional practices that can prevent losses in production. The local organisation is aware of the problem, however, testimonies point out that farmers don't have the capacity or the economical resources to mitigate the risk in production. Several actions have been considered to promote the adaptive capacity; nevertheless the current target is to improve existing livelihoods and reducing vulnerability in the long term in comparable short time.

Keywords: Adaptation, Andes, climate change, participatory vulnerability assessments

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Link Between Cash Crop Production and Household Food Security in West Africa: The Case of Cashew Promotion in Benin

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Cash Crop production often is suspected to be contradictory to food security. In order to understand the impact of cashew promotion on food security in Benin, a survey has been conducted by the African Cashew Initiative (ACi) in 2010–2011.

In Benin, cashew nuts represent the second export cash crop after cotton. For about 200,000 people the cashew sector plays an important role in setting their livelihoods, within those 180.000 small scale farmers. In 2011, the total cashew export from Benin was about 140,000 MT and its contribution to GDP was 4 %. With about 1–2 ha only, Cashew orchards are largely cultivated by small-scale farmers beside food crops for consumption and selling.

Data from 657 cashew farming families in 13 districts was collected and used to **(1)** determine the extent to which income from cashew helps to avoid or helps to reduce the frequency, duration and severity of poor households' food shortages and **(2)** to determine the potential impact of the ACi interventions on household food security, especially the potential for reducing or eliminating food shortages.

The findings show, as dry season coincides with the start of the cashew harvest and trading, farmers have the chance to earn money by selling cashew and to reinvest it into households' food security. One can state that cashew production and selling helps to avoid food shortages. 43 % of the surveyed households experienced food shortages while 57 % did not. Amongst those who had experienced food shortages, 94 % pointed out that income from cashew had worn away households´ food shortage and/or reduced the severity of the situation. Concerning the group who had not experienced food shortages, 75 % mentioned likewise their additional income from selling cashew.

The Benin case shows, that cash crop production and food security are linked and not necessarily contradictory. Small-scale farmers do profit from income generated by cashew production on their fields especially in a time, when households need money to stay food secure.

Keywords: Benin, cash crop production, Cashew, food security, small scale farmers

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Winds of Change: Livelihoods of an Iban Community in Transition

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As the Malaysian economy becomes increasingly globalised, and interventionist policies of agricultural modernisation are pursued, rural communities are changing. Many livelihoods which were traditionally farm-based are shifting towards a state of mixed rural-urban strategies. In this case study, a number of trends and shocks were examined in order to assess the resilience of rural Malaysian communities against crisis.

The study was conducted in an Iban longhouse community in South-West Sarawak, Malaysia. An interdisciplinary approach to data collection was employed, incorporating both social and natural science methods. Multiple shocks and trends were found to affect assets in the village, acting as drivers of livelihood decisions. To these belong mobility, land tenure, government incentives, fluctuations in cash-crop markets, logging and environmental degradation.

The identified shocks and trends were not found to pose a major threat to the current livelihood strategies due to the abundance of relatively diversified livelihood portfolios and a general shift towards wage labor. The households most vulnerable were those involved in cash-crop farming and a lack in stable sources of income. Food security in the village is high, due to the maintenance of subsistence lowland rice cultivation by the majority of households. Culture and tradition play a key role in continuing traditional farming systems, despite some signs indicating that a lack of labor, as a result of migration, has influenced the abandonment of hill rice cultivation. Logging and environmental degradation have affected natural assets, but decreasing reliance on these assets means that livelihoods have not been significantly affected. Although land tenure currently remains under Native Customary Rights law, the community's recent application for land titles provides a positive outlook for future land security and even opportunities to diversify livelihoods through re-engaging in agriculture (re-agrarianisation). However, the benefits of the titling process will vary greatly among households. At present, increasing mobility and the continuing process of de-agrarianisation are most prevalent in providing resilience, by reducing vulnerability to environmental degradation and dependence on cash-crop markets. Flexibility of livelihood portfolios increases resilience by allowing for new livelihood opportunities to be capitalised upon.

Keywords: Cash crops, de-agrarianisation, diversification, Malaysia, mobility

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China' Soybean Import Demand: An Analysis of Impacts of Price Fluctuation and Agricultural Policy Transition

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After WTO accession in December 2001, China's international trade developed rapidly. In 2004, China started to have an agricultural trade deficit and its deficit has been increasing at a large rate since then thanks to the soared agro-food imports. China is the largest destination market for global soybean exports and accounts for about two-thirds of the total global soybean trade. The soybean import value of China increased dramatically especially after 2001 from 2.2 USD billion in 2000 to 29.7 USD billion in 2011, with average annual growth rate more than 31 %. With the increasing global food price and expanding domestic demand of China, the soybean import demand analysis becomes the central issue concerned by scholars and Chinese government. In recent years Chinese government pays more attention to "San-Nong" problem (*i.e.* the three agricultural-related issues: agriculture, rural areas and peasants). Accompanying the reduction and elimination of agricultural taxes and fees, the Chinese government has started to introduce various subsidies-including direct payments to grain producers based on acreages, subsidies for purchased farm inputs, for improved varieties of seeds and for the purchase of agricultural machinery. Since 2008, soybean production has been subsidised from the government. In order to analyse China's soybean import demand and forecast the future trend under the increasing global food price and domestic agricultural policy transition, China's soybean import demand function is built and ARIMA model is used. Results show that the policy transition from taxing to subsidising agriculture, domestic soybean production and exchange rate have significant effects on soybean import. After parameter estimation and test, ARIMA (1, 4, 1) is chosen as the best forecasting model and can predict the trend of soybean import. Although there is a slight decrease in soybean import in 2011, it is predicted that in 2012 China's soybean import will increase around 10.5 %. More domestic agricultural subsidies are necessary to encourage Chinese domestic soybean production and trade policy adjustment to satisfy domestic consumption.

Keywords: Agricultural support, ARIMA model, China, soybean import demand

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Household Food Security under the Conditions of Poverty: Evidence from Kordofan Region, Central-West Sudan

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Despite the proper efforts that have been made by government and NGOs to support the food security in Sudan, there are still significant numbers of food insecure people in the country. Several factors are responsible for this, including: limited access to food, due to low productivity of agricultural crops and drastically increase of food prices which effects on the food security status of farm households, who access the majority of their food from the market. This situation forced the farm households to adopt different coping mechanisms in order to secure their food consumption. This paper will give detailed findings on the potential impact of socio-economic and environmental factors that hinder the household food security under the conditions of poverty. It will also argue that if the income from agricultural growth is spent locally and rural off-farm activities are promoted, this can have a considerable impact on the incomes of the poor. The data were collected in Kordofan region, Central-West Sudan during the season 2009/2010. A structured questionnaire was prepared and distributed to 200 farm households using multi-stage random technique. In addition, group discussions were conducted with key informants to ensure the accuracy of the data in the questionnaires. Descriptive statistics and econometric estimates were used to analyse the primary data obtained from the survey. The results of the descriptive statistics show that 75 % of sampled households did not have sufficient food to secure their needs, especially during the off-season, whereas 73 % of households reported inadequate income to buy food. In addition, the results of OLS regression show that the costs of production inputs, seed, area cultivated, type of land, rainfall distribution, net farm income, off- farm income, and animal ownership are the significant variables determining the food security status in the area. Given the close link between local production and food insecurity, investments in the agricultural sector that increase food availability and strengthen the resilience of the food production system will have immediate positive impact on all elements of food security in food insecure areas.

Keywords: Environmental factors, food prices, food security, off-farm income, poverty, productivity

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Effects of Vietnamese Controlled-Price Policy on Competition with Thailand

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Vietnam and Thailand are the two top rice exporters who contribute more than 50 % of market shares in the international market. Therefore, any changes in their rice policies have a strong influence on the world market.

Currently, the strongest and most frequently impact on the Vietnamese rice industry is the controlled-price policy that regulates the competition in rice market. It restricts the volume of export rice in order to ensure national food security. In terms of economic efficiency, this policy keeps Vietnamese rice production under its full potential compared with the Thai rice industry. Many experts suggest that Vietnam puts more attention on national food security than necessary. This causes market distortion and weakens the Vietnamese competition with Thailand.

In order to examine the effects of the controlled-price policy with a quantitative method, we build and run a spatial equilibrium model with 3 different scenarios: (1) Controlled-price policy updated every week; (2) Controlled-price policy updated every month; (3) Controlled-price policy updated every 3 months. With known production, consumption, domestic price, transportation cost and elasticities of demand and supply function of Vietnamese and Thai rice industry, the model shows that with less changes in the controlled-price policy, the competitiveness of the Vietnamese rice on international markets rises without having negative effects on the national food security goal. Non-rice farmers will be losers due to higher domestic prices for rice, but the majority of the population who are farmers, accounting for more than 70 % of the population, will benefit from the higher volume and turnover of rice export, and so the net social revenue will increase also. Therefore, we highly recommend that the controlled-price policy should not be too often changed in order to achieve a better competitiveness of Vietnamese rice.

Keywords: Rice export, Vietnamese rice policy

Plant Breeding and Food Security:
Targeting the Needs of Resource-Poor Farmers in Plant Breeding Programs for Marginal Areas

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We establish the internationally agreed definition of food security, which rests on the three conditions of food availability, access to food, and issues of food utilisation. We then outline how decentralised and participatory plant breeding approaches (PPB) can effectively address each of these aspects, based on experiences gained in various geographical regions. In the past, conventional plant breeding programs have mainly concentrated on increasing food availability. Other aspects of food security have attracted far less attention in most breeding programs. Furthermore, poor farmers working under marginal conditions do not "automatically" profit from breeding work done under more favourable conditions. Rather, plant breeding for marginal environments requires that the specific set of conditions which is typical for such environments will be addressed.

Participatory breeding methods can contribute to all three aspects of food security – availability, access and utilisation. Even under marginal conditions, yields can increase substantially and periods of food shortage can be curtailed, and not at the expense of other factors such as yield stability or food quality.

Several studies suggest that farmers can increase their revenue or make cost savings through the implementation of PPB. Informal rural seed networks combined with PPB measures play an important role in assuring access to food, particularly for the poorest members of farming communities. Owing to its decentralised organisation, PPB programs generate many different varieties for different production conditions and purposes. The approach tends to enhance food diversity and to maintain traditional knowledge that can help counteract food shortages and malnutrition.

Thus, the unique potential of PPB for improving food security is the impact it can make in those very situations where people are afflicted by food insecurity. Progress can be achieved for specific production conditions and user groups, not simply through breeding in its narrowest sense, but by bringing the context, the objectives and the direction of the breeding programme more sharply into focus. PPB approaches can form part of comprehensive strategies to adapt farming systems to climate change by increasing the options available to farmers for flexible adaptation to shifting circumstances.

Keywords: Food security, marginal environments, plant breeding

Community Resilience and Climate Change

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The effects of climate change present some of the major challenges that will haunt mankind for a long time to come. Climate change has already affected the livelihoods of many smallholder farmers across Africa, who largely rely on rain-fed agriculture and other natural resources.

For instance, farmers around Soroti, Northern Uganda, can observe a change in rainfall patterns over the past few years. Living in the floodplains close to Mount Elgon, they are used to frequent floods but also droughts. However, the unpredictability of rainfall patterns is a new phenomenon and presents a challenge they have to adjust to and cope with. An investigation was undertaken by a team of DAAD Alumni from eastern Africa region to i) assess the climate change resilience of the rural communities and ii) identify their coping strategy to the above challenge brought by climate change and variability. Household surveys and historical data analysis were conducted in two sub-counties namely Gweri and Dokolo of Soroti district. The rural communities of Soroti district are very vulnerable to climate change related impacts, due to their low level of resilience to these shocks; exacerbated by high demographic pressure, low income; inappropriate food storage, inadequate access to health services, erosion of indigenous knowledge, limited access to energy; violent conflicts with neighbouring communities, high frequency and magnitude of the shocks. Farmers have taken steps to adapt to the climatic changes and variability related negative impacts. The most common adaptation strategies in the region include change in lifestyle from livestock keeping to agriculture; change in the types of crop, planting date and migrating to other areas. A strategy to enhance resilience was participatory developed with the two rural communities in order to increase their productivity with minimum soil degradation, increase their access to market and market information, empower them in participatory planning and plan implementation.

Keywords: Climate change, participatory planning, resilience, rural communities, vulnerability

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Natural Shocks, Risk Perceptions and Resilience: Evidence from Cameroon

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Invariably it is the poorest of the poor who are the most affected in the event of disasters, policies, laws or enabling milieu for safeguarding their livelihoods. A major concern in disaster research is to explore the relationship between shock experiences and victims' perceptions of risk, as well as possible effects on victims' behaviour towards future shocks. Taking the victimized households of the 1986 Lake Nyos disaster as our sampling units, a quasi-experimental design was employed. Matching was done by comparing former disaster–affected and non–affected households. Both groups sampled were of adequate size, and subject to the same questionnaire. Selection of test households (470) was purposely limited to nine of the ten towns accommodating both survivors and non survivors of the 1986 Lake Nyos disaster. A list constructed with traditional rulers in each village allowed for random sampling of non victims for comparative analysis. All selected households were interviewed. The t-test for equality of means was applied and the results related to theory because we think this straight-forward statistical approach best suits the complexity of the topic with regard to interpreting power. Within the t-test for equality of means, we compare households affected by the Lake Nyos disaster with those who were not. The results reveal differentiated perceptions of risk and management behaviour contingent on households' experiences from the examined shock (mean membership in groups and networks amongst victims, 1.65 > for non victims, 1.23; $p = 0.001 < 0.05$). However, solidarity and reciprocity remained extremely high and not significantly different amongst both household types. This suggests resilience of endogenous, informal risk response mechanisms to natural shocks. The article concludes that analysing risk perceptions can help explain why some individuals, households or communities may be resilient to shocks and others are not. Perceptions should therefore be integrated in shock analysis especially if the analyst hopes to influence policy.

Keywords: Lake Nyos, natural shocks, resilience, risk, rural Cameroon, t-test

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Analysis of Urban Consumers' Willingness to Pay a Premium for African Leafy Vegetables (ALVs) in Kenya: A Case of Eldoret Town

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Kenya has close to 210 species of African leafy vegetables (ALVs) that have been integrated for use as food by rural families for many generations. The continued dominance of ALVs in the diets of vulnerable rural families resulted to the vegetables being regarded as poor man's food given that exotic vegetables connoted civilisation and thus commonly consumed by urban population. However, in the recent past, the demand for ALVs has been increasing as a result of urbanisation, emergence of supermarkets, change of dietary habits and increased awareness about its value. Furthermore, they are pertinent in view of the fact that they are resilient enough to thrive in poor soils and well-suited to the small plots especially with the current increasing costs of production, demographic pressure and environmental degradation. This study surveyed 204 urban consumers in Eldoret Town of Kenya to determine the willingness to pay (WTP) a premium for African leafy vegetables (ALVs) and the underlying determinants using the semi-double bounded contingent valuation choice and logit models, respectively. The results show the consumers prefer ALVs than exotic leafy vegetables - on average, ALVs would fetch a premium of 79%; 88 % and 70 % in open air and supermarkets respectively. Consumers preferred ALVs because they were perceived to be more nutritious than the exotic vegetables. The results also indicate that most consumers were planning to increase their consumption of ALVs in future. The Consumers' WTP a premium was positively influenced by: age, presence of children in the household, years of schooling of the household decision maker and the number of years the consumers have been consuming ALVs. Therefore, greater effort to explore the potential of such vegetables could lead to enhanced agricultural productivity, more-stable vegetable supplies, improved nutrition and higher incomes in rural areas.

Keywords: African leafy vegetable, consumers' willingness to pay, Kenya, open air markets, semi-double bounded contingent valuation, supermarkets

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Value Chain Promotion for Food Security in Small-Scale Farming Context: Results of two Year Experiences in Atacora-Donga Region, Benin

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During the food price crisis in 2008, the German cooperation programme for agriculture and resource conservation has formulated a food security programme co-financed by the European community. Between October 2009 and October 2011, the food security programme Atacora/Donga (PASA) in the northwest of Benin worked with about 90.000 small scale farmer households to improve productivity of rice and corn. A special attention was made on the processing and marketing of cereals. Activities were planned and implemented using the value chain approach ValueLinks, with special regards to economic potential and promotion of women activities in the value chain. The implication of all stakeholders from public and private sector has allowed a strong ownership. The final evaluation in January 2012 revealed:

- An increase of cereal productiveness of 40 % (rice) up to 50 % (corn)
- The rate of local processing of rice produced in the region passed from 24 % in 2009 to 50 % in 2010 with an improved quality.
- An increase of more than 20 % of income for women participating at the processing trainings
- Food security in the region

New strategies for input supply, training and private sector participation in the value chain approach ensure durability for a long-term food security in the region. The active involvement of local stakeholders at different stages of planning and implementation contribute now to a better integration of the value chain approach in local development plans. The public agricultural training agency helps to stimulate private investments in agriculture and processing with Public Private Partnerships (PPP).

Keywords: Benin, food security, value chain approach

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Engineering

Innovations in agricultural engineering

Development of a New Low Cost Long Time GPS-Device for the Recording of Grazing Itineraries

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Knowledge about grazing itineraries is important in order to understand decision making processes in pastoral production systems. Recently the use of GPS-technology has enabled a detailed spatial description of animal and herd movements in pastoral systems. Researchers either follow herds themselves - or equipped herders - with handheld GPS devices to record larger scale movements of entire herds, or place collars on individual animals to track herds or record individual animal movements on pasture. Animal or herd GPS data yields particularly informative data on grazing management in extensive livestock systems if recorded for longer periods and over different seasons and on larger numbers of animals or herds simultaneously but both above GPS-devices have disadvantages for expanded studies. Most handheld devices have a battery life of only around 24 hours and therefore require daily maintenance, whereas GPS-collars are too expensive to be used on many animals or in many herds simultaneously. The goal of this study was to develop a GPS-tracking device with the capacity to record the daily herd movements for a long period of time at reasonable cost. Commercial low price GPS-tracking devices, which require no maintenance, were combined with solar backpacks to warrant energy supply for the GPS. Two types of solar backpacks and three types of GPS-trackers were used and tested with Gabra pastoralists in northern Kenya. The devices were given after a short briefing to three herders, each of which carried the backpacks when herding their goats for 2 consecutive months. During this period, each herder was visited thrice to download data and monitor equipments. The combination of the VOLTAIC™ solar charger backpack and the Wintec™ WBT 202 GPS proved reliable and recorded data for 65 days with a total of 685 hours and 933 km of recorded tracks. On average the herder moved 10.5 hours per day a distance of 21.9 km with an average speed of 2.09 km h $^{-1}$. A combination of a solar backpack with a GPS-tracking device is a reliable long term and low cost alternative for recording grazing itineraries.

Keywords: Daily herd movements, GPS-technology, grazing itineraries, herd tracking, low cost, pastoral production

Irrigated Agriculture in Niger: Which Strategy to Adopt Against Food Crises and Poverty?

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One of the most vulnerable ecosystems of the African continent is situated in the Sahel. Shaken by repeating food crises, the Sahel suffers from the devastating consequences of climate change and population pressure. Precipitations are irregularly distributed as to their spatial and temporal occurrence, the Sahara Desert expands inexorably, cropping soils turn more and more barren every year, the climate refuges move to the country's south where the annual demographic growth attains 3.6 % in some communes. Given this staggering situation, the Nigerien peasants have followed the lead of other peasants of the Sahel and chose to intensify the cultivation by irrigating crops around water courses, fountains and pools to compensate the lack of food. Since three decades, however, this practice has under achieved the peasant's expectations. Actually, the husbandry techniques are still archaic and the products are not competitive with imported goods, moreover the consumers' skepticism is rampant. Additionally, the lobbying practice of the grocery merchants contributes to the precarious situation of the agricultural producers. The state which has been attempting to valorize these agricultural systems through several support schemes is faced with the precariousness of the public finances and the peasants' mentality. By means of a qualitative study conducted between March and October 2011, the present work strives to contribute to the analysis of irrigated agriculture systems in the southwest of Niger. The research focused on the traditional rice cultivation, vegetable gardens and the irrigation facilities. The study examined in detail the existing irrigation practices, the profits made and the difficulties the peasants faced. Finally, the problem-solving approaches chosen by the public authorities are discussed.

Keywords: Irrigated agriculture, foods crisis, Sahel, Niger

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Assessing Governance of Small-Scale Irrigation Scheme in Eastern Ethiopia

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Erer River small-scale irrigation scheme in eastern Ethiopia provides a range of benefits to a number of users, including agropastoral, pastoral, state-farm and town communities, which has increased the complexity of governance. This paper examines the governance of small-scale irrigation scheme with particular focus on assessing irrigation institutions and the dynamics of interactions among user-groups that in turn affect the scheme's governance system. We rely on in-depth case study and survey to capture perceptions on performance of institutions for different purposes. The results reveal that governance of the irrigation scheme is often found to be dysfunctional and unsustainable due to the dynamics of social, political, historical, economic and environmental dimensions affecting water availability. The regional trans-boundary nature of the river and lack of effective formal institutions governing inter-group relations at a wider scale are crucial in influencing governance. The result suggests that institutional resilience in governing the scheme can be realised if different social actors (communities, regional government officials and local administrators) create a platform that provides opportunities for dialogue among contesting user-groups, craft institutions facilitating equitable intergroup distribution of benefits, devolve decision-making and transfer accountability to user-groups where community-based institutions could play greater role in transforming water-use relations.

Keywords: Access, governance, institutions, irrigation scheme, user-group

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Can Water-Saving Technology Increase Resilience in Smallholder Irrigation Schemes? Experiences from Bangladesh from a Socio-Economic Perspective

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Dry-season rice in Bangladesh is mostly produced with small-scale irrigation using groundwater. The uplifting of groundwater requires fuel or electricity which is expensive for smallholder farmers. Additionally, electricity is highly unreliable. Both factors hamper a secure water supply for irrigation. Farmers increasingly develop their own solutions to enhance irrigation efficiency such as repairing canals, irrigating at night or even switching to alternative crops in regions with severe water stress. In this context, the water-saving technology "Alternate Wetting and Drying" (AWD) is discussed as a possible means to enable farmers to cope with scarce water and energy resources. The study is based on a research collaboration of the Centre for Rural Development and the International Rice Research Institute in 2010.

AWD is based on the knowledge that irrigated rice requires 15–30 % less water than generally applied. Our results confirm the economic benefit – farmers practicing AWD report cost savings up to 18 % as the irrigation frequency decreases. This mostly applies to farmers who own a water pump. However, smallholder farmers and share croppers mostly depend on pump owners for buying irrigation water often at a fixed seasonal rate irrespective of their actual water consumption. Furthermore, they have little control over the timing of irrigation which is crucial for maximising economic savings and ensuring that no harvest losses take place when practicing AWD.

In principle, AWD has a great potential to increase resilience of farmers in dealing with the challenges of water scarcity and energy cost. However, the frequently found seasonal payment arrangements and the scheduling of irrigation which is not aligned with the requirements of AWD decrease the incentive or the possibility of farmers within an irrigation scheme to practice AWD. Only when these structural issues within local irrigation schemes are adapted, AWD can unfold its full benefits to the individual farmer.

Therefore, local stakeholders within the same irrigation scheme should be encouraged to find mechanisms that allocate economic benefits to all farmers on a fair and collective base. Furthermore, organisations involved in disseminating AWD should be capacitated to address economic and organisational aspects during their advisory services.

Keywords: Alternate wetting and drying, irrigation organisation, smallholder rice farmers, water and energy scarcity, water-saving technology

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Non-Destructive Mango Quality Assessment Using Image Processing: Inexpensive Innovation for the Fruit Handling Industry

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Thailand is one of the most important mango producers in Southeast Asia, but fruit sorting is still done by hand which is tedious and inaccurate. Thus, the need exists for improvement of efficiency and accuracy of fruit quality assessment that can meet the demands of international markets. Low-cost and non-destructive sensing technologies capable of sorting fruits according to their properties would help promote the mango export industry in Thailand. Image processing techniques have been applied increasingly for sorting applications in recent years. This work has assessed the application of image processing for detecting value parameters in Thai mango varieties, namely 'Nam Dokmai' and 'Maha Chanok'. An automatic image acquisition system was developed and laboratory experiments were conducted to obtain optical data and reference analyses. Fruit qualities including colour and the presence of defects such as anthracnose, bruises and latex stains were monitored during the ripening process. To evaluate origins of mechanical damage, field research using mock fruits included in transport shipments was conducted to record conditions during the post-harvest handling chain. Image processing and quantitative analyses were used to assess the data. The Pearson correlation coefficients and p-values have provided a confidence that the machine vision system is able to collect accurate colour data from the mango fruits. For the defects detection, the images acquired by the automatic picture acquisition system were segmented and analysed by using discriminant analysis to evaluate the threshold of detection. The results will be incorporated for development of a robust classification system for quality prediction and establishment of a machine vision system for automatic grading and sorting of mangos. The work has also helped to recommend better post-harvest practices. Proper post-harvest handling and quality assurance will improve product value. As a result, farmers and exporters can have better access to high-value international markets, enabling them to increase their income and provide consumers with a premium product.

Keywords: Image processing, mango, post-harvest handling, quality assessment, Thailand

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Effects of Plant Essential Oils on Storage Decay of Valencia Oranges

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Oranges are among the most important fruits produced in Iran. Kerman province and Jiroft region represent the most important production zones in Iran. Blue and green decay of citrus fruits are the major reasons for reduction in fruit quality and market losses. Decaying due to blue and green molds in citrus fruits is caused by *Penicillium digitatum* and *P. italicum*. In commercial production chemical pesticides are used for controlling the disease. So, in this study the effects of three plant essential oils from rosmary, thyme and artemisia at three levels of 0, 500 and $1000\,\mathrm{mg\,l^{-1}}$ on disease infection of the Valencia orange fruits were evaluated in three replicates.

The results showed that when fruits were inoculated with fungi suspansion solution using scrashing, fruits independent of the essential oil type and the concentration were almost completely decayed in less than one week. But, when fruits were inoculated just with soaking of fruits in fungi solution, treatments were significantly different regarding the number of healthy or decayed fruits, percent of weight loss, decaying intensity, fruit juice soluble solids, titrable acidity, and the content of vitamin C, but not for fruit juice pH ($p < 0.05$).

In this study the control group, fruits without any treatment, showed the highest percentage of healthy fruits with the highest fruit weight, total soluble solids, vitamin C and titrable acidity at the end of experiment. There was no significant difference between this control and the second level of artemisia and thyme application ($500\,\mathrm{mg\,l^{-1}}$) which in part showed a significant improvement compared to control 2 and both levels of rosemary.

Keywords: Artemisia, decaying, essential oil, rosemary, thyme, valencia orange

Water and energy

Water Spreading Weirs: Improving Resilience in Dry Areas

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The Sahel is characterised by adverse climatic conditions and degraded natural resources. Due to a rising population density and unsustainable cultivation practices, degradation of natural resources, particularly of soils, is progressing. Additional challenges result from the effects of climate change: the probability of dry spells and heavy rainfalls increases, and the repartition of rainfalls changes. Rural households in such fragile contexts are seriously affected by food insecurity and poverty.

Various soil and water conservation measures have been introduced over the past decades to combat land degradation and desertification. They can ensure a more effective use of natural resources, if they are integrated in a systems approach, considering the various types of uses, *e.g.* for agriculture, livestock husbandry, and forestry.

German development cooperation has extensive experience in the rehabilitation of degraded land, both individually and community owned. A relatively new technology for the rehabilitation of degraded inland valleys are water spreading weirs, which have been introduced in the late nineties.

Water spreading weirs are masoned constructions that extend from one side of the valley to the other, usually built in a series to stabilise the entire valley. The weirs permit spate flows to overflow and flood the inland valleys. Due to the reduced speed of the water flow, fertile soil is deposited, and water infiltrates into the ground, thereby lifting the water table. This allows farmers to grow crops all year round (rainfed and irrigated), even on formerly degraded land, thereby contributing to food security and resilience.

In order for water spreading weirs to be successful and sustainable, they need to be planned participatively with the local population, and they need to be integrated in the relevant land use planning instruments. Land rights need to be clear, and local maintenance structures need to be created and trained.

Water spreading weirs are now widely implemented in Burkina Faso, Niger and Chad, and have the potential for further upscaling.

Keywords: Desertification, land degradation, resilience, Sahel, soil and water conservation, sustainable use of natural resources, water spreading weirs

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Optimal Site Selection for the Construction of Small Dams as a Water and Soil Erosion Management Option: Case Study from Kermanshah Province, Iran

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Worldwide, semi-arid areas face water deficiency and soil erosion. A fast growing population and the resulting increase in food demand, increase the pressure on water and soil resources. An appropriate management and an optimal utilisation of soil and water resources are key to fight water scarcity and erosion in semi-arid zones. One effective management solution is the use of small dams. It is important to select the appropriate locations for small dam projects and to implement the right dam type such as cement dams or gabion dams. The site selection is difficult because spatial information and many influential variables must be gathered and analysed; these variables include technical, social and economical criteria.

This case study concentrated on the 9092 ha Meykhoran rural watershed located in Kermanshah Province, Iran. Geological, pedological, hydrological, and topographical information was gathered. Data analysing was done using tree-stage analytical hierarchy process. ARC-GIS, GS+, and PCI-GEOMATICA software were applied to analyse the gathered spatial information. The first stage involved the determination of hierarchical levels consisting of object, criteria, sub-criteria. During a second stage, standardisation, weighting, and paired comparisons of criteria and sub-criteria was done. In a last step, after overlaying criteria layers, the final maps for the determination of the optimal sites for the constructing of small dams were prepared. Using these patterns to locate further natural resources management projects will help to optimise usage of spatial information, save time, and decrease costs.

Keywords: Geographical information systems, small dams, soil erosion, spatial information, water deficiency

Sustainable Agriculture in Drought Prone Regions of Iran by Using Indigenous Knowledge

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During the length of history, in the face of different disasters and stressful conditions in the central and eastern parts of Iran, indigenous people of these area developed technologies and knowledge, which enable them to live. Now a day this knowledge and many traditional practices which in the past have been regarded as primitive or misguided are now seen sophisticated and acceptable. It is clear that the concept of traditional knowledge does not exclusively belong to indigenous peoples. In the central and eastern parts of Iran, the availability of water is the most limiting factor for the agricultural development. The dry regions of Iran are characterised by high temperature, low rainfall and limited renewable water resources and knowledge of the local ecosystem simply means survival of community. There is tow type of problems in these areas; first of all the lack of fresh water and secondly the availability of fresh and clean water at the right place and time. Indigenous practice and knowledge of the farmers played an important role in sustainable development in drought prone regions of Iran. Some of these positive practices such as religious practices and social beliefs are based on symbolism, and other positive practices are based on the experience of different people during the long time of resident in a given area. This paper document different examples of indigenous practices such as Qantas and tube wells, subsurface dam, clay pot irrigation, participatory irrigation, drought early warning and rainfall prediction which rural use for decreasing the negative effects of water stresses in drought prone areas.

Keywords: Irrigation management, traditional practices, waters harvesting system

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Statistical and Trend Analysis of Surface Water Quality for the Upstream of Karkheh River in Iran

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Karkheh Basin drains an area of about $51\,843.22$ km^2 and originates from the middle and southwestern parts of the Zagros Mountains in western Iran. Karkheh River ranks as number third in terms of mean discharge amount of Iran after Karun and Dez Rivers. River surface water quality and quantity changes in the upstream of Karkheh basin has been a major concern for water managers. This study is focusing on the upstream areas of Karkheh River basin which involve Gharehsoo and Gamasiab subbasins and some parts of Saimareh Miani subbassin. The climate of the study area is semi-arid and the precipitation decrease from north to south. Trend analyses have been employed to determine whether a significant change has occurred in surface water quality or not. Considering the effects of precipitation and river water quantity on river surface water quality, both sudden and gradual trends over time with and without precipitation and flow adjustment for the effects of exogenous variables have been investigated. Finally the various parametric and non-parametric tests strengths and weaknesses are discussed. The removal process involves modelling, and thus explaining the effect of exogenous variables with regression or LOWESS (LOcally WEighted Scatterplot Smooth) are helpful to reduce the background variability so that any trend "signal" present can be seen. However, if the probability distribution of the surface water quality parameters has changed over the period of record, a trend in the residuals may not necessarily be due to a trend in river discharge and precipitation. In this context, removing the significant role of exogenous variables reflect the real conditions.

Keywords: Exogenous variables, Karkheh, Mann-Kendall, regression, surface water quality

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Study on Driving Factors for Water Pollution in China

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Since 1970s, the N and P eutrophication of major Chinese lakes and water systems has worsened. Investigation revealed that non-point source pollution from agriculture and rural regions is the leading source of water pollution. The contribution of non-point source pollutants from fertilisation of crop land, rural animal husbandry and untreated sewage of transition regions between rural and urban areas is much greater than that of point-source of domestical and industrial wastes in urban areas with developed wastewater pipe nets. Since the 1980s, the acreage of vegetables, fruits and flowers has increased by 4.4 times. Due to high profit, it is common use to apply very high rates of N and P fertilisers on these crops. The average fertiliser application rate is 569–2000 kg (pure nutrient) per ha on a single crop, about 10 times more than applied on grain crops. The increasing vegetable area with high fertiliser input is one of the biggest problems for eutrophication of water bodies in watersheds. At the same time, animal units in rural regions tend to develop towards a very high concentration of animals in certain townships. N and P amounts from animal husbandry in such concentrated regions has reached very high levels, as much as 1721 kg N and 639 kg P_2O_5 per hectare agricultural land area, far more than the acceptance capacity of soil for these nutrients. In almost all of the important watersheds in China, non-point source N- and P-discharge to aquatic ecosystems from animal husbandry is becoming a crucial pollution source. Fast expansion of new city zones without wastewater pipe nets in transition regions between rural and urban areas make such zones the main non-point source for pollution. Although the non-point source pollution is already serious in the country, the growing influence of certain factors will lead to an even worse situation in the early 21 century. The non-point source pollution from agriculture and rural areas will become one of the biggest challenges for a sustainable development of China.

Keywords: Eutrophication, non-point source pollution, nitrate pollution

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Development of Passive Sampler for the Monitoring of Herbicides in Aqueous Environments

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Atrazine (ATR) is widely used to control broadleaf weeds, *e.g.* in the cultivation of corn and it has been identified as a principal contaminant of surface waters. For a better understanding of the environmental impacts of ATR herbicides on the aqueous environment, it is important to have an analytical tool to easily measure chemical compounds. Therefore, the development of a sensitive analytical methodology in water quality monitoring is needed for the detection of persistent pollutants in marine biota and aqueous environments.

Passive samplers are highly sensitive, reproducible monitoring tools which offer the ability to integratively sample a wide range of environmental pollutants over an exposure period in water resources. In this study we investigated the solute transfer rate of atrazine through polyethersulfone (PES) membrane under a flow condition of 400 RPM of stirring speed. PES is a semi-permeable membrane which allows the transport of hydrophilic chemicals through to the sorbent, while excluding colloids, particles, biogenic substances. The analysed water extraction has been carried out by GC-MS.

Keywords: Atrazine, passive samplers, water contamination

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Subsurface Irrigation by Auto-regulative Working Porous Pipes Tested in Field Trials

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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. The authors present a BMBF joint research project dealing with an innovative approach to water-saving irrigation, based on porous irrigation pipes as an upgrade of both subsurface and traditional pot irrigation. Clay pot (pitcher) irrigation 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.

In the BMBF joint research project (partners comprise both Algerian , Kenyan and German Universities, GIZ, DITSL, C.R.S.T.R.A - Research Center for Science and Technologies in Arid regions, German industry companies) which investigates in an effective subsurface irrigation technology following the pot-irrigation principle. Due to the specific material properties, the irrigation pipes are auto regulative, *i.e.* they release water depending on soil moisture and thus the plants' water demand. This innovative irrigation technology will be field-tested in Algeria and Kenya from 2012 through 2013.

The irrigation 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 operating costs. It is easy to handle and to maintain and environmentally sustainable.

Preliminary research works on the method of operation, laboratory tests and first results of the field-trials will be presented.

Keywords: Auto-regulative, intelligent irrigation, irrigation, subsurface irrigation, water saving

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Assessing the Effect of Gross Domestic Product and Energy Consumption on Water Pollution in Iran

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Today water pollution is one of the major environmental problems. Clean, safe, and adequate freshwater is vital for the survival of all living organisms and the functioning of ecosystems, communities, and economies. But the quality of the world's water is increasingly threatened as human populations grow, industrial and agricultural activities expand, and as climate change threatens to alter the global hydrologic cycle. The effectiveness of Gross Domestic Production (GDP) process on pollution development is slight. Investigating the amount of economic growth and energy consumption on Iran's water pollution is the main goal of this study. This investigation used time serie data for 1979–2007 and the vector error correction model (VECM). Results show that with increasing economic growth firstly the amount of pollution will increase but finally with increasing GDP it will decrease. Also with an increasing energy consumption equal to one percent, water pollution will increase equal to 0.55 percent. With respect to the positive effect of energy consumption on water pollution, any policy on energy productivity increase, will decrease water pollution. Finally, results showed that for adjusting shock effects on water pollution, it will need more than 1.54 years periods. Using the alternative clean energy sources like wind and solar energy is an important factor to reduce the level of water pollution in Iran. Also more realistic price for water resource and technologies led to more efficient use of water resources. In addition technologies with less concentration of energy consumption, have been suggested to reduce the level of water pollution in Iran.

Keywords: Environment, energy consumption, GDP, VECM, water pollution

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Development of LPG and Household Woodfuel Consumption: Case Study of two Rural Areas in Gezira State, Sudan

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Sudan depends mainly on the forestry sector to supply its energy need. However, Woodfuel (WF) are one of the main causes of deforestation. The new petroleum discoveries in the end of this century and LPG availability allow following new policy to alleviate the pressure on forest. Trying to understand the effect of this new energy development, this study was designed to investigate the level of and patterns of WF consumption, WF share in energy budget and household WF dependency as well as main determinant of household energy demand (*i.e* the price of WF, price of alternatives, income and family size). Based on survey, group discussion and official interview (during the period between 1998 and 2007) from two rural areas in Gezira state the study was conducted. The level of house WF consumption before and after these energy developments was investigated in the two selected areas with different access to woodfuel and LPG resource. The collected data were analysed and discussed using SPSS program. Descriptive, regression and elasticity's of demand analysis were performed.

The results suggested that the level of household WF consumption significantly decreased in the two areas compared with the national reported level. Among the variable tested WF consumption was found to be affected mainly by price of LPG and to less extend by its own price. There was variation between the two study areas concerning the effect of income, main energy source and WF dependency. The result reveals significant reduction in share of WF in household energy expenditure in the two periods associated with increase in LPG expenditure. In the light of the results and the discussion a numbers of valuable policy recommendations were suggested. The study support the presumption that LPG price reduction policy and charcoal price policy, have succeeded in reducing WF consumption but in the long run other policy option might be necessary specifically under the expected increase in price of LPG in future.

Keywords: LPG, woodfuel, woodfuel demand, woodfuel consumption

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Optimisation of Mechanical Oil Extraction from Husked Kernels of *Jatropha curcas* L. Using Matrix Additives

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The need of renewable fuels produced from various plants is increasing significantly nowadays. *Jatropha curcas* L. is an important plant potential source for biofuel production. The plant is used by various industries as raw material for biodiesel production. However, the mechanical extraction efficiency should be increased because the kernels are husked and this fiber is decreasing the quality of feed from detoxified press cake. In order to facilitate the process of mechanical oil extraction and improve feed quality, an addition and optimisation of matrix material in feedstock is necessary. As for the additives, cellulose is considered to be one of the prospective additives, because it increases fiber contents which later on, will increase the efficiency of the oil extraction. In this study, three different types of additives are selected such as corn, wheat and triticale. The objective of this study was the investigation performance of the additives in oil extraction from Jatropha kernel. Therefore, the additive type and amount are selected to be the main variable parameters. The experiments were conducted using mechanical screw press type – Komet D85-1G. With respect to the physical properties of the machine, another four processing factors are also determined; screw press (16 and 21.5 mm choke ring size), press cylinders (1 and 1.5 mm bore size), nozzles (8, 10 and 12 mm nozzle diameter), and rotational speed (220, 290, and 355 rpm). It is expected that the addition of additives such as corn, wheat or triticale will provide structure and strength for improving the extraction process with better oil recovery value.

Keywords: Additives, *Jatropha curcas*, matrix pressing, oil extraction, physic nut

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Post-harvest technology

A Review of Computational Methods for the Design of Innovative Drying Systems for the Prevention of Postharvest Aflatoxin Contamination of Maize in Kenya

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Maize (*Zea mays* L.) is the preferred staple food crop in Kenya. It is grown in all agro-ecological zones and on two out of every three farms and accounts for about 40 percent of daily calories with an annual per capita consumption of 98 kilograms. Aflatoxin contamination of maize is a recurrent problem in Kenya. In 2004 and 2005 alone 157 deaths were documented and in 2010, 2.3 million bags of maize grown in the Eastern and Coastal regions were declared unfit for human consumption by the Ministry of Public Health and Sanitation due to unacceptably high levels of aflatoxin contamination. Kenya is yet to attain food self sufficiency and enhancing the resilience of the maize production system to aflatoxin contamination is necessary for food security.

Aflatoxins are produced by the fungi *Aspergillus flavus* and *parasiticus*. They are known carcinogens and have also been shown to be antinutritional, mutagegenic, teratogenic and immuno suppressants. The risk of aflatoxin contamination is enhanced during growth by prolonged moisture and nutrient stress conditions and also by exposure to high humidity and temperature in the harvest/post harvest period. Climate change, evidenced by erratic rainfall distribution during the crop cycle, is responsible for the escalation of both these risk factors and poses a significant challenge for the management of aflatoxin contamination. The optimal temperatures and water activity for the growth of *A. flavus* and *A. parasiticus* is 35–37°C and 0.95 respectively, and for aflatoxin production, between 28–33°C and 0.90–0.95 respectively. This paper reviews documented numerical simulations of low temperature drying of maize and assesses the suitability of the provided partial differential equations, modelling heat and mass transfer, on the basis of their accuracy, range of application and ability to predict the occurrence of high aflatoxin contamination risk factors in drying.

Keywords: Aflatoxin contamination, computational methods, maize drying, post harvest loss management

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Drying Kinetics of Yam *Dioscorea batatas*

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In Asian countries such as China and Japan there is an increasing interest to use Yam (*Dioscorea batatas*) as a food additive due to its nutritive and technological properties. Also in European organic food production it can have a future market as component of blends of flour for bakery and pasta that until now are typically based on maize, potatoes, rice, soybean or buckwheat and often contain locust bean gum or guar flour. New additives based on Yam can upgrade these standard blends with respect to sensory, physiological and health aspects. Due to the increasing number of people with allergic problems, Yam can also play an important role in bakery and dairy industry *e.g.* as thickening agent in yoghurt production. Typical processing consists of convective drying which enables milling and further distribution/use as flour. In order to create a production line in food industry, the drying kinetics of Yam need to be investigated including the knowledge of sorption isotherms and the determination of the final moisture content required for proper milling behaviour.

The poster presents systematic lab trials to investigate the influence of temperature (40, 60 and 80°C), size (slice thickness), shape (cubes, slices, sticks) as well as the effect of peeling and the cutting direction as pre-treatments of raw material of Yam on the duration of the drying process. In addition colour changes were investigated to proof quality aspects using the L*a*b* system measured by chromameter technology. Out of the results optimum processing parameters can be named which enable to build up optimised production lines.

Keywords: Drying kinetics, processing, quality, yam

Drying of *Mentha spicata* in a Dual Solar-Biomass Tunnel Dryer in Colombia

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Colombia is a country with a very high production potential of aromatic plants due to its variety of climatic conditions and available arable land. The currently industry of aromatic plants is incipient with a production concentrated only on fresh product. The commercialisation of dried products is limited to local market. The drying process is inefficient causing high energy consumption and a product with low quality standards. The development and implementation of efficient economic driers in which high quality products can be obtained is a very important task in Colombia.

A dual (solar-biomass) tunnel drier, based on the Hohenheim type which overcomes the problem of different climatic conditions is constructed and tested. This new concept includes a modular structure that facilitate mobility, side windows to help control the temperature inside the dryer while running in the solar mode and trays for the up and download of the product. The dryer is designed for 24 hours operation; the thermal energy is obtained through solar radiation during the day and biomass burning during the night. The total area of the solar collector is 16 m^2, the drying area is 20 m^2. The capacity of the drier is 2 to 5 kg m^{-2} depending on the drying product. The dryer operates in a farm near Bogotá, the capital city of Colombia, which is located in the Andean region of the country. The mean radiation varies between 300 and 900 W m^{-2} between 9:00 a. m. and 5:00 p. m. Coffee shells, a residual biomass available in large quantities in the country, are used as biomass source. The power consumption of the dryer is 240 W when it works with the solar system and 260 W when it works with biomass.

Experimental results of the performance of the tunnel during drying of *Mentha spicata* are presented. Air temperature and relative humidity together with product temperature and water content were continuously measured at different lengths of the drier. Collector and burner efficiencies were determined. The loss of essential oils and colour changes of the product during drying were also measured.

Keywords: Drying, renewable energy, tunnel dryer

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Postharvest Food Safety Innovation: Non-Chemical Hermetic Cowpea Storage Technology in Northern Nigeria

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Nigeria has comparative advantage for cowpea production as evident by being Africa's major producer with an estimated 2.44 million tons annually (about 66 % of the world yearly production). Post-harvest infestation with weevils is the main challenge facing cowpea producers and traders. Farmers are therefore compelled to sell off the cowpea immediately after harvest, when the prices are lowest or resort to the use of toxic chemicals to preserve the cowpea from weevil attack. The chemicals contaminate the cowpea grains, and hundreds of human fatalities have been reportedly linked to the consumption of such polluted cowpea in Nigeria. Adoption of health conscious storage techniques such as hermetic sealing of cowpea in plastic bags (Triple bagging) is a safe alternative to prevent food borne illness from consuming contaminated cowpea. The technology involves 'bagging' the cowpea using non-chemical, hermetic storage bags with very low oxygen density (less than 2 %) to suffocate and thereby killing the insects. RIU-Nigeria brokered a multi-stakeholders collaboration with IITA in 2009, to contribute to the dissemination of Purdue Improved Cowpea Storage (PICS) technology. The demand for triple bags soared within the first three years of intervention and production increased from 500 bags in 2007 to about 80,000 bags in 2010. An analysis of the benefit cost ratio of using triple bags for cowpea storage revealed an increase in income by about 48 % per bag stored within 4 – 6 months. Reduction in media reports on hospitalisation and deaths attributable to cowpea poisoning could also be an indication of wide adoption and use of non-chemical, hermetic storage. Based on the estimated annual total production of 2.44 million MT of cowpea grains in Nigeria, if one third of the production is consumed without storing, it implies that about 16.3 million bags (1.63 Million MT/100 kg = 16.3 Million triple bags) will be needed annually to meet potential market demand. There is need for policy advocacy to create enabling environment for the uptake of this innovation through strengthening the triple bag production and distribution network and also reinforce the regulation and control against the use of toxic and banned chemical in cowpea storage.

Keywords: Cowpea, hermetic, RIU-Nigeria, storage, technology, tripple bag

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Investigation of Laboratory Freeze Tolerance of Field Grown Fennel (*Fueniculum vulgar*) Ecotypes

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In order to investigate the freezing tolerance of field grown Fennel (*Fueniculum vulgare* Mill) under controlled conditions, a factorial experiment with completely randomised design was conducted with three replications at the Agricultural College, Ferdowsi University of Mashhad, in 2004. Treatments were two fennel ecotypes (Khorasan and Kerman), two planting dates (Oct 8th and 29th) and six temperatures (0,-3,-6,-9,-12,-15°C). Plants were harvested from the field on Dec 7th in controlled conditions and exposed to the freezing temperature. Plant survival percentage and re-growth after 21 days under the greenhouse, and degree of plant necrosis after six days under the lab condition were evaluated. Greenhouse results showed that there was no significant difference between Khorasan and Kerman ecotypes for survival percentage, height and number of nods but Kerman ecotype had a higher leaf number than Khorasan. Planting date had a significant effect on survival percentage, height, number of leaves, number of nods and percentage of plant dry weight, with the late planting date being higher than the early one for all measured criteria. With lower temperatures, survival percentage, height, number of leaves, number of nodes and dry weight tended to decrease. There was a significant difference between planting dates in degree of plant necrosis on day 6 under lab conditions, being 3.4 % and 2.8 % for 29 Oct. and 8 Oct., respectively. The highest degree of necrosis showed with the -15°C freezing treatment, being twice the necrosis degree at 0°C.

Keywords: Dry weight, height, necrosis degree, survival percentage

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Effects of *Aloe vera* Coatings on Quality Characteristics of Oranges Stored under Cold Storage

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Three hundred and twenty (320) oranges of Valencia variety were stored under cold conditions in the refrigerator for 8 weeks. The following parameters were measured during storage: total soluble solids, titratable acidity, weight loss, firmness, pH, vitamin C and sugar/acid ratio.

The final value for firmness for coated oranges was found to be 1781.25 ± 118.30N, while that of uncoated oranges was 1531.25 ± 185.53N. The pH was gradually increasing during the course of storage in the two treatments, whereas vitamin C was found to be decreasing in storage. The total soluble solids for coated oranges was $9.79 \pm 1.14\%$ while that of uncoated oranges was found to be $9.34 \pm 0.06\%$ at the end of storage. There was a linear decrease in titratable acidity during the course of storage. It was found that the value obtained for coated oranges was higher than that of uncoated oranges which was obtained to be 1.14 ± 0.07 at the end of storage. Converse to this was obtained for % weight losses in the two treatments. The weight loss for coated oranges was $29.20 \pm 0.55\%$, while that of uncoated oranges was $53.30 \pm 1.17\%$ at the end of storage. A linear increase was observed in sugar/acid ratio in the two treatments during the course of storage with higher value being recorded for uncoated oranges as 8.90 ± 0.87, while lower value was gotten for coated oranges as $7.43 \pm 0.34\%$.

Keywords: Aloe vera, coatings, oranges, quality, storage

Post-harvest Losses and Food Sustainability Challenges of Rural Farmers in Developing Countries: A Case Study of Rural Maize Farmers in Ghana

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Post-harvest losses in crop production are of great concern today. Resources such as labor, land, water and fertilisers/chemicals used as production inputs are wasted. An attempt was made to quantify these losses in maize production during storage and its impacts on the livelihoods of rural farmers in Ghana. Three hundred and seventy one (371) maize farmers from 9 districts in 3 regions were interviewed in order to gain the farmers' perceptions of post-harvest losses and causes. Data collection was done between March and April 2011 (after the minor season of maize farming). Formal and informal interviews were conducted among experts in maize storage. A visit to some storage sites revealed poor storage facilities, which are prone to factors responsible for maize losses and low level of technical expertise among maize farmers. Some findings show that about 51.8 % of farmers still rely on saved maize seeds from previous harvest as source of planting material. Only 20.2 % of farmers use certified seeds, while others get their seeds from the open market. Over 94 % of farmers harvest maize when matured and dried on the stalk. This according to experts is a major source of pest infestation and mycotoxins contamination. Fifty-five per cent of the farmers store their maize in bags, 32.6 % in local cribs and only 0.3 % store in household metal silos. This may account for the high losses recorded, which ranges from 10–30 %. The farmers identified insects, rodents and fungal infestation as the major problems they experience during maize storage, which is usually up to a period of 3–9 months. Statistical analysis was carried out using factors that could contribute to maize losses. These factors are location of the storage structures (in the field or in the house); period of storage (months *i.e.* between 3–9 months) and methods of treating storage structures before storage. None of the above-mentioned factors was statistically significant to maize storage losses at $p < 0.05$.

Keywords: Maize and food sustainability, post-harvest losses

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Controlling *Sitophilus zeamais* (Coleoptera: Curculionidae) in Maize Grains by Using Microwave and Radio Frequency Energy

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Infestation with insect pests is a serious problem associated with raw and processed stored products. Among the stored product pests, maize weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae), is one of the most economic primary pests of stored cereal grains, particularly maize. Generally, chemical fumigants are used to disinfest product, however, these pesticides have a negative impact on human health and environment. Therefore, the industry has been forced to explore non-chemical alternatives. One possible alternative is the use of dielectric heating, microwave (MW) or radio frequency (RF) energy to rapidly heat product to lethal levels.

To study the potential of MW and RF treatments for controlling insect pests in stored grains, the adults of *S. zeamais* were exposed to the MW (2450 MHz) and RF (27.12 MHz) at different temperatures 45, 50 and 55°C for 3 min in maize grains at 10, 14 and 18 % initial moisture contents (IMC). Moreover, the germination capacity of treated maize was also determined to study the effect of these treatments on grain quality. Results show that there is a possibility for controlling *S. zeamais* adults with MW and RF energy. However, in comparing between the effect of MW and RF on the mortality of the adults, the results proved that the mortality rates of the adults were lower in MW treatments than those of RF. The lethal temperature of the adults was estimated as 55°C under MW treatments, while it was 50°C under RF treatments at all studied levels of IMCs. Both MW and RF treatments significantly ($p < 0.05$) reduced the germination rate of maize grains. However, the germination rate of the grains treated with RF is higher then the MW treated grains.

In conclusion, the current study indicated the potential application of MW and RF as alternative methods in controlling stored pest. Moreover, the findings confirm that radio frequency heating was more effective than microwave heating in the eradication of *S. zeamais* as well as maintaining higher germination rates of maize grains than those treated with microwave heating.

Keywords: Germination, maize weevil, microwave, mortality, radio frequency

Innovative Development of a Cassava Processing Machine

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Climate change has affected weather patterns. The global weather system is threatening to spin out of control; seasons are becoming unpredictable, global warming is affecting agricultural systems. Food production systems are all being undermined, the impact is being felt by the world's poorest people. Africa's most important food crop used to be maize, however, production of maize in Africa became risky due to unpredictable rainfall, and it is not financially feasible to depend on irrigation. For this reason, cassava (*Manihot esculenta*, Crantz) became the most important food crop in Africa. The crop could play vital roles in the world food security because of its capacity to yield under marginal soil conditions and its tolerance to drought. The processing stages in cassava to flour include peeling, washing, grating, dewatering, pulverising, sieving/sifting and drying. Dewatering of cassava mash is the second after peeling and second to drying in rate determining factor. It is the most difficult operation when producing high quality cassava flour (HQCF). This HQCF can replace maize or wheat flour. A study was conducted and cassava dewatering parameters was evaluated. TMS 4(2) 1425 variety of cassava at three levels of maturity (9, 12 and 15 months) was used in the study. Dewatering pressure was obtained from hydraulic jack. Evaluated parameters were pressure drop, face area of the filter medium and cassava mash resistance. The cassava mash resistance varied with the tuber harvesting age. Grated cassava mash had a porosity of 0.0181. The result presented the distribution and values of parameters used in developing a combined processing machine for conveying, dewatering, pulverising and sifting process. The machine was evaluated with cassava mash at 68 % moisture content wet basis. Feed screw speeds at 20 rpm interval from 20 rpm to 100 rpm; dewatering pressure was created by the use of spring at 100 N, 200 N and 300 N. The machine at 40–50 rpm produced a mash with an average moisture content of 47–52 % wet basis good enough for HQCF production.

Keywords: Global warming, HQCF, innovative machine, cassava

Non-destructive Method for Determining Inner Quality Attributes of Intact Mango by Near Infrared Spectroscopy

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To evaluate the feasibility of near infrared spectroscopy (NIRS) technique in measuring inner quality in intact mango, relationships called calibration models between soluble solid content (SSC), ascorbic acid, total acidity (TA) measured by standard laboratory measurement and near infrared diffuse reflectance spectra in the wavelength range of 1000 - 2500 nm were established. Multivariate analysis was then applied to develop these relationships to predict inner quality attributes from a set of wavelength as predictor variables. A total of 58 mangos, cultivar Kent were used as samples with an acceptable range of maturity stages. Multiplicative scatter correction (MSC) was applied to mango NIR spectra prior to calibration model development. A partial least square regression (PLSR) combined with ten-segments of cross validation was then used to develop the models for predicting SSC, ascorbic acid and TA of intact mango fruit. The quality of calibration model was then quantified by the correlation coefficient (r), standard error of calibration (SEC) and root mean square error of prediction, resulted from cross validation (RMSEP). The result showed that MSC-PLSR can predict and determine inner quality attributes of intact mango fruit satisfactorily, with correlation coefficient, SEC and RMSEP were (0.82, 1.36°Brix and 1.47°Brix), (0.84, 0.66 mg/100g and 0.8 mg/100g) and (0.98, 26.05 mg/100g and 26.94 mg/100g) for SSC, Ascorbic acid and TA respectively. These results demonstrated that near infrared spectroscopy technique was feasible for determining inner quality attributes of intact mango fruit. It may also conclude that this technique combined with a proper calibration model can be considered as one of non-destructive method and should be able to replace laborious and costly standard laboratory measurement.

Keywords: Inner quality, mango, multivariate analysis, NIRS, non-destructive method

Improving of Thermal Uniformity of Mango During Radio Frequency Heat Treatment for Insect Control

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Hypothesis in this study was to improve the distribution of electromagnetic energy from radio frequency (RF) heating of mango fruit (*Magnifera indica* L.). Therefore, a rotating container was developed and filled with a medium (water) to support a homogeneous movement and uniformity of electromagnetic energy. The experiment was to compare the uniformity of heat inside mango fruit treated by several thermal methods based on U.S (USDA-APHIS-PPQ, 2002) regulation for control fruit fly in mango. Design of rotating container combined with RF applicator was done. The indicator affected on movement of mango fruit then was investigated by using three different weights (360, 330 and 250 g) of mango (*Magnifera indica* L.) to determine the flow rate as well as the velocity of the movement of fruit around the container per time was also measured. Comparison of heating method between radio frequency, hot water and hot air on mango fruit were evaluated by infrared camera for the uniformity of heat in treated mango fruit. The result was found that 1000 watt RF heating energy applied to container of fruit-roll could provide a consistent distribution of thermal treatment in mango with exposure period for 5–10 minutes which was equivalent to the result from dipping in hot water for a period of 40 minutes. Besides that the thermal distribution in mango treated with hot air showed non-uniform heat distribution inside flesh fruit. Moreover, the RF heating operation process required shorter time than immersion into hot water and exposure to hot air. The results recorded also that there were no contact damages observed since the mango fruit moved freely in water filled chambers.

Keywords: Heat uniformity, mango, radio frequency, rotating container

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Monitoring of Ripening Processes in Mango Fruits Using Laser Backscattering: An Innovative Optical Technique

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Thailand is the most important mango (*Mangifera indica* L.) producer in Southeast Asia. Demands for non-destructive techniques for mango quality prediction have been increasing with an expansion of overseas markets supported by several export promotion programs. Laser light backscattering measurements based on photon absorption and light scattering properties of materials have been increasingly studied for the application in the food industry. In this work, the possibility to use laser light backscattering for monitoring of mango quality during ripening was studied regarding. The potential to predict physiochemical parameters of the fruit such as total soluble solid (TSS), individual sugar content, starch content, dry matter content (DM), texture and peel and flesh colour was evaluated during ripening experiments with Thai mangos. Images of the laser light backscattering on the fruit surface were obtained from fruits using laser diodes irradiating at four wavelengths. The laser backscattering was captured by a CCD camera as a monochrome image. The captured images were then analysed to create intensity profile to derive backscattering properties in pixel number to compare the fruit qualities measured by conventional destructive methods. Differences in backscattering behaviours were found during different ripening stages due to changes in photon absorption and reflection of tested wavelengths corresponding to chemical compounds of the fruits. Laser images at 635 nm showed less photon migration in later stages of ripening which resulted in the increase of scattering due to the changes in the fruit compounds. The results from the study show the potential use of laser backscattering for the prediction of mango quality during ripening. Further development and improvement of the technique regarding the image acquisition and the determination of sensitive wavelength corresponding to certain chemical components of the fruit are required.

Keywords: Laser backscattering, mango, non-destructive analysis, ripening

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The Quality of Syrian Shanklish a Traditional Dairy Product

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Shanklish is an important dairy product in the Middle East, particularly in Syria, Lebanon and Turkey. It is used in the traditional cuisine as main component on a daily basis especially in the harsh mountainous coastal regions, where it is difficult to make a living from agriculture. Shanklishis typically formed into 6 cm diameter balls and ripened in jars for two months. Due to the mold growth during the ripening process the end product may contain aflatoxins, which is seen as one of the major etiological factors in the development of hepatocellular carcinoma. To address this problem a survey was carried out in the Syrian mountain region where Shanklish is mainly produced.

Twenty eight Shanklish samples were collected from nine villages at different ripening stages. The traditional processing methods were observed and documented. The chemical composition and aflatoxin content were determined.

It was found that 66 % of the farmers in the study area, process all their milk into Shanklish, and another 22 % process 50 % of their milk. The average Shanklish produced per farm is 114 kg per year. Almost 27 % of the farmers face a problem of crumbling due to overheating of butter milk which negatively affects Shanklish texture. Product spoilage due to elevated product moisture was observed in 11 % of farms.

The content of fat was affected by location and varied from 4.4 to 12.7 % reflecting a low efficiency of churning. Total solids and protein also varied from 50.2 to 57.3 % and from 30.7 to 42.3 % respectively, according to different processing practices. The total aflatoxins in the collected samples varied between locations from 0.22 to 2.55 $\mu g\,kg^{-1}$. Due to the heavy aflatoxin contamination Shanklish from eight out of nine locations did not meet the standards of the United States Food and Drug Administration. Improvements in processing practices and hygiene can overcome the observed problems of Shanklish quality.

Keywords: Aflatoxins, shanklish, traditional dairy products

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Phytotoxicity by Essential Oil May Play a Role in Postharvest Browning Disorder of Cinnamon Myrtle (*Backhousia myrtifolia*) Tissues

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Cinnamon myrtle (*Backhousia myrtifolia*) is an Australian native ornamental that has a strong potential to Japanese cut flower market. However, cut stems of this flower are easily susceptible to postharvest discolouration (browning), which generally becomes a hurdle to its export industry. Temperature stress was suggested to be one of the possible causes of the disorder. However, the descriptions of browning symptom varied from one flowering season to another. There is therefore a need to understand what may involve in the browning process and later to develop treatments that ideally could eliminate the problem. To innitially elucidate the mechanism, leaf and floral tissues were heat treated at 60°C for 30 min to induce browning. Light (LM) and scanning electron microscopes (SEM) were used to follow up physiological changes of cell structures. The oil gland structure was well charecterised by SEM. LM images suggested that browning was initiated around cells surrounding tissue oil gland. Also, upon exogenous treatment with *B. citriodora* leaf oil, young *B. myrtifolia* leaves showed greater susceptibility to browning than did mature leaves. However, no such effect was observed on treated floral tissue. Discolouration caused by oil released upon cell rupture was also monitored. Tissue disruption by abrasion caused less tissue discolouration than did essential oil application and is possibly due to the epidermal and hypodermal cells acting as barriers. This is the first report on the evidence of essential oil damage that may involve in tissue browning of *B. myrtifolia*. Further investigations are on physiological and biochemical responses of the plant tissues during browning process.

Keywords: Australian native cut flower, cell structures, discoloration, oil glands

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Food, health and nutrition

The Rheological Properties of Wheat - Finger Millet Composite Flour as Influenced by Vital Wheat Gluten and Enzyme Lipopan F

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Finger millet (*Eleusine coracana*) is a drought tolerant cereal crop which thrives in marginal areas prone to drought particularly in Africa where it is considered as one of the staple crops. On the other hand, many African countries import, at a premium price, wheat for the baking industry. Therefore substitution of a proportion of wheat flour with finger-millet flour would reduce the cost of bread making in these countries. This study was designed to examine the rheological properties of a wheat-finger millet composite flour suitable for bread making. Composite blends of wheat flour each containing 10 %, 20 % and 30 % of finger millet flour were constituted. Vital wheat gluten and enzyme lipopan F were added to the wheat-finger millet composite blend containing 20 % finger millet flour. The effects of these flour substitutions on the rheological properties of the resultant composite doughs were determined using the farinograph and mixograph methods. The finger-millet flour substitutions did not affect water absorption significantly. Dough development time generally increased with the proportion of finger millet flour substitution. Vital wheat gluten and enzyme lipopan F decreased dough stability by approximately 42 % and 14 % respectively. However dough stability decreased with the addition of vital wheat gluten alone. The mixing tolerance index showed a positive correlation with the finger millet proportion as well as with the addition of either the vital wheat gluten or enzyme lipopan F or a combination of both the gluten and the enzyme. The results of this study indicated that a combination of 0.3 % gluten and 0.002 % lipopan F at 20 % finger millet flour substitution in wheat flour were optimum in improving dough rheological characteristics. This blend of flour composite holds promise in the bread-making industry in countries with abundant finger millet grain but limited wheat grain particularly in southern Africa. In addition, the finger millet growers in the marginal areas could benefit from an increased demand for the grain in the region and abroad.

Keywords: Composite flour, dough, enzyme, finger millet, wheat flour

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Nutritional, Zn Bioavailability and Antioxidant Properties of Water Leaf (*Talinum triangulare*) Mucilage

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In South-West and South-East Nigeria, when water leaf (*Talinum triangulare*) is to be cooked the leaves are squeezed with or without salt to remove the mucilage from the leaf before cooking, the resultant extracted mucilage are thrown away. Water-leaf mucilage was extracted to obtain a greenish, viscous solution. The solution was heated and precipitated with ethanol and acetone. The greenish coloured solid was dried in an oven at the temperature of 45°C to give a yield of 21 g mucilage kg^{-1} water leaf. The nutritional evaluation (proximate composition, mineral and Zn bioavailability determination) and antioxidant properties investigation (vitamin C, total phenol, flavonoid, Ferric reducing antioxidant power (FRAP) and DPPH free radical scavenging ability) of the mucilage was subsequently carried out. The result of the study revealed that the water leaf mucilage is high in protein (54.30 g per 100 g) and fat (29.00 g per 100 g) with a high energy value (499.8 kcal). However it has low fibre content of 3.50 g per 100 g. The mucilage is also high in minerals Ca, Mg and Fe but low in Zn 0.76 ppm. The calculated phytate : zinc molar ratio of 30.0 for the mucilage was twice the critical value for reduced zinc bioavailability (15.0). However the calculated calcium : phytate molar ratio of 5.44 was just below 6.0. The calculated [Ca][Phytate]/[Zn] molar ratio (0.59 mol kg^{-1}) was just above the critical level. The flavonoids of the mucilage was found to be 9.17 mg QE g^{-1} at 250μg ml^{-1} and 3.57 mg QE g^{-1} at 500 μg ml^{-1} while the total phenol was 2.98 mg GAE g^{-1} at 50 μg ml^{-1} and 1.23 mg GAE g^{-1} at 100 μg ml^{-1}. The water leaf mucilage exhibited a high level of antioxidant activities as depicted by high reducing power FRAP (6.37 mg AAE g^{-1}) and DPPH scavenging ability (28.78 %).

The high antioxidant activity as depicted by the high FRAP and DPPH scavenging ability of the muculage of waterleaf vegetable can contribute to the health management of man.

Keywords: Antioxidant, nutrient, total phenol, water leaf, Zn bioavailability

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Iron, Zinc, Carotenoids, Bioactive Compound, and Antioxidant Activity of Indonesian Black Colored Rice

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Black rice (*Oryza sativa* var Malang) is one variety of rice which has dark colour. In Indonesia black rice has only been used in a small amount as an ingredient in traditional ceremony. The objective of this research were to investigate the effect of boiling on iron, zinc, carotenoids, phenolic, and anthocyanin contents of back rice, and the antioxidant activity of the extract using DPPH, FRAP, superoxide radical scavenging, and linoleic acid bleaching methods (TBARS).

There were no significant differences on iron and zinc contents between raw and boiled rice. The iron content for raw and boiled rice were $1,66 \pm 0,42$ and $1,87 \pm 0,39$ mg/100g, respectively, and the zinc content were $2,24 \pm 0,22$ and $2,0 \pm 0,50$ mg/100g, respectively. Boiling could significantly decrease the anthocyanin and phenolic contents. The anthocyanin content were 205,54 and 52,59 mg cyanidin equivalent/100g for raw and boiled rice, respectively. The phenolic content were 728,9 and 553,04 mg catechin equivalent/100g, respectively. For carotenoids, lutein was the major compound identified, followed by α-carotene, ß-carotene, ß-cryptoxanthine, lycopene, and zeaxanthine. The contents for raw extract were 1106,49; 547,90; 50,70; 11,40; 7,80; and 3,57 ng/100 g, respectively. There were no significant differences between raw and boiled sample.

The antioxidant activities were significantly reduced by the boiling process. Scavenging activity against DPPH was reduced from 87,49 % to 61,4 %. Feric reducing/antioxidant power (FRAP) was reduced from 1101,24 to 758,05 mmol Fe [II]/mg extract, superoxide radical scavenging was reduced from 72,14 % to 46,39 %, and inhibition of TBARS formation for raw sample was 0,54 μmol and 1,05 μmol for boiled sample.

Based on the results black rice could potentially be used as a substitute for white rice in Indonesian diet. The iron, zinc, and carotenoids content of black rice could give a better contribution than white rice for micronutrient intake. Moreover black rice has bioactive compounds such as anthocyanin and phenolics, which could act as natural antioxidant.

Keywords: Anthocyanin, antioxidant activity, black rice, carotenoids, micronutrient, phenolic

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Carotenoids and Carotenoid Derived Compounds in *Pandanus amaryllifolius* from Indonesia

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In Indonesia, several herbal leaves also generally for condiments to improve aroma and flavor in foods *e.g.* pandan leaves. *Pandanus amaryllifolius* leaves, commonly known as pandan, are often used to give a refreshing, fragrant flavor to both sweet and savoury South-East-Asian dishes (rice, chicken, jellies, drinks, puddings, custard or sweets). Pandan leaves are also used in cooking ordinary non-aromatic rice to imitate the more expensive aromatic Basmati and Jasmine rices. As a traditional herbal this leaves are generally used to treat the typhus illness in Indonesia. The effect of antimicrobial effect of *Pandanus amaryllifolius* leaves have been investigated on the preservation of stored milk.

In this research the general objective is to investigate the formation of natural aroma compounds (norisoprenoids) from carotenoids as an approach for "green technology" application that can be applied for further application in flavors or fragrance industries. At the beginning we used *Pandanus amaryllifolius* leaves from Indonesia as a model plant. Several natural resources in Indonesia as one of developing countries have not yet been fully utilised and have low economical values, so that give further impact for the food security in Indonesia and thus correlated to the sustainable development.

In our preliminary research, we have investigated carotenoids (ß-carotene and lutein as major carotenoids) which are potential as enzymatic precursors by HPLC RP-C18. Carotenoid derived compounds or norisoprenoids (alpha-ionone and ß-ionone) as putative enzymatic reaction products are identified by HS-SPME GC-MS as one approach for solvent-less flavor analysis which is suitable to green chemistry. These analytical approaches are used to investigate the enzymatic reaction activities in this model plant.

Keywords: Indonesia

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Effect of Drying Temperature on the Quality of *Stevia rebaudiana*

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Recent research has shown that consuming stevia in its raw form, fresh or dried, helps to treat several health problems such as diabetes, allergies, digestive problems, anxiety, and high blood pressure. Besides these benefits, it also contains vitamin C, calcium, beta-carotene, niacin, chrome, iron, magnesium, potassium and silicium, proteins and fiber. Therefore, it is important to find alternatives to dry the plant's leaves trying to minimise its negative effects and keeping the amount of medicinal properties.

The main objective of the drying process is to eliminate moisture and to stabilise chemically and microbiolically natural products. Generally, the drying process leads to a reduction of the visual, organoleptic and functional characteristics of the plants which affect negatively its final quality parameters like colour, texture, aroma, essential oil content and shape. These effects are caused by the increase of the product's temperature while drying, the drying time and the elimination of moisture. The knowledge of the drying parameters that minimise these effects and that allow to obtain products with the required quality characteristics is a necessary task to study.

The purpose of this study is to establish the effect of the drying temperature on the colour of *Stevia rebaudiana*. Since this plant is used as tea or as herb infusion, the colour is also an essential criterion for quality which influences the consumers' acceptance of the product. The herbs were dried in a tray oven at temperatures between 40°C and 80°C with controlled air flow and relative humidity of the air. The change in colour was determined with a colorimeter Minolta CR400 which allows a tridimensional colour representation in coordinates L*, a* and b*. The drying kinetics was also determined. Finally it was found that combinations of temperatures beginning with high temperature are not advisable since they produce severe changes in the colour that affect negatively the final quality of the product, diminishing their medicinal properties and their commercial value.

Keywords: Drying, quality, stevia

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Effect of Gamma Irradiation and Storage on Fungal Growth, Aflatoxin Production and Quality Characteristics of Groundnuts

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Gamma irradiation has been established as a safe and effective physical means for microbial decontamination, disinfestation, shelf-life extension and improvement of overall nutritional attributes. The aim of this study was to determine the fungal growth, aflatoxin production, nutritive value and the quality characteristics of extracted oil of two groundnut (*Arachis hypogaea*) cultivars namely Sodari and Madani as affected of gamma irradiation at dose levels of 0, 1, 1.5 and 2 kGy followed by storage at room temperature.

After two years storage at room temperature, the results revealed that the fungal growth was significantly ($p < 0.05$) lower in the irradiated seeds compare to the control one for both cultivars. Furthermore, gamma irradiation treatments significantly ($p < 0.05$) reduced the production of aflatoxin especially at the dose of 2 kGy, which was 5.50 and 4.50 ppb in the cultivar Sodari and Madani, respectively. Moreover, the results indicated that gamma irradiation had significant ($p < 0.05$) effects on crude oil and crude protein contents after storage for both cultivars. For the quality characteristics of extracted groundnut oil, the results proved that gamma irradiation treatments with storage caused significant ($p < 0.05$) reduction in the acid value and the peroxide value, while the relative viscosity significantly increased, however, no significant change in refractive index was observed for both cultivars.

In the current study, the obtained results confirm that application of gamma irradiation prevent the fungal growth as well as production of the aflatoxin effectively for a long period of time extending to two years without adverse damage in groundnut quality.

Keywords: Aflatoxin, fungal growth, gamma irradiation, groundnut, storage

Nutrient Composition of *Artocarpus lakoocha* Fruit: A Minor Indigenous Fruit Can Meet the Nutrient Requirement of the Rural Peoples of Bangladesh

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Bangladesh has been blessed with a plenty of minor indigenous fruits that are very rich in micronutrients. Minor fruits are edible fruits which have no real commercial value. However, they are rich in vitamins and minerals, are easily accessible to the poor people and can be an economically viable nutrient source. They grow naturally in the wild, relatively free of serious insect and disease problems. As part of the development of a new food composition database for Bangladesh, the minor fruit *Artocarpus lakoocha* Roxb. was collected from four different wholesale markets located at entry points to the city of Dhaka and two remote areas of Bangladesh. After washing and drying, which removes unwanted substances from the fruits, the edible part (EP) was analysed for ascorbic acid, carotenoid, dry matter (DM), calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P), iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn). Ascorbic acid and the carotenoid content of the fruit samples were analysed by spectrophotometric measurement. Macrominerals (Ca, Mg, K and P) were analysed by flame photometric and spectrophotometric procedures and trace elements (Fe, Mn, Zn and Cu) were analysed by atomic absorption spectrophotometry. The results were compared with literature, Indian food composition tables and the United States Department of Agriculture National Nutrient Database for Standard Reference. *Artocarpus lakoocha* contained higher amounts/ of carotenoids (4609.00 μg per 100 g EP) and other nutrients than some of the major fruits of Bangladesh. The results of this study will help to create awareness among the people of Bangladesh of the importance of eating more Artocarpus lakoocha fruits and of protecting this tree from extinction in order to maintain biodiversity.

Keywords: *Artocarpus lakoocha*, Bangladesh, minor indigenous fruit, nutrient composition, rural people

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Raw Milk Consumption Behaviour and Assessment of its Risk Factors among Dairy Producers in Urban and Peri-Urban Areas of Debre-Zeit, Ethiopia: Implication for Public Health

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A cross-sectional study was conducted from October 2009 to March 2010 in order to assess the risk to public health associated with raw milk consumption. The study investigated raw milk consumption behaviour, factors associated with the consumption of raw milk and milk handling practices among dairy farming communities in urban and peri urban areas of Debre-Zeit. A total of 170 dairy farmers were surveyed. Whether the levels of education, income, urbanisation and awareness of milk borne diseases could be associated with raw milk consumption was tested by statistical analyses. Of the 170 participants, 54 (31.8 %) producers had a habit of consuming raw milk. The proportion of dairy farmers consuming raw milk was significantly higher in peri urban areas (94.8 %) than in urban areas of Debre-Zeit (13.0 %, χ^2=89.3, df=1, OR=124.1, $p < 0.001$). Of the factors tested, only residing in peri urban areas was significantly associated with consumption of raw milk ($p < 0.001$). All, 29.4 % and 19.4 % of the farmers included in this study used plastic containers for transporting, milking and storing milk, respectively. The proportion of farmers who stored milk at room temperature (46.5 %) was significantly higher than those who stored at refrigeration temperature (24.1 %, χ^2=13.9, df=2, $p = 0.001$). Storage of milk at room temperature for more than 24 hours for milk fermentation was a common practice among those who did not boil milk for consumption (82.0 %, 41/50). The majority of the 170 dairy farmers (85.6 %) were unaware of milk borne diseases associated with consumption of raw milk. The study showed that the habit of raw milk consumption, poor milk handling practices and inadequate knowledge of milk borne diseases among dairy producers imply the risk of milk borne diseases in the study area.

Keywords: Consumption habit, Debre-Zeit, milk borne disease, raw milk, risk factors

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Assessment of Microbial Contamination in the Traditional Beverage of Farm Workers in Limpopo, South Africa

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Agricultural systems in the smallholder sector in southern Africa are largely subsistent. Household members of each smallholder farm provide all the necessary labor requirements at the farm. The farmers often prepare traditional foods and beverages for consumption during the long working periods in the fields. One such traditional non-alcoholic beverage called 'mageu', prepared from the porridge of cereal grains (such as corn or sorghum), is widely consumed in the region during field work. Partly because of the simplicity in its preparation, it has gained popularity in both rural and urban areas. It is now also produced commercially in many countries in the region. However, there is insufficient information about contamination of 'mageu' by micro-organisms such as *Salmonella* that may cause health problems for farm workers, thus jeopardising farm labor and hence farm production. This study was designed to assess microbial proliferation in traditionally prepared 'mageu' (TPM) in comparison with commercially prepared 'mageu' (CPM). The total plate count method was used to detect the proliferation of four commonly occurring micro-organisms namely Salmonella, Escherichia coli and Basiluss cereus. The pH and titratable acidity were also determined. The plate counts for the TPM was significantly ($p < 0.05$) high, attaining approximately 68.5×10^2 CFU mL^{-1}. In contrast, the mean proliferation of the micro-organisms in the CPM was significantly lower reaching a maximum of $0.3 \times 10^2 \times$ CFU mL^{-1}. The TPM was more acidic (pH=3.5) than the CPM (pH=4.6). Similarly, the titratable acidity ranged between 0.4–0.5 % for the CPM and 0.3–0.8 % for the TPM. It was recommended that the traditional preparation of 'mageu' could utilise a commercial starter and a simplified HACCP procedure in order to minimise microbial proliferation. Improving the hygienic preparation of this traditional beverage by the farmers could contribute to both their health status and efficient farm production in the harsh agro-ecologies that are prevalent in southern Africa.

Keywords: Farm worker, labor, microorganisms, traditional beverage

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Health Monitoring of Packed Agricultural Products Using Dynamic Analysis

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Mechanical injuries are responsible for considerable decay of fresh fruits and vegetables. Produce discarded because of damage in the chain between the grower and the consumer is estimated at around 30–40%. With regard to transportation, frequent attention has been devoted to delicate fruits such as apple. Effectiveness of cushioning materials and damping ratio in protecting impact damage of apples is the primary objective of this research. Health monitoring of packed agricultural product are not only important from practical and economical view point, they also exhibit interesting dynamics. In this study the variation in dynamic response and modal parameters (natural frequency, damping ratio, mode shape) as the main features of damage have been analysed. The measurements of the dynamic response looked at two types of fruit package: carton and plastic and three cushioning materials to control vibration: without paper - with paper-wrap - with foam-net. The modal parameters estimation was based on the acquired data using vibration exciter as an actuator and piezoelectric accelerometers with pulse analyser. Six vibration modes were identified in the following range (0–1.6 kHz) by two techniques frequency domain decomposition and enhanced frequency domain decomposition. The cushioning material interaction is also studied for damage feature. The study showed that: tight-filling of the container with cushioning material may move the natural frequency of fruit out of range that transport vehicle and reduce resonant vibration and vibration bruising. The technique of enhanced frequency domain decomposition introduces significant improvements for estimating damping capacity and identifying very close modes.

Keywords: Cushioning material, damage detection system, health monitoring, identification modal analysis, quality of fruits

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Combining Radio Frequency Drying with Hot Air Oven for Energy Reduction in GABA Rice

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Fresh GABA rice contains high moisture content approximately 38 % wet basis (wb). Most of fast drying process require high energy consumption and affect negatively to its quality. Beside that, the microorganisms are easily grown in the wet grain. Therefore, immediately drying to prevent the growing of microorganisms is also needed. This study has been conducted in order to compare the effectiveness of different drying methods in order to decrease the moisture content (MC) of the fresh GABA rice (36 % MC) to 14 % MC wet basis and the control the microorganisms on the dried product. The treatments were hot air drying (50°C and 60°C), solely radio frequency (RF) drying at 27.12 MHz for 65°C, 75°C and 85°C and combination of hot air drying and RF drying by applied first the hot air drying at 50°C until they decreased their moisture to 30 %, 25 % and 20 % and thereafter apply RF drying at 65°C, 75°C and 85°C until the final moisture reached to 14 %. The specific energy consumption (SEC) was calculated. The moisture content, the cooking quality were determined followed by their viscosities as well as disease decontamination was also detected regarding to Bacteriological Analytical Manual (BAM) and the GABA content were also determined. The results showed that RF solely drying took significantly shorter period of time than other methods. SEC value completely confirmed that hot air drying consumed higher energy (52.56–17.37 MJ kg^{-1}) than combination with RF (between 12.43–6.21 MJ kg^{-1}) while solely RF drying expressed the SEC between 0.81–0.42 MJ kg^{-1}. Drying with RF treatments decreased the number of microorganism contamination effectively. Furthermore, their treated rice provided better cooking qualities. However, the highest number of GABA content was found in the treatment of combined hot air oven method to 20 % followed by RF 65°C, 75°C and 85°C treatments. Therefore, it can be concluded that RF drying combine with conventional hot air drying is an alternative way for saving energy consumption in GABA rice process and the microorganism decontamination could be achieved with positive improvement on their cooking qualities.

Keywords: Cooking qualities, drying, GABA rice, radio frequency

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Modelling

Systems modelling

Using Systems Modelling to Assess Production Efficiency in Contrasting Agricultural Systems

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The prospects for increasing global agricultural productivity can be assessed by comparing current performance of farm enterprises relative to their potential productivity as well as the riskiness of current and proposed intensification options. The concept of eco-efficiency, the production of food and fibre products relative to the ecological resources used as inputs, is used in this paper to diagnosis of state of agricultural production in contrasting agricultural systems in Australia (rainfed wheat systems), China (irrigated wheat-maize double crop systems) and Zimbabwe (rainfed maize systems). Surveyed crop yields in these three countries were compared against simulated yields at farmer-specified levels of inputs and risk.

In this study APSIM is used to simulate the potential and attainable yields of surveyed crops from three diverse production systems that are prominent in Australia, China and Zimbabwe. APSIM is well suited to this application, having been widely tested against experimental and farmer field data for the systems of interest in this study. The pathway of closing yield gaps is evident in all three systems. However, for Australian wheat farmers, new technologies and practices are also essential to increase production without added riskiness. In contrast, Chinese farmers can reduce inputs and risks without sacrificing production through more efficient use of their fertiliser inputs. African farmers have the opportunity for significant production increases with current technological inputs but to do so requires acceptance of much higher risks. This paper uses a novel return–risk analysis framework to benchmark contrasting production systems and to identify likely pathways for improving their eco-efficiency.

Keywords: Eco-efficiency, farm yields, systems modelling

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Transitions in Agro-Pastoralist Systems of East Africa: Impacts on Food Security and Vulnerability

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Climate-induced livelihood transitions in the agricultural systems of Africa are increasingly likely. There is limited evidence on what such transitions might look like. We tested the hypothesis that sedentary farmers in transition zones that may become warmer and drier in the future may be forced to increase their reliance on livestock vis-à-vis cropping in the future. We carried out fieldwork in 12 sites in Kenya, Tanzania and Uganda to understand changes in farming systems in the recent past. We then evaluated what the impacts of these changesmay be on household incomes and food security in the future, using crop and household modelling. We found no direct evidence for the hypothesised extensification of production in the study sites. Human diets have changed considerably in the last 40 years, as cropping has been taken up by increasing numbers of households, even in marginal places. Maize predominates, but some householders are increasing their crop and diet diversity, particularly in the locations with higher annual rainfall. At all sites people wanted to have more livestock. Food insecurity was common at all sites with an annual rainfall of 800 mm or less, and critical levels were seen at the sites with less than 700 mm of rainfall. Households were self-sufficient in securing adequate dietary energy from food production in 7 of the 12 sites, all with rainfall higher than 800 mm. Model results indicate that climate change may create opportunities for diversifying cropping in some places and allowing cropping to start whereit is not currently possible. Other places might see substantial reductions in crop yields. Although many householders have some knowledge about drought-tolerant crops, few cultivate millet, sorghum and cassava. Reliance on maize may be increasingly risky in view of its susceptibility to climate change impacts. Policies aimed at increasing the consumption of cassava, sorghum, millet and pigeonpea could be highly beneficial for future food security in the region. Vulnerability in the drier locations is already high, and policies should support safety nets and market and infrastructural development. Households in the wetter areas need to manage risk and to increase cropping diversity. Acritical requirement is knowledge transfer concerning the growing and utilisation of unfamiliar and untraditional crops.

Keywords: Food security, pastoralism

Central American Bean Systems and the Changing Climate

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In order to be able to adapt to climate change, bean producing smallholders in Central America have to know which type of changes and to which extent and ranges these changes will occur. Adaptation is only possible if global climate predictions are downscaled and distinct/regionally specific, to give farmers a direction on what to adapt to, but also to provide detailed information about the extent of climate change impact and the exact location of the affected population to local, national, and regional governments and authorities, and the international cooperation/donors in order to coordinate and focus their interventions in the future. Our analysis show that there will be people who will be more affected by climate change than others; some might have to leave the agricultural sector while others will have to change their whole operation. But there will be also new opportunities for those who will adapt quickly making them winners of changes in climate. This presentation seeks to assess the expected impact of climate change on bean production in 4 countries in Central America. We downscaled GCM (Global Climate Models) to a local scale and predicted future bean production using the dynamic crop model Decision Support for Agro-technology Transfer (DSSAT). Based on the DSSAT-results 3 types of focus-spots where impact is predicted were found to be significant. Simultations were repeated with the full range of available GCMs to address uncertainty of model predictions. Alongside this analysis we started a field trial using 10 bean varieties in 5 countries to calibrate DSSAT and run it in order to make assumptions on determining factors and possible breeding strategies. Outputs of downscaled climate data show that temperature is predicted to increase in the future, while precipitation will slightly reduce. Crop modelling shows that bean yields will decrease high along the dry corridor in Central America and Hot-Spots with more than 50 % yield reduce could be identified in the study area. Based on the results we finally made recommendations for adaptation- and mitigation strategies such as irrigation and water-catchment, controlled agricultural land use shift, genetic improvement for heat-stress besides others.

Keywords: Adaptation strategies, bean production, Central America, climate change, crop modelling, impact focus spots

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Models and Implementation of Carbon-Optimised Land Management Strategies in Southern Amazonia: Carbiocial

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The globally relevant land use frontier of southern Amazonia is extremely dynamic. Deforestation is accelerating along the Cuiabá-Santarém highway and is associated with further major C losses and GHG releases. Global interest in curtailing these emissions is high as the relevance of the affected ecosystems (rainforest and savannahs) for C storage and GHG cycling is of global importance. Model calculations of C and GHG fluxes from the respective ecosystems for different land use scenarios are still highly uncertain because (a) dynamic land use patterns are not fully captured yet and (b) GHG models need precise in-situ calibration. Consequently, regionally specified models are essential and the key target of this project.

The main goals of this multi- and interdisciplinary approach for Brazilian-German cooperation within the BMBF-FONA-programme are viable C-optimised land management strategies mitigating GHG emissions and maintaining ecosystem services (ESS) under changing climate conditions. They are urgently needed to meet the goals set by Brazilian national plans and international treaties such as REDD and the Kyoto protocol.

Three regions along the land use frontier of southern Amazonia were selected: Novo Progresso (southern Pará): most active deforestation; Sinop (northern Mato Grosso): young soy bean production; Cuiabá (Central Mato Grosso): established cultivation (>20 years) and adapted mechanised cropping (*e.g.* no till). Analyses focus on soil carbon (C) turnover, climate, ecosystem functions and socio-economic processes. Simulation models will be combined as software packages to support the decision-taking process based on field and acquired data, including a step-by-step up-scaling from local to landscape and regional scale. All research and implementation activities include direct involvement of the stakeholders. Furthermore, joint field experiments for improving C storage and ecosystem functions will be performed on-farm in tight cooperation with state (Environmental Agencies, district administration) and private organisations (farmer) of Mato Grosso and southern Pará.

The presentation will give an overview on the Brazilian-German collaborative research and progress of research results.

Keywords: Carbon-optimised land management, climate change, decision support system, ecosystem services, land use change, southern Amazonia

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Economic Gains from Benefit Sharing Based Water Allocation in the Aral Sea Basin

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Water scarcity is rapidly increasing in many arid and semi-arid regions of the world due to population growth, irrigation expansion, industrial development, and climate change. At the same time, since water is delivered to the water users without considering its real economic value, water wastage is very high, especially in water abundant upstream regions of river basins, leaving less water to the downstream water users. Thus, there is strong need to provide efficient and equitable distribution of basin water resources among water users. Administrative water allocation fails to maintain Pareto efficient allocation and thus there is a potential for further increase in benefits of water users in the basin without losses incurred by any. This paper presents alternative water allocation mechanism which is based on benefit sharing by introducing tradable water use rights and incentives water users for rational water use. To this end, hydro-economic model combining both econometric and mathematical programming approaches was developed and applied to the case of the Aral Sea basin, where water is a critical resource for sustainability and development, as evidenced by the Aral Sea desiccation - one of the worst ecologic disasters in the world. Preliminary results show that all the riparian regions get additional benefits after introducing tradable water rights. In a normal year, overall basin benefit due to improved water productivity and efficient water allocation can increase $US 83 million under intra-catchment water rights trading, while $US 124 million under intra-catchment water rights trading without increase in total water use. Concurrently, if water users agree for keeping benefits unchanged while admitting conditions of benefit sharing based water allocation, water rights trading would allow saving additional water which can be released to the Aral Sea and thus serve to improve ecological sustainability in the region. It is argued that benefit sharing based water allocation, once its transaction costs are acceptable, can be more feasible option to increase water use efficiency in the basin than other technological improvements which require huge investment expenditures.

Keywords: Hydro-economic model, inter- and intracatchment, sustainability, water rights trading, water use rights

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Comparison of Fitting Crop Seedling Emergence Models with Some Nonlinear Models

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Seedling emergence is one of the most important processes determining yield and the possibility of crop failure. There has been accomplished numerous researches in recent years to understand and predict the emergence patterns of crop and weed species for different objectives. Nonlinear regression models have been developed to explain crop and weed emergence patterns as a function of time. In this study, we tested some seedling emergence models by field data of three crop species including green bean (*Phaseolus vulgaris* L. var. Sunray), sunflower (*Helianthus annuus* L. var. Alistar) and maize (*Zea mays* L. var. Merit). Prediction of crop seedling emergence with the France and Thornley model, and growth by the Logistic, Gompertz and Monomolecular models were also attempted. Seed emergence indices (SOE, MED, ERI, T0.5) showed that seedling emergence of maize was greater than green bean and sunflower. The values of the median emergence date (T0.5) predicted by the logistic model were in close agreement with the time required for 50 % emergence calculated directly from interpolation of the raw emergence data. While shoot length (Lf) of crop seedling emergence fitted by Logistic and Monomolecular models were significant, it was not significant in Gompertz model statistically. Among the three models, the Gompertz and the Logistic models gave quite satisfactory results as the predicted values from the model and the observed values from the experiment were close (ME 0.9 in most of the cases and RMSE<8.0). The Monomolecular model was not suitable for prediction of studied crop seedling emergence due to its higher RMSE values (>12 in all cases). Results showed that the empirical models with an inflection point are recommendable because they predicted growth of crops seedling superiorly.

Keywords: Growth, model fitting, nonlinear regression

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Modelling the Effect of Sowing Depth on Green Bean, Sunflower and Maize Seedling Emergence

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Crop prediction models often assume a standard sowing depth but this may vary both between and within crops. Quantitative information about sowing depth effects on seedling emergence in green bean (*Phaseolus vulgaris* L. var. Sunray), sunflower (*Helianthus annuus* L. var. Alistar) and maize (*Zea mays* L. var. Merit) are scarce. The main objective of this study was to develop a seedling emergence model for these crops and was select a best-fitted model associated with sowing depth. To do this, a factorial experimental based on completely randomised design was conducted at Research Greenhouse of Agriculture College of Ahar, to quantify the response of seedling emergence to sowing depth. Several linear and non-linear functions were used to describe the relationship between emergence percentage and rate with sowing depth. The pot experiment was conducted in a constant temperature ($21°C \pm 1$) using ten sowing depths (1–10 cm). The results indicated that the percentage emergences of all species in the shallow first five levels of sowing depth (1–5 cm) were high, but at deeper levels, seedling emergence were suffering a severe loss. Emergence percentage per 1 cm increase in sowing depth according to linear regression models in green bean, sunflower and maize were 9.0 %, 10.8 % and 10.0 % percent and emergence rate 0.59, 0.64 and 0.95 days, respectively. Emergence indices (SOE, MED, ERI, D50 %) showed that seedling emergence of maize was greater than green bean and sunflower. For all species an increase in pre-emergence mortality with increasing depth was observed in the experiments. However, the fitted probit curves for each illustrate that the rate of increase varied between species. The rate of emergence varied between species. In addition, the quadratic model appeared to provide the best-fit overall for emergence response to sowing depth in the experiment.

Keywords: Emergence indices, model fitting, modelling seedling emergence, probit curves

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Analysis of the Economic Efficiency of Investments in Cotton Production in the Municipalities of Kouande and Kerou in Northern Benin

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Since the years 2000, the cotton sector in Benin was faced with a crisis due to institutional and financial management. The adverse effects of this crisis were known to be a drastic decrease in farmers' incomes and a worsening of poverty in rural areas. This paper aims at analysing in this context the economic efficiency of investments in cotton production. For this, data were collected by surveying 140 randomly selected in the municipalities of Kouande and Kerou in Northern Benin. Data collected were related to cotton productivity and its unit price, to quantities of inputs used and their unit prices. A Cobb-Douglas and a Translog models were estimated by considering six inputs, namely cotton acreage, mineral fertiliser, insecticide, herbicide, capital and family labor. The estimated models allowed computing the marginal productivities of the different inputs. As a result, the analysis with the Cobb-Douglas model shows that investing in land and inputs of mineral fertiliser, insecticide and herbicide was economically efficient. In fact, the marginal productivities of the named inputs were higher than their unit prices, respectively. In contrast, the Translog model did reveal that a given production input, when isolated from the others, was not economically efficient. However, the cotton productivity was determined by the inputs interactions such as labor- herbicide, labor-capital and capital-herbicides, which helped significantly improving the economic efficiency of the investments. From these results, institutional and financial management of the sector should be oriented toward the identified input factors and their interactions in order to mitigate the adverse effects of the crisis in the study area.

Keywords: Cotton, economic efficiency, investment, Kouande, Kerou, Benin

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Climate Change and the Vulnerability of Water Resources in Northern Cameroon

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Water resources in northern Cameroon have continuously been reducing over the past years. Many studies have suggested two principal causes and these include:

1. Human activities such as poor farming practices, unsustainable use of water resources, increased demand of water, deforestation, land use change etc.;
2. Human induced climate change.

Northern Cameroon in this study includes: the Adamawa, North and Far North Regions located closer to the Sahel regions of Africa. These regions are already water stressed because of their location and any further change in climate with rising temperature would impact water resource either positively or negatively. Time series analysis and a 12 month Standardized Precipitation Index (SPI) with digital data between 1957 and 2006 were used to investigate the variation of water resources in this Sudano-Sahelian region of Cameroon. The results obtained varies between the different regions with an increased annual trend in temperature and precipitation for Ngaoundere (Adamawa Region) and Garoua (North Region), whereas Maroua (Far North Region) had a decreased annual trend in both precipitation and temperature. Further variability results obtained from the 12 months Standardized Precipitation Index (SPI12) showed that wetter periods outnumber drought periods in all 3 regions. The study then concluded that water resources vary with changing climatic conditions and the severity of the impact varies from region to region. Furthermore, water deficiency in northern Cameroon might not be due to climate change. The reasons might be a combination of poor water management and other factors such as population growth, environmental conditions etc.

Keywords: Climate change, northern Cameroon, rainfall, vulnerability, water resources

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Simulating Potential Yield in Oil Palm: Its Application in Yield Gap Analysis and the Limitations

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Knowledge about yield gaps, *i.e.* the difference between attainable and actual yield, is key information for sustainably intensifying crop production systems. For oil palm, one of the fastest growing agricultural industries in SE Asia, increasing yields on existing plantations is needed to meet the increasing demand for vegetable oil and to avoid further pressure for new plantations. Considering that average yields of $4\,t$ oil ha^{-1} are commonly reported in Indonesia and that yields of $8\,t\,ha^{-1}$ at the block scale and $6\,t\,ha^{-1}$ at the plantation scale are achievable, large yield increases should be possible. One of the most promising methods for increasing yield is through the use of "Best management practices" (BMP) to increase the yield in mature plantations. These practices, promoted by the International Plant Nutrition Institute (IPNI), include practices such as improved harvest techniques and optimised nutrient management. From 2006–2010, these BMP's were tested on block scale at six sites located in Kalimantan and Sumatra. Results show that yields in blocks managed according to the BMP guidelines were significantly higher than in standard managed blocks across these different sites. However, as the potential yield is unknown at the specific site, it is hard to judge how much BMP contributes to closing the hypothesised yield gap. A recently developed oil palm growth model PALMSIM has been employed to simulate potential yield based on incoming radiation and water availability for the blocks in the six sites.

The paper will present the simulated results compared with yield achieved under standard management and BMP. The difference between actual and simulated yield answers how much BMP contributes to close the gap in relation to potential yield. It is argued that simulating the yield by a potential crop growth model is a necessary first step, but as long as site-specific yield determining factors such as rooting depth and local hydrology are ignored, the potential yield can be often overestimated. For some sites soil restrictions may cause a larger gap between potential and site-specific potential yield. Future modelling work in oil palm has to address effects of inherent soil characteristics on site specific potential yield.

Keywords: Crop growth modelling, Indonesia, oil palm, potential yield, yield gap analysis

Different Environmental Indicators Lead to Conflicting Impact Assessments - The Example of South American Beef Production

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Beef is one of the most important food commodities which is reflected in its high international trade volume. Global demand for beef has been rising consistently over the past five decades. About one third of all agricultural land on the globe is wholly or partially occupied by beef production systems. Beef production systems have a bad reputation in terms of environmental impacts from land area and total water requirements to GHG emissions. The paper examines three different evaluation tools applied to extensive and semi-intensive beef production systems in South America. System behaviour was tested for the impact of interventions on energy efficiency and methane output by using simulation models. Compensatory carbon sequestration area was calculated for 31 beef production enterprises with three levels of production intensity using a "carbon footprint" type of accounting. Evaluation of water productivity was carried out by calculating "virtual water contents" for three levels of production intensity typically found in South America. Results were conflicting. Energy efficiency was not improved through intensifying interventions. Likewise there was no reduction in methane outputs when yield enhancing interventions were applied. On the other hand intensification had a marked positive effect on carbon footprint, *i.e.* a significant reduction of the required carbon sequestration area. Yield enhancing measures had no effect in either way on water productivity with the exception of increasing nutrient densities in the diet, which were found to improve water productivity but not energetic and or economic efficiency. The complexity of the findings points to the necessity to develop an evaluation system which takes into account conflicting responses by weighted assessment of the different environmental impacts against different economic and political backgrounds.

Keywords: Beef production, environmental impact, greenhouse gases, landscape use, South America, water footprint

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Monitoring Sand Encroachment on Agricultural Land in White Nile State, Sudan, during 1975–2008 using Remote Sensing and GIS

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Wind erosion is an important soil degradation process affecting arid and semi-arid regions worldwide. This process is destructive and damaging; covering fertile lands, bushes, trees, roads and buildings. Sand encroachment in the White Nile State has been recognised as the most serious environmental problem, thus also facing the study area 50 km south of Khartoum, including the El Geteina and Ed Duim localities, which are part of the Gezira agricultural scheme. The objective of this study is to monitor and assess the encroachment of sand dunes and vegetation degradation in the study area during a period of 34 years using remotely sensed imagery and GIS techniques as well as to evaluate the efficiency of remote sensing and GIS in achieving these objectives. For this purpose four satellite images (MSS 1974, TM 1986, ETM+ 2000 and 2008) were analysed in addition to field information, soil analysis and other existing information (topographical and geological maps). The study was based on visual interpretation, digital analysis, laboratory analysis and field work, whereupon geometric and radiometric correction, image enhancement, visual interpretation of colour composites, unsupervised and supervised classifications as well as change detection were applied. The results revealed that during the study period the shifting dunes increased 11 % (annual rate 0.32%/year) and the vegetation cover decreased by 20 % (annual rate 0.58%/year) while the cultivated areas (rain-fed agriculture on sandy soils, rain-fed agriculture on clay soil and irrigated agriculture) increased 2 %, 10 % and 7 % (annual rate 0.05%/year, 0.29%/year and 0.20%/year) respectively. This trend indicates accelerated land degradation as the result of regional climatic change and human misuse of land. The study proves that remotely sensed image and geographic information system techniques provide detailed results which should be further exploited in similar studies.

Keywords: Remote sensing, GIS, sand encroachment, White Nile State, wind erosion

Modelling the Adaptation Strategies of Farmers of the Andes Against Climate Change and the Related Development of Land Use / Land Cover

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There is a strong demand from policy makers for predictions about the impacts of climate change and the effect of potential adaptation responses on the local scale. This can be a difficult task, especially when dealing with highly complex socio-ecological systems. This paper discusses the suitability of agent-based-models (ABMs) for such a task. Formally, agent-based modelling is a computational method that enables a researcher to create, analyse, and experiment with models composed of agents that interact with each other within an environment.

The research uses mathematical programming-based multi-agent systems (MP-MAS), an ABM software application for simulating land use change in agriculture and forestry. We use MP-MAS for assessing the development of farming systems under potential climate change scenarios in agricultural systems of the Andes of Peru. MP-MAS couples a cellular component representing a physical landscape with an agent-based component representing land-use decision-making. The uniqueness of MP-MAS lies in the fact that it incorporates whole farm mathematical programming to simulate land use decision-making.

A prototype was implemented with the data available from the INCA project in the Achamayo watershed located in Junín, Peru. As environmental driver of land use change the model used information about daily average, minimum and maximum temperature of the last 30 years to predict three different scenarios for the year 2050. Main land uses included agriculture, grasslands, forest plantations and urban areas. Preliminary results show in all scenarios an expansion of the agricultural land while grasslands decrease in total area and also in quality (with more grassland area categorised as "low density"). Between the adaptation responses of farmers, agroforestry was the one with a higher increase.

Further model development considers water availability as abiotic driver of land use change, market forces, as well as potential policy interventions (*e.g.* credit, subsidies) for local livelihood improvement. The relative impact of these drivers on systems dynamics will be discussed.

Keywords: Adaptation, climate change, farming system, land use, land use change, modelling

Assessing Variations in Land Use Land Cover of Kassala State, Eastern Sudan Using Multi-temporal Landsat Imagery

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Land cover change plays a pivotal role in regional socioeconomic development and global environment changes. In semi-arid region, where fragile ecosystems are dominant, the land cover change often reflects the most significant impact on the environment due to excessive human activities.

According to the location of the selected study area in semi-arid region, human activities such as livestock grazing by nomads and large scale mechanised farming operation has influenced the ecological pattern of the area thereby resulting to loss of natural vegetation, reduction of ground water via a low rainfall trend and decrease in clay soil which accelerate desert-like condition and introduction of unfavourable mesquite tree. The study attempt to assess and analyse variation of land use land cover changes and it is impacts in Kassala state, particularly the changes on the agricultural territories in the Gash river scheme, Eastern Sudan. Multi-temporal remotely sensed data (Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM+) between 1986 and 2011 were used together with Geographical Information System (GIS) techniques to assess changes in the study area. To minimise the seasonal fluctuation and removal of different distortions from the satellite images, atmospheric correction, radiometric correction for the spectral reflectance, geometric correction, resembling and rectification using a nearest neighbourhood method were done. To identify the land use land cover classes, a supervised maximum likelihood classification routine were used for the entire sub areas. The classes identified were: labid soil (clay soil), badopa soil (sandy clay soil), high dense mesquite trees, low dense mesquite tree and sand land. The study reveals that there was rapid increase of invasion of mesquite tree as well as increase in sand land during the period of the study and clear decrease in cultivated and grass land.

Keywords: Kassala state, land used land cover, remote sensing, semi-arid region, Sudan

Sustainability Assessment by Fuzzy Evaluation: Case Study in Urban Vegetable Cultivation Systems in Red River Delta, Vietnam

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Fuzzy logic is a scientific tool that permits the simulation of system dynamics without a detailed mathematical description by using "if-then" linguistic rules. There rules describe the logical evolution of the system according to the linguistic values of its principal characters that we call linguistic variables. This paper presents the results of the sustainability assessment by fuzzy evaluation of urban vegetable cultivation systems in Red River Delta, Vietnam. The case studies were conducted in three selected communes in urban areas of Ha Dong district in Hanoi in Red River Delta, Vietnam. The farms in those communes are small-scale vegetable and/or mixed vegetable-rice farms. Vegetables grown in the study area included cabbage, bean, cucumber, leafy cabbage, cauliflower, tomato, kohlrabi, and cauliflower. Average farm size was 0.107 ha in which 0.089 ha was used for vegetable production, the number of plot was 4.52 and plot size was 0.025 hectares. A workshop was carried out in February 2010, total 476 rules were gathered based on twelve indicators by using farmers' perceptions as well as their preferences into the decision making process. The fuzzification and defuzzification processes have done by using Fuzzy Logic Toolbox in MATLAB software. The results showed that the value for environmental sustainability indicators was 0.33, the social sustainability indicator was lowest (0.25), and economic sustainability was highest (0.50). The overall sustainability index of vegetable cultivation systems in the study area was very low (0.31). The results of this study indicate that urban vegetable cultivation systems in Red River Delta, Vietnam were unsustainable.

Keywords: Fuzzy evaluation, Red River Delta Vietnam, sustainability assessment, vegetable

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The Environmental Impact on Carbon Balance of Rubber Plantations - A Case Study on Nabanhe National Nature Reserve in Xishuangbanna, China

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Rubber plantations in the Nabanhe National Nature Reserve (NNNR) keep expanding at an accelerated rate since the 1970s, displacing primary and secondary tropical seasonal rainforests and change the land use in the buffer zones of the forest reserve. This conversion can revert ecosystem carbon sinks to sources due to burning and clearing, so that large amounts of carbon are emitted to the atmosphere. This contributes to the already constantly increasing atmospheric CO_2 concentration, which is considered to be one of the most important contributors to the present climatic variability and climate change. Nevertheless, it is not clear to what extent rubber plantations are able to store carbon under different environmental conditions compared to other land uses.

The aim of this research is to study the carbon balance of rubber plantations in the NNNR depending on different environmental and management conditions.

Rubber plantations in the NNNR are located at higher elevations than are usually recommended for rubber cultivation. The biomass and latex yield therefore decrease with increasing elevation and thus decreasing temperatures. As a consequence of a lower biomass production under such conditions, carbon sequestration potential of rubber plantations would be lower, thereby decreasing its mitigation potential concerning atmospheric carbon concentration.

The study is based on a literature review and application of the LUCIA model (Land Use Change Impact Assessment tool). The carbon sequestration potential of the area's different land uses (primary forest, secondary forest, rubber and rice) will be assessed using the LUCIA model, which will allow evaluating the impact of rubber cultivation compared to the other land uses. Primary forest has the highest capacity for sequestering carbon, while secondary forest and rubber plantations perform similarly, and rice contributes the least to carbon sequestration. Additionally, the carbon emissions of the changing land use in the area during the past 20 years will be computed, and different management options to enhance carbon sequestration in rubber plantations such as intercropping and appropriate fertilisation will be assessed. The results of different scenario runs will be presented at the conference.

Keywords: Carbon sequestration, China, land use change, rubber, Xishuangbanna

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Spatio-Temporal Integration of Socio-Economic Factors Related to the Land-Cover Changes in the Blue Nile Region, Sudan

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Considering the dramatic loss of natural resources occurred in the Blue-Nile region of Sudan, this study is of great value of developing a method for monitoring the changes over time and its driving forces. Moreover, especially when we deal with communities a high dependency on natural resources for their everyday needs and income generation that has to be considered. The study utilised three consecutive optical multispectral images to evaluate the land-cover dynamics during the period 1990 to 2009. The method adopted in this research uses cross operation of multi-temporal classified images and subsequent reclassification of the overlaid images to be compared for change detection. New layers of segments were created representing the change areas (from-to) as well as the overlapped areas (no change) of each pair of classified images. Aggregated to the community-level, social survey of household data provides a comprehensive perspective additionally to earth observation data for predetermining hot spots of degraded and successfully recovered areas. Hence, the study utilised a well designed questionnaire to address the factors affecting land-cover dynamics and the possible solutions based on local community's perception. Population Proportional to Size (PPS) sampling technique was applied to collect 120 questionnaires distributed among six villages. The data was analysed based on descriptive statistic analysis using SPSS Software. Randomly selected sites mentioned by the respondents were visited and spatially allocated. Subsequently, these data were introduced to develop rule sets for the change analysis based on object-based approach. The present study exhibits a great potential for accurate land-cover change detection, when utilising object-based post-classification technique with optical multispectral satellite imagery. It also shows the strong capability of the adopted method for gaining knowledge of the change dynamics and it is driving forces. At the community level, the study indicates that due to the disregarding of customary land laws the local community no more look at the forest as their own, and thus have commenced to practice all their activities in the forests as illegal. Moreover, the results of the combined analysis indicate that the mechanised rain-fed agriculture was the major force of forest cover loss.

Keywords: Land tenure, land-cover dynamics, natural resources, object-based, optical multispectral imagery

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Measuring and Modelling the Decomposition Dynamics of Diverse Crop Residues

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In many tropical farming systems, organic sources play a dominant role in the cycling of nutrients in the soil-plant system. The quality of plant residues as indicated by C:N ratio, lignin, tannin and other indicators of quality has a profound effect on the decomposition patterns and in effect on the mineralisation/immobilisation dynamic of N. A closed chamber incubation experiment was conducted to measure the interaction of soil type and crop residue quality (canola, wheat, pea and *mucuna*) on decomposition. Briefly, residues were incorporated into 2 soil types (Alfisol and Calcaresol) and incubated at 25oC for 14 weeks. The production of CO_2 was measured in NaOH traps which were regularly titrated and renewed. A treatment that contained soil but no residues was included as a control. Over the entire period of the incubation, the C mineralisation was significantly higher in the Alfisol than in the Calcaresol soil. The rate of CO_2-C release in both soils decreased with time during the incubation, and the treatments containing *mucuna* residues released less CO_2-C than other residue treatments. Meanwhile, the mineral N in the 2 soils was initially dominated by the NH_4^+-N form, this declined within 14 days of the start of incubation and thereafter remained low.

To date there have been limited attempts to model the decomposition pattern of diverse plant residues in farming systems models such as APSIM, DSSAT and CropSys. This is a priority area of research for low input agricultural systems, which relies largely on crop residues and manures for nutrient input. Using the Surface Organic Matter (SurfaceOM) module in APSIM, the input of fresh organic matter (FOM) was adjusted to represent the residues used in the incubation experiment via the "FPOOL" which describe carbohydrate, cellulose and lignin like parameters of the residues. By adjusting these proportions from the typical 0.2:0.7.0.1 ratio with constant C:N ratio, to ratios which better match the measured quality parameters, we were able to better represent the results of decomposition processes of the residues inputs and importantly more closely simulate N mineralisation.

Keywords: APSIM, crop residues, decomposition, incubation, mineralisation modelling

Can Smallholder Farmers in the Sahel Benefit from Payments for Carbon Sequestration?

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Carbon finance is often cited as a potential source of income for smallholder farmers in developing countries, yet for many environments, data on carbon scheme viability are unavailable. To close this knowledge gap for West African parkland systems, we used ecological niche modelling and a literature review to estimate potential carbon stocks in newly established parklands for 19 climate scenarios. Based on resulting carbon sequestration rates, the economic viability of hypothetical carbon finance schemes was evaluated using a carbon finance business model. Climate analogue analysis was used to illustrate the climatic trajectory of selected current parkland locations.

For a hypothetical scenario, in which parklands were assumed to cover the maximum area possible, potential carbon stocks in agricultural land were estimated at 1,284 Tg C, compared to 725 Tg C for a 'treeless agriculture' scenario under baseline climate conditions. Carbon sequestration potentials were much lower for most future scenarios. Due to low annual sequestration rates of about 0.4 Mg per hectare, profitability of carbon sequestration schemes was low. Even when large numbers of farmers (>40,000) participated, projects targeting small farms (2 ha of new parklands per farm) required high carbon prices of >US\$ 11 t^{-1}, even for the most viable payment scheme tested. For farmers, profitability was always low, even at higher carbon prices. Under optimistic assumptions, net present values (perceived value over a project lifespan of 25 years) of carbon sequestration were below 50 USD for all project schemes targeting small farmers. It seems unlikely that Sahelian farmers will engage in such activities, unless substantial non-carbon benefits are also derived. Climate analogue locations for three sites in Senegal, Mali and Niger indicated decreasing climatic suitability for parkland agroforests for most future scenarios. In this light, carbon sequestration does not seem like a promising source of income for project managers or farmers in the Sahel. However, parkland agroforests have been shown to benefit farmers through diversifying farm incomes, improving soil fertility and providing positive microclimatic effects. The prospects of agroforestry to provide adaptation benefits to farmers are thus much greater than their potential to generate substantial cash flows through carbon finance mechanisms.

Keywords: Agroforestry, carbon sequestration, climate analogue analysis, climate change, ecological niche modelling, maximum entropy (MaxEnt), parklands

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Climate Analogues for Climate Change Impact Projection and Adaptation Planning

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Climate change will affect land use systems around the world, yet reliable projection of the impacts of particular climate scenarios is currently only possible for selected systems, for which robust models exist. Many smallholder farming systems throughout the developing world are characterised by mixed cropping, integration of trees with annual crops and suboptimal crop management. Such situations cannot currently be modeled at the scale and accuracy required for adaptation planning. Climate analogue analysis promises potential for overcoming this constraint. The premise of this approach is that for most places of interest and for most climate scenarios, it is possible to find a currently existing location that presently has a similar climate to the projected climate at the target location. Comparison of environmental and socioeconomic conditions at target and analogue locations can deliver information that is informative for climate change impact projection. Land use strategies at the analogue locations may be useful for adapting the target location to climate change. Visits by land managers from the target location at analogue locations may serve to increase awareness of the need to adapt and to gain useful insights into what kinds of management practices are possible under climate regimes expected in the future.

The usefulness of the climate analogue approach is currently constrained by a number of factors: (1) site-specific climate data is not normally available, especially for the future, so that climate matching is limited to monthly means of temperature extremes and rainfall; (2) differences in soil types and other crucial environmental and socioeconomic factors cannot currently be captured, casting doubts on the transferability of land use strategies between analogue and target locations; (3) the approach has yet to prove its applicability in the field. Strategies to overcome some of these constraints are proposed.

Keywords: Adaptation, climate analogues, climate change impacts, climate data

Quantification of Water Flows and Sediment Transport in Paddy Cascades in Vietnam and Representation in a Landscape-Scale Model

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In Vietnam, the second most important rice producer in South East Asia, most of the rice is grown on paddy terraces. These terraces modify water flow and sediment transport in sloping landscapes, holding back sediments originating in uplands fields. The Land Use Change Impact Assessment tool (LUCIA) is a dynamic and spatially explicit model developed at the Institute for Plant Production in the Tropics and Subtropics, University of Hohenheim. LUCIA simulates consequences of land use change on watershed functions, biomass production, environmental services and soil productivity and fertility at landscape scale in small mountainous catchments. The aim of this work was to develop a module simulating the water flow and sediment transport in paddy cascades and implement it in LUCIA.

To calibrate the model field measurements were conducted 2011 in Yen Chau, Northwest Vietnam. The topography of the cascade was mapped first. Water inflow and outflow into a cascade and flow between the individual paddies were quantified using water clocks and sediment loads of the water were measured using turbidity sensors. After the rice harvest top soil samples were taken on a grid of $10 \, \text{m}^2$ and analysed using Mid-Infrared-Spectroscopy (MIRS) for organic carbon, total nitrogen and texture. For MIRS- validation data from Schmitter (2009) were used.

Inflows into the cascades occur only during the rice season (when inlets are not blocked). Each cascade is seen as one tank with limited outflow through pipes or, during heavy rain events, overflow surpassing the paddy bunds. Inflows into a tank are rainfall and channel flow, while evapotranspiration, infiltration, bund flow and outflow leave the cascade. First standalone runs of the paddy module have been undertaken and the integration into the LUCIA model has been technically accomplished. Further steps include plausibility tests of the combined model.

Keywords: Landscape modelling, paddy hydrology, paddy model

Mapping Land Degradation Patterns Using NDVI as a Proxy: A Case Study of Kenya

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Land degradation remains a major challenge to food production and environmental integrity particularly for sub-Saharan Africa. Once productive soils have been ruined due to human and natural degradation processes, the mapping of the patterns of degradation in order to propose intervention approaches is a challenge. This study employed the use of Normalized Difference Vegetation Index (NDVI) as a proxy to assess land degradation patterns in Kenya. The study employed the use of 500 m, Moderate Resolution Imaging Spectroradiometer Normalized Difference Vegetation Index (MODIS/NDVI) and the gridded climate CRU TS 3.1 ($0.5° \times 0.5°$) data for the period (2000–2009). The relationship between annual green biomass (as reflected by NDVI) and mean annual precipitation (MAP) dynamics was computed using Pearson's correlation coefficient while linear regression was performed to determine the magnitude of change of the NDVI over time (inter-annual change in NDVI). All computations were done in a GIS environment using ArcGIS 9.2. Mean precipitation over the 10 year period ranged between 550 and 870 mm at national level. There was relatively reduced precipitation in years 2000, 2003, 2005 and 2008. Despite the annual fluctuations, there was a general increase in mean precipitation at national level over the period of assessment. Correlation between NDVI and MAP at national and regional levels revealed clear patterns of NDVI change and hence potential for degradation or improvement. The degrading areas span across different agroecological zones humid (Kakamega, Kisii) to arid (Kitui, Narok, Turkana, Garissa) lands suggesting that there are various drivers of degradation in these respective regions. Positive and significant changes in the NDVI slope were observed for some selected locations such as Wajir and Baringo that are located in the dryland areas implying the 'greening' of the drylands. Despite the assessment showing solid visual extent of the land degradation problem, assessments using NDVI do not identify the actual causes of degradation or improvements. There is need to follow up such assessments with detailed field observations at selected georeferfenced sites to ascertain the causes of the patterns observed.

Keywords: Food production, Kenya, land degradation, mean annual precipitation, normalized difference vegetation index

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Challenges Presented by Climate Change in the Andean Region: Land Use Cover Change and Adaptive Response of Small Farmers

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For people living in the Andean Mountains, climatic change is not a problem of the future - thea already face the effects. The Andean region of Peru is bearing the consequences of climate change, such as retreat of glaciers and extreme weather events, which are increasingly affecting the livelihoods of small local farmers and increasing the vulnerability of the farm systems they depend on.

This paper presents the first results of the "International Network on Climate Change in the Andean Region (INCA)" project. The INCA is a scientific network specialised on climate change that seeks to understand the situation of local farming and forestry systems in the Andean Region, deriving and testing livelihood strategies for farming systems and indigenous communities.

First results of the INCA project, based on research in the Achamayo Watershed in Peru, include: a) A study of the perception of local people towards the development of climate over the last 10 years. b) An analysis via satellite images and field research on land use cover/change since 1921. c) An assessment of the adaptation strategies available and used by small-scale farmers.

Project results show that farmers are well aware of the ongoing changes in weather patterns, signaling the occurrence of frosts and heavy rainfall as main causes of agricultural loss. The decrease of water springs during dry season was reported to have a direct impact on the livestock which rely on natural grasslands as main fodder source. The analysis of land use cover change supported this former statement, reporting severe grasslands degradation, with 21.26 % decrease of the "high density grassland" land cover since 1921. Concrete strategies to forecast, disperse and mitigate the climatic risk were identified.

Ongoing research within the INCA project applies modelling techniques for assessing the development of farming systems under potential climate change scenarios and the consequences of the resulting land use mosaics on economical utilities (food security and income) and environmental services.

Keywords: Adaptation, Andean Region, climate change, land use, land use cover change, small farmers

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Analyzing Sectorial and Regional Heterogeneity Effects in Agricultural Efficiency: A Mixed Model Approach

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Technical and allocative efficiency of farm households has been widely studied in the context of panel data. While these techniques account for the estimation of efficiency in different frameworks, they do not investigate the latent heterogeneity at the sector level and at the regional level; an accurate analysis of the heterogeneity at the regional and sector level, as the one proposed here using mixed models, might, for instance, reflect differences in policy impacts, in technological progress, or even knowledge of the farmer at the regional or sector level. A common approach in this extent is to define farm types and analyse them using a consistent methodology, the estimation of a production function per sector. On the other hand, regional heterogeneity is often accommodated by adding regional categorical variables as a set of dummy regressors in the estimation.

A more general framework which is capable of accommodating these sources of heterogeneity in a flexible way is the mixed model approach. In the existing literature, this framework has been introduced in several different ways. First, by defining a second level error as an indicator of the firm's efficiency rate. Another approach, with the aim of relaxing the distributional assumptions, allows for time-varying efficiency levels with heterogeneity in slopes and intercepts for individual firms.

Our data allow classifying the farms according to agricultural subsectors and regional location, on the basis of a rotating panel data for 5 years (2003–2005) from the Farm Business Survey in The United Kingdom. Five types of farms to account for sector heterogeneity were defined; the data also allow us to identify the county to account for regional heterogeneity. Although our data come from the UK, the mixed model approach developed here will be of great potential for similar applications in developing countries, since sector and regional heterogeneity might be a major concern in this setting.

We compare the estimation results of several mixed models approaches like the one described before with the conventional stochastic frontier procedure. Estimations show similarities in coefficient and efficiencies estimations; on the other hand, variation between sectors and regions seem to have strong magnitude.

Keywords: Efficiency analysis, linear mixed models, stochastic frontier, unobserved heterogeneity

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Assessment of Land Use / Land Cover Changes Using Multi-Temporal Satellite Imagery (South Darfur, Sudan)

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South Darfur lies in a region that suffers significantly from the impacts of environmental degradation. Overgrazing, deforestation and overcropping have caused soils with an inherently low fertility. As a result the land use changed and led to a further competition and overexploitation of the natural resources. Subsequently conflicts has resulted in the majority of the population abandoning their homelands and becoming internally displaced or refugees.

The aim of this study was to map and assess of land use land/ land cover change in Edd Al Fursan locality which located in Southern Darfur State during the period 1999–2008. Multi-temporal Landsat (ETM) & (Aster) data have been utilised to detect land use/ land cover change. The images were geometrically corrected to a common map projection, followed by image processing operations, namely atmospheric correction, supervised image classification and accuracy assessment. The major Land Use Land Cover classes present in the study area are: grass land, forest land, fallow land, cultivated land, and bare land. Two methods of change detection were applied; these were Post Classification Comparison (PCC), and Multivariate Alteration Detection with Maximum Autocorrelation Factor Postprocessing (MAD/MAF). The comparisons of land use/ land cover showed that the natural vegetation cover (grass and forest lands) decreased from 21 %, 19 % in 1999 to 19 %, and 17 % in 2008 respectively, while the agricultural land increased from 25 % to 30 %. Moreover the fallow land has decreased from 24.5 % to 20.5 %, at the same time the bare land increased from 11 % in 1999 to 14 % in 2008. The linear transformations of (MAD/MAF) (unsupervised change detection) were applied to examine the quality of change. The study indicates that change in land use/ land cover in the study area is due to overpopulation as the results of conflict and environmental crisis that led to clearance of forest cover either for agricultural expansion or other domestic purpose (building materials or fuelwood). On the other hand overcultivation resulted in decrease of fallow period and increased in bare land.

Keywords: Change detection, land use/ land cover change, multi-temporal data

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Can the Social Mechanisms Framework be Applied in Modelling Natural Shocks?

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Theorizing in the social sciences has generally been characterised by a dichotomy between concrete (practical) and abstract models. While concrete models attempt to explain social phenomena based on observable outcomes, abstract modelling has often departed from logical thinking, being characterised by critical assumptions, culminating in logically attractive but often practically unrealistic models. Many sociologists however agree that the social mechanisms framework is useful model for rigorizing the identification, understanding and analysis of real world social phenomena. In summary, the social mechanism framework departs from the assumption that the relationship between inputs and outputs of social phenomena must necessarily be explained by the underlying mechanisms, and not based on simple relations displaced for instance by regression or correlation coefficients. This article extends this conventional wisdom in the social science to the analysis of natural shocks, whose rapid upsurge has been observed in recent years. It suggests that this concept in itself provides a middle ground theory that sufficiently combines abstract logic and empirical validity in understanding and explaining natural shocks. It is argued that an adequate theoretical and methodical approach of examining formal and informal responses based on the social mechanisms framework is prerequisite for understanding and explaining the black box often existing when such shocks occur in developing countries. This is very crucial as formal (state and market) mechanisms often fail or function only partially in such countries. An adapted theoretical model is proposed that enables natural shocks to be conceptualised as social phenomena. Such an approach can help explain aspects of vulnerability, adaptability and resilience observed or not when extreme events occur. Apart from providing a theoretical model with respect to shocks, empirical examples are provided to strengthen the argument that the social mechanisms framework provides an adaptable model that can significantly improve quantitative analysis of shocks, as long as they are perceived as social phenomena.

Keywords: Modelling, natural shocks, social mechanisms, social phenomena

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Resilience of Rainfed Farming Systems under Changing Climate

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Climate change is a phenomenon that affects resiliences of agricultural systems against crisis. Adaptation approaches are required to increase/maintain resiliences in the near future. Without the implementation of suitable adaptation options, climate change is expected to negatively impact food production, food availability and food access. Food security is at risk especially among subsistence farmers in the tropics and subtropics.

Modelling agricultural systems is one approach to understand and identify future agricultural vulnerabilities against climate change at the one hand, and adaptation options on the other hand. Recent studies on future climate impacts on agriculture production emphasised on mean climate change patterns. Vulnerabilities to annual climate fluctuations have rarely been considered, although, they affect food security in general and food stability/persistency in particular.

We assume that climate change impacts are underestimated when relying only upon analysis of mean climate changes. For that reason, our study focuses on changes in the year-to-year crop yield fluctuations due to changing climate variability. We compare these trends with trends in mean yields. Since such impact assessments are strongly influenced by the climate scenario input, we additionally analyse the effect of the large disparities among global circulation models (GCM), emission scenarios and bias correction methods on the crop yield calculations. Therewith, we consider climate uncertainties in the calculation of future agricultural resiliences.

In the study, we apply three state of the art climate models, two emission scenarios and two bias correction methods to drive the dynamic vegetation model LPJmL for the computation of crop yields. From the gridded yield series, we analyse changes in the standard deviation of crop yields (and their means) between the baseline (1971–2000) and the 2050s (2041–2070). We analyse the crop signal robustness (agreement) over the different sets of model runs. Finally, we classify regions in respect to the potential changes of agricultural resiliences. This classification is spatially differentiated and considers the different natures of climate impacts (changing means and changing variability).

The study results can contribute to more effective and efficient adaptation planning to promote resilient farming systems in the future.

Keywords: Climate uncertainty, climate variability, crop modelling, food security

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Evaluating Spatio-Temporal Relationships between Climate Variables and NDVI in Humid Grasslands of Northeastern Argentina

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In northeastern Argentina, subtropical grasslands occupy over 50,000 km^2 and are mainly devoted to raising cattle, representing the main economic resource for the inhabitants. Some evidence have shown that precipitation and temperature in this region are changing according to global change forecasts. Therefore, our objective was to confirm the existence of such patterns and evaluate if vegetation is responding to it. For this purpose, a 11-year series of biweekly NDVI (MODIS, 2000–2011) were used. Integrated NDVI values for early, middle, late and the entire growing season were calculated. For the same period, information about temperature, amount of precipitation and days with precipitation was considered. Trends of NDVI and its correlation with climate variables were analysed for five different grassland types identified in the study region. The annual precipitation and temperature did not show a significant negative trend (slope was -0.105 and -0. 041, $p > 0.05$ respectively). However, the number of days with precipitation during the current growing season showed a significant negative trend along the years (slope = -0.550, $p < 0.001$). This indicates that, despite the total amount of precipitation remains unchanged, it is concentrated in less frequent and bigger events. Indeed, this variable was strongly correlated with the NDVI (r=0.78, $p < 0.001$), which also decreased significantly over the analysed period (slope ranged from -0.144 to -0.253, $p < 0.001$). The amount of precipitation was strongly correlated with NDVI late in the growing season and there was a weak correlation in the early season (r=0.85 and 0.38, respectively). In conclusion, the trend of climate variables in the study region is mainly represented by changes in the frequency and intensity of the precipitation, which is affecting negatively the grassland productivity. As a consequence, implementation of management practices tending to optimise the water fluxes is necessary to minimise the impact of climate change on this ecosystem. Moreover, given that NDVI and its related variables are good indicators of the vegetation attributes, understanding their relationship with climate variables would allow predicting changes on productivity under different climatic scenarios, being also a key when looking for adaptive responses of grassland and livestock production systems.

Keywords: Argentina, climate change, grassland productivity, NDVI, subtropical humid grasslands

Agricultural Land Use Change, Resource Competition and Conflict in the Tarim Basin, Xinjiang, China

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The Tarim River Basin is a continental arid region in the Northwest of China, which is characterised by extreme vulnerability. Rainfall is very rare and thus all kind of human activities, as well as the natural ecosystems depend on the water, which is supplied through snow- and glacier-melt to the Tarim River. A tremendous land use change can be observed in the last decades, which puts severe pressure on natural resources. This publication examines the changes in agricultural land use in the last decades, investigates the causes of change, and elaborates the consequential resource use conflicts. Statistical yearbooks of the local regions, literature review and data obtained through expert interviews and a stakeholder workshop constitute the data base for the analysis. Land use change was assessed for the four administrative regions along the Tarim, namely Bayangol and Aksu prefecture, as well as the Division 1 and Division 2 of the military farms. In total the area for annual crops nearly doubled to more than one million hectare from 1989 to 2009, with the strongest increases in cotton area. The increase was significantly higher outside the military farms, which can mainly be attributed to the strong population increase in the same period. Furthermore the "Grain-for-Green" policy promotes the establishment of perennial production systems, especially orchards. This led to an increase of orchard area from 40,000 to 300,000 hectare in total, again with the highest increases in Aksu prefecture. As orchards have about double the water demand compared to annual crops, the promotion of perennials further aggravates the competition for water, not only between agriculture and the natural vegetation, but also between upstream and downstream farmers. As a consequence limited water availability restricted the expansion of agricultural land in the Division 2, which is located at the lower reaches of the river. This has a direct impact on the agricultural GDP, which increased at a four times lower rate in Division 2 compared to the other three regions. Ultimately a population decrease in the lower reaches can be observed in the last years, with farmers being re-settled to other parts of Xinjiang.

Keywords: China, cotton, grain-for-green, land use change

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Global Impact of Climate Change on Coffee Suitability

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The fact that climate change will have an adverse impact on agriculture is evident. Various studies show that the exposure of coffee systems to climatic changes will result in decreased suitability, yield, inferior quality and increased pest and disease pressure. This is commonly related to in increases in temperature and changes precipitation patterns. To date, no global study on the impact of climate change on coffee suitability exists.

To assess the impact of climate change on coffee suitability globally we first quantified changes in predicted climate patterns by 2030 and 2050 using 18 Global Circulation Models (GCM). Then, we modeled the potential current world coffee distribution using the Maxent crop prediction programme training it on over 5200 unique coffee evidence locations worldwide. This model is widely acknowledged to yield the most accurate results. Finally, we projected the future global coffee distribution to using the GCM' to identify the level of exposure of coffee suitability under progressive climate change. As climate input data we used 19 bioclimatic variables from Worldclim (current climate) and 18 GCMs (future) under emission scenario A2 and on 2.5 arc-minutes (approximately 5 kilometers) scale.

The specific results show that suitability in the Mesoamerican coffee regions tend to be lower in areas between 400 − 800 m. a.s.l. While South American coffee regions show increasing suitability of 40 % in areas close to the equator with an average altitude between 1600 − 2000 m. a.s.l., the areas north and south of the equator show a decrease of suitability up to 60 %. In some African coffee regions (Ethiopia, Kenya and Madagascar) coffee-suitability gains up to 40 %. While in some South East Asia coffee regions (Vietnam) coffee-suitability loses close to 60 %.

Thus, our model reveals drastic losses of coffee area in low regions at high latitudes. However, our model implicitly assumes unchanged cultivation practices. We therefore conclude that coffee research must focus on developing new means that address the coming changes. Our results are expected to serve as an analysis tool for future projects related to socioeconomic, vulnerability and political analysis of the adaptation of coffee production.

Keywords: Climate change, *Coffea arabica*, modelling

Potential of Waste Water Use for Jatropha Cultivation in Arid Environments

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Water is relevant for all socio-economic development and for maintaining healthy ecosystems. As population increases and development calls for increased allocations of groundwater and surface water for domestic, agriculture and industrial sectors, pressure on water resources intensifies, leading to tensions, conflicts among users, and excessive pressure on the environment. Additionally, energy demand scenarios show an increase over time that leads decision makers to look for renewable energy sources. Indeed, imbalances between availability and demand, the degradation of groundwater and surface water quality, competition and conflicts contribute to water scarcity. Scarcity often occurs in the arid and semiarid regions affected by droughts and wide climate variability. This induces countries to use sewage effluent after a certain level of treatment resulting generally in nutrient rich treated sewage effluent (TSE). Jatropha has been introduced as an option for energy supply since it is claimed to be drought resistant and can grow on marginal sites. In order to evaluate the suitability of jatropha cultivation in a combined plant production / effluent treatment system, considering both the advantage of using available resources (water and nutrients) and also the fact that salinity issues may arise, jatropha water requirements were calculated using CROPWAT 8.0. Concentrating on a case study of Southern Morocco, the crop evapo-transpiration (ETc) during the growing period (February - August) was 768 mm. Additionally, the gross irrigation requirements ranged from 868 to 1,329 mm. Moreover, the corresponding nutrient input from the effluent irrigation was 84–129 kg ha^{-1} for N, 24–37 kg ha^{-1} for P, and 169–259 kg ha^{-1} for K, respectively. The average soil salinity in the root-zone was between $2 \, \text{dS m}^{-1}$ and $> 9 \, \text{dS m}^{-1}$ depending on the leaching fraction. Since Jatropha has been reported to be salt sensitive, the use of waste water while controlling soil salinity has to be reconsidered even if the nutrient and water supply can be satisfied.

Keywords: Bioenergy, fertiliser, Morocco, salinity, waste water

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Landscape Vulnerability Assessment in Data-Poor Regions: A Case Study in a River Basin, Central Vietnam

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Landscapes worldwide undergo highly dynamic land use development to promote economic growth and thus human well-being. This causes conversion of forests and other natural areas of vegetation to agricultural land or settlement area, and is frequently accompanied by the expansion of road and electricity networks and an increased use of natural resources. Consequences, namely fragmentation of natural landscapes, deforestation, biodiversity loss, soil and water pollution, and soil erosion, add to landscape vulnerability, and in the long run will negatively affect human well-being.

The present study aims at identifying the spatial distribution of landscape vulnerability of the Vu Gia Thu Bon River Basin (VGTB) in Central Vietnam. The construction of such a vulnerability map is a first step to identify critical areas in large regions, where more detailed research is necessary. The study is conducted as part of LUCCi project (http://www.lucci-vietnam.info), which comprises a topographically heterogeneous area of $> 12,000\,\mathrm{km}^2$ for which hardly any spatial data are available.

The landscape vulnerability assessment focuses on four criteria relevant degradation in the study area:

- forest loss and degradation;
- contaminant input by rivers;
- illegal logging impact by roads (of firewood and non-timber forest products NTFPs);
- soil erosion.

The following spatial data are classified into vulnerability classes and transferred into a gridded map: forest classification data is based on LANDSAT satellite images and distinguishes between forest (low vulnerability) and degraded forest (high vulnerability).

Buffer areas along rivers are classified based on distance ranging from very high (0–50 m) to low vulnerability ($>200\,\mathrm{m}$) to contaminant input. Illegal logging impact areas are classified based on distance from road, ranging from very high (0–200 m for firewood and NFTPs) to medium (200–1,000 m for firewood and NFTPs) to low (> 20 km, maximal range for illegal logging).

Multicriteria Analysis for Land Suitability Assessment for "Gia Lun" Banana in Nam Dong District, Thua Thien Hue Province, Vietnam

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"Gia lun" banana (*Musa sapientum* Linn.) is one of the major fruit crop in Thua Thien Hue province, Central Vietnam. However, productivity of "Gia lun" banana was low to compare to those in other regions in Vietnam and other countries. The considerable constraints facing "Gia lun" banana development included socio-economic factors and physical conditions. This study aims to determine physical land suitability areas for the "Gia lun" banana production in Nam Dong district, Thua Thien Hue province, Vietnam by using multi-criteria evaluation, and the GIS technique to achieve optimum utilisation of the available land resources for sustainable agricultural production following framework for land evaluation FAO (1976). Eight parameters for crop suitability and five parameters for environmental suitability are considered and suitability analysis was carried out by fuzzy membership classification. In addition, this study also incorporated farmers' perceptions as well as their preferences into the decision making process by using analytic hierarchy process (AHP). Geoprocessing models were used to excuse the sequence command to generate physical suitability index map for "Gia lun" banana in the study area. The physical suitability of "Gia lun" banana map showed that there was 26 The results of this study will be brought forward by local land users and administrator who need to have scientific support in order to meet the increased demand for fruit production without enhancing environmental degradation for their decision on the future land use systems in the study area.

Keywords: Geoprocessing models, GIS, land suitability assessment, multi-criteria analysis, "Gia lun" banana

Maize Yield Response to Deficit Irrigation using the Aquacrop Model under Shallow Groundwater Conditions in Uzbekistan

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Maize is one of the most widely consumed cereal crops grown worldwide under different environmental conditions. The growing global population puts more strain for increased cereal production in the next decades to feed this population which greatly drive the global water demand for different purposes. Meanwhile humankind has to cope with the predicted impacts of future climate change on water resources availability especially in the arid and semi-arid regions. Irrigated agriculture is hence under high pressure to increase the water use efficiency during these conditions. For this purpose several techniques and models have been developed to simulate the current and future scenarios for future planning and management of the water resources. AquaCrop, is among such models which reliably simulates achievable yields of major crops as a function of water consumption under rainfed, supplemental, deficit, and full irrigation conditions, with comparatively less data demand. In this study, carried out in Khorezm province of Uzbekistan, the AquaCrop model was used to derive the optimal and deficit irrigation schedules for maize crop. Groundwater levels in the region are shallow. We used Hydrus-1D model to simulate the capillary rise. Later capillary rise contribution was introduced into the AquaCrop model. Hence, together with optimal irrigation schedule, deficit irrigation strategies were derived as proportionally reduced water supply (RWS) of 20, 40, 50 and 60 % throughout the crop growth and as a stress introduced at specific crop growth stages. The results show that proportionally RWS of 20, 40, 50 and 60 % resulted into 3, 20, 30 and 45 % yield reduction respectively. In these simulations, 20 % proportional reduction in irrigation water application led to a negligible 3 % yield loss. During stress at the late yield formation stage, at least 25 % of the optimal supply can be saved easily for almost no yield loss. It means that deficit irrigation is more feasible in the late yield formation stage rather than vegetative stage. This study is unique due to the fact that capillary rise contribution quantified by Hydrus-1D model has been introduced into AquaCrop. This way it overcomes the missing consideration of capillary rise contribution by the standard version of AquaCrop model.

Keywords: AquaCrop, capillary rise, deficit irrigation, shallow groundwater

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Understanding Soil Organic Carbon Dynamics at the Landscape Scale: Hotspot Mapping

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Soil organic carbon is an important indicator of soil health as it integrates inherent soil properties as well as aboveground landscape dynamics, including land-use change. Establishing regional soil organic thresholds using systematic and spatially explicit baseline data can guide restoration activities and land-use planning. The Land Degradation Surveillance Framework offers a methodology to assess soil organic carbon values and stocks across the landscape, while accounting for the variability at three different spatial scales. Seven sentinel sites were sampled in Tanzania in 2010. Each site has 160 plots, where topsoil (0–20 cm) and subsoil (20–50 cm) as well as cumulative mass samples were collected, current and historic land use was recorded, and vegetation measurements were made. A total of 1,993 plots were included in the current study. Average topsoil organic carbon was 10.9 g C kg^{-1} (n=1058) and average subsoil organic carbon was 8.3 g C kg^{-1}(n=935) for the seven sites. Organic carbon concentrations measured in the lab were related to satellite image reflectance data using multilevel and ensemble models, and predictive maps were generated. These maps were also used to assess spatial patterns and landscape features that influence soil organic carbon concentrations and to identify low-carbon hotspot areas. These results can also be useful for establishing regional soil organic carbon reference values, for example according to climatic zones and native vegetation types. The systematic sampling employed in this study allows for robust comparisons of soil organic carbon values and soil mass within and between land uses and at different spatial scales.

Keywords: Hotspot mapping, landscape assessment, soil organic carbon

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Development of China Digital Soil Map at 1:50,000 Scale

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In order to meet the increasing demands for soil information with a high resolution by different disciplines such as agriculture, environment and economy, China Digital Soil Map at 1:50,000 Scale (CDSM-50000) has been developed since 1999. Soil and soil nutrient maps at 1:50,000 scale and soil profile records were collected from 2400 counties of China. These maps and records were achieved during the period of the 2nd Chinese National Soil Survey from 1979 to 1985. A data model called CDSM-50000 was developed, which contains 10 map layers and 16 attribute tables. Data of about 150,000 soil profiles were, for the first time, integrated into CDSM-50000. Every profile contains dozens of soil physical and chemical properties, such as soil depth, texture, organic matter, pH value, contents of N, P, K, S, etc. Soil nutrient information of 80,000 plough layer samplings during the period from 1999 to 2008 was also collected and integrated into CDSM-50000. To merge different county soil maps with different mapping standards into one map according to the data model of CDSM-50000, a complicated soil data processing procedure was developed. Map data of 1100 counties had been already merged to CDSM-50000. The data model was approved to be successful to organise all soil survey information of China of the last 50 years. Hundreds of soil profiles were collected from 5 provinces to test the reliability of the developed CDSM-50000. A good coherence was found between CDSM-50000 and the reality of soil type distribution. The finalised digital soil map was supplied to 15 provinces and applied in cropland nutrient management, arable land fertility evaluation, strategy development in eutrophication controlling, and to study the effects of climate chance.

Keywords: Digital soil map, organic matter, soil profile, soil quality

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Development Cooperation

Soils and resilience (CIAT session)

The Need for Eco-Efficient Landscapes to Prevent Irreversible Degradation of Agroecosystems in Deforested Amazonia

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Considerable effort has been devoted to the conservation of primary forest in the Amazon, but less so to design and implement ecoefficient uses of cleared land for meeting the economic, social and environmental challenges faced in the region. We conducted a multidisciplinary diagnostic of ecoefficiency in 51 farms from six regions of the Brazilian and Colombian Amazon cleared between 15 to 60 years ago, with diverse colonisation histories. Land-use intensity was assessed with an indicator based on present landscape composition and structure and the historical land-use change. Indicators of soil ecosystem services (ES: chemical fertility, hydric functions and C storage) and biodiversity of plants and 5 soil and above ground invertebrate groups

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were assessed. Intensity of land-use increased with time elapsed since deforestation along with production efficiency (farm incomes per ha and per labor unit) and social wellbeing. Meanwhile, an indicator of biodiversity continued unchanged as land-use intensity increased until a well-marked tipping point, beyond which biodiversity fell sharply. A composite indicator of soil ES decreased regularly with land-use intensity. An ecoefficiency index, that combines indicators of social wellbeing, productivity, biodiversity and ES, also exhibited a sudden decrease when land-use intensity exceeded a critical threshold value. This tipping point corresponds with a shift from predominantly forested to open agropastoral landscapes, when the last forest patches become fragmented before disappearing. At that point, only 20 % of the original primary forest is left on average. Landscapes dominated by agroforestry production systems had much higher ecoefficiency, with a higher productivity than extensive livestock breeding systems and greater conservation of biodiversity and ES. Our study indicates the need for reconstructing landscapes in deforested Amazonia, by identifying the best spatial combination of productive systems that sustain livelihoods and natural ecosystems that act as buffers to prevent degradation of ES and biodiversity.

Potential of Short-Term Legume Fallows for Conserving Soil Macrofauna Diversity and Enhancing Maize Productivity in Semi-Deciduous Forest Landscapes, Ivory Coast

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It is increasingly admitted that one option to reduce land degradation in humid tropical countries is to adopt sustainable farming practices that conserve belowground biodiversity and enhance crop yields. However, very few field investigations have documented this assertion. A study based on the beneficial effects of 1-year-old improved fallows (*Cajanus cajan*, *Pueraria phaseloides*) on a subsequent maize crop in degraded agro-ecosystems landscapes in Western Ivory Coast, was designed to assess the relationship between increased crop yield and soil macrofauna abundance and diversity. The methodological approach consisted in (i) a comparative impact of natural and improved fallows on soil chemical properties, soil macro-invertebrates diversity, and maize productivity, and (ii) the modelling of the relationship between maize productivity and soil macro-invertebrates. Results revealed positive impacts of improved fallows on earthworm diversity and species richness, while only soil pH and total phosphorus were significantly increased beneath legume fallows. However no consistent rises were found in maize production apart from slight and marked changes in total biomass and cob production, respectively when improved fallows were pooled as one treatment. Mixed-effect models suggested that improved fallows have beneficial impacts on macrofauna communities, which presence significantly increased maize grain yield and total production. On the other hand, some taxonomic units of soil macrofauna, namely termites, diplopoda, earthworms, diptera larvae, chilopoda, hemiptera were found to be indicators species of legume fallows, with hemiptera being specialist and restricted to *P. phaseloides*. Overall, results provide more insights into the role of improved fallows in sustaining agricultural production in agro-ecosystems through soil macro-invertebrates. Additionally, the contribution of these organisms in the resilience of agricultural systems is discussed.

Keywords: Biodiversity, improved fallow, indicator species, soil macro-invertebrates, sustainable agriculture

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Ecosystem Services from Smallholder Agriculture through Slash-and-Mulch Based Agroforestry on Hillsides of Central America

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Ecosystem services (ES) can be defined as the benefits that people get from nature. They embrace provisioning (*e.g.*, food and freshwater), regulating (*e.g.*, regulation of climate and maintenance of soil quality); supporting (*e.g.*, primary production and nutrient cycling); and cultural (*e.g.*, educational and inspirational values) services. Generation of ES by smallholder farming communities on hillsides of Central America has been severely affected by the extensive use of traditional-unsustainable practices combined with anthropogenic pressures and climatic variability. The Quesungual Slash and Mulch Agroforestry System (QSMAS) has been demonstrated as a land management strategy with high potential for generating multiple ES in these agroecosystems. QSMAS is a smallholder production system that combines basic management principles applied with simple technologies to improve the use and conservation of vegetation, soil, and water in drought-prone areas of the sub-humid tropics. It has been successfully promoted as an alternative to the traditional slash and burn (SB) agriculture. Research work conducted in Honduras between 2005 and 2009 showed that QSMAS contributes to food security through a sustainable increase in productivity of maize (*Zea mays* L.) and common bean (*Phaseolus vulgaris* L.), and by enhancing the resilience to extreme weather conditions (water deficit and excess), compared

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to the traditional SB system. In addition QSMAS enhances the generation of other ES at agroecosystem scale by contributing to the restoration of degraded resources (soil and biodiversity) at plot and landscape scales, and by reducing deforestation, soil erosion and global warming potential compared to the SB system. Experience from on-farm participatory validation in Nicaragua and Colombia suggests that slash-and-mulch based agroforestry systems have high possibilities of acceptance by local authorities and adoption by smallholders in vulnerable agroecosystems.

Agroecoregions with potential for adaptation and adoption of QSMAS have already been identified, based on site similarity analyses integrating biophysical and socioe-conomic conditions. Additional studies are being conducted to evaluate the feasibility of QSMAS' integration with silvopastoral systems in smallholder farms of Nicaragua, and to use the system as a strategy for restoration and conservation of biodiversity in El Salvador.

Keywords: Bean, maize, QSMAS, Quesungual slash and mulch Agroforestry system, slash-and-burn, sorghum

Understanding Variability in Crop Response to Fertiliser and Amendments: Example from SSA

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The African Soils Information Service (AfSIS) implemented diagnostic trials in 10 different sites within 5 countries of sub-Saharan Africa: Kenya, Malawi, Mali, Nigeria and Tanzania, to identify soil fertility constraints to crop production. At each site, 23 to 32 trials were conducted within 10 km by 10 km sentinel sites. The treatments tested included a control, a full NPK treatment, 3 treatments in which the N, P and K nutrient were omitted at a time from the full NPK treatment, and one treatment in which multi-nutrients (Ca, Mg, micronutrients) were added to the full NPK treatment. Two optional treatments, manure or lime were included depending on the availability of manure and soil pH levels in case of lime. The test crops were maize and sorghum. In most sites, nutrient limitation was in the order N>P>K except in more acidic soils (*e.g.* in Kontela, Mali) where P was more limiting than N and in Mbinga, Tanzania, where K was as limiting as N and P. Nutrient omission resulted in significant yield reductions averaging 30 % for N and 20 % for P, relative to the full NPK treatment. For maize growing sites, yield increases of at least $0.5\,t\,ha^{-1}$ following application of lime ($500\,kg\,ha^{-1}$) on acidic sites and of manure in comparison to the full NPK treatment were common. In each site soil amendments consisting of lime, manure and multi-nutrients, had higher grain yield than NPK treatments in at least 40 % of the cases, indicating wide existence of non-responsive soils. A clustering technique is explained as an attempt to identify the different patterns of crop responses to nutrient omissions and amendments. Distribution of the fields to the resulting clusters depicted observed variability in the tested sites. The contribution of different covariates such as soil carbon, pH and available P to the responses are also presented. Suggestions for minimum treatments needed to diagnose soil constraints, and analysis framework for such trials are made.

Keywords: Nutrient omission, responsive soils, soil constraints, spatially-explicit

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Biological Indicators of Soil Quality and Impacts of Land Use Management in Agricultural Landscapes of Northern Nicaragua

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The tropical dry forest region along the western slope of Central America is a highly biodiverse and fragile area that is under increasing pressure from agricultural production, thus threatening the provision of ecosystem services, biodiversity, and ultimately the integrity of these landscapes and the communities who depend on them. To address this issue we evaluated the impact of common agricultural management practices (cropping and livestock systems) *vs.* the Quesungual slash and mulch agroforestry system (QSMAS), a promising alternative land use based on the inclusion of native trees with active pruning and residue management. In February of 2011 soil sampling was conductedon a series of hillside farms near the town of Somotilloin northern Nicaragua to assess soil physical properties, chemical fertility and the abundance and diversity of soil macrofauna within four management systems: 1) QSMAS based on maize production; 2) traditional maize cropping system with few trees (TC); 3) pasture system with few trees (PS); and 4) secondary forest (SF) was used as a reference. In addition to examining the influence management, we sought to develop indicators of soil quality based on the presence or absence of particular soil invertebrate species as well as basic soil physical and chemical properties. Macrofauna excavated from the soil (0–30 cm) were more abundant under QSMAS (657 individuals m^{-2}) than in TC (177 individuals m^{-2}; $p = 0.011$), with PS and SF demonstrating intermediate populations. At the same time, SF presented significantly higher richness of taxonomic groups than either TC or SP ($p < 0.001$), and demonstrated the greatest populations of Arachnida, important top-predators and potential indicators of food web structure. While we found no significant influence of management system on soil chemical variables, soil compaction (penetration resistance and shear strength) was significantly higher under SP than either SF or QSMAS ($p < 0.05$), with TC intermediate in value. Multivariate co-inertia analyses suggested significant covariation between most data sets (chemical fertility, physical status, aggregate morphology and macrofauna). Most notably, a strong association between macrofauna and soil physical status ($p = 0.013$), suggested that compaction by livestock strongly limits the activity and diversity of soil macrofauna. Finally, we used the Indicator Value index, which ranks species according to their specificity and fidelity across sites, along with farmer consultation to identify key indicator species of soil quality that could greatly facilitate future evaluation land management impacts by farmers and technicians in the region.

Keywords: Indicator species, land use management, Quesungual agroforestry system, soil macrofauna, soil quality

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Analysis of the Impact of Management Scenarios in Tackling Land Degradation in Sub-Saharan Africa: Multi-criteria Approach to Match a Problem to its Potential Solution

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Land degradation is a serious environmental problem with widespread effect at different scales. Due to its complexity and wide geographical coverage, it is not economically and technically possible to manage all areas affected. Tackling land degradation and restoring degraded landscapes thus require information on hotspots that require priority intervention. Long-term (1982–2003) satellite based vegetation greenness signal (NDVI) and rainfall data were used to analyse land productivity and identify major areas of concern in sub-Saharan Africa (SSA). Next, available literature has been consulted to identify suitable management options that can be adapted to the environmental conditions of hotspots. The impacts of the identified management and restoration options in reversing land degradation were then assessed using scenario analysis. Results show that application of conservation agriculture to restore degraded croplands can improve land productivity and food security of about 14 million people. Setting-aside degraded areas and allowing them to recover (*e.g.*, through enclosures) could improve productivity of ca. 0.3 million km^2 land. However, this intervention requires designing ways of accommodating the needs of about 8.7 million people who utilise those 'marginal' areas for cultivation or livestock grazing. The study illustrates the impact of land degradation on land productivity and the feasibility of suitable land management and restoration measures to tackle the problem. Such analyses can make an important contribution to achieving the Millennium Development Goals 1 and 7, enhancing food security without compromising ecological health and integrity.

Keywords: Land degradation, management scenarios, NDVI, rainfall, restoration, sub-Saharan Africa

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Central issues on resilience of agricultural systems against crises (GIZ session)

The Approach of the German Ministry for Economic Cooperation and Development (BMZ) and GIZ Experience

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The rural population in developing countries is increasingly exposed to longer-term deteriorations of the ecological, political, economical and social environment due to population growth, climate change and/or excessive exploitation of natural resources. Long-term degradation of the environment increases the vulnerability of rural populations. Sudden disasters and shocks are worsening the effects of long-term progressive degradation and destabilisation processes. Rural development bears considerable potential to reduce rural people's vulnerability and to strengthen their resilience. Some examples of the impacts of rural development on resilience will be presented in this session.

Keywords: Disaster, destabilisation, resilience, rural development

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Approaches and Starting Points for Supporting Agricultural Development in the Conflictive Environment in Afghanistan

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Agriculture and rural development are key sectors in the Afghan development process. Some 85 % of the population in Afghanistan live in rural areas and depend on agriculture for their living. Topographic and climatic conditions are limiting factors for agricultural activities and development opportunities in rural Afghanistan. Additionally, current initiatives for development and reconstruction are confronted with political instability and a conflictive environment that poses risks for the local population as well as national and international staff, and endangers the development process in general. The presentation provides insights into the status quo of Afghanistan's agriculture: How to support a gender-sensitive agricultural development in such an environment? What are challenges, potentials, successful methods and best practices?

Keywords: Conflicts, gender sensitive, risks, rural development

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A Knowledge Hub for Efficient Agricultural Water Use: www.agriwaterpedia.info

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The agricultural and water sector is facing a tremendous challenge in the upcoming decades:

The need for food and agricultural products will continuously increase while at the same time the availability of water resources will decrease; a situation which is aggravated by climate change. With water resources being already scarce in many countries, water allocation, access and effective agricultural water use are key for food security and sustainable development. Globally, practitioners, scientists, politicians and the private sector have developed much knowledge in water management. Hence, one of the major challenges is the accessibility of this knowledge as agricultural water management was a niche topic during the last years. Knowledge is documented in paper reports, stored in archives and libraries while experts shifted to other sectors. Making accessible, linking and further developing the former experiences with regard to the new challenges will form an important corner stone for effective and sustainable water use in agriculture. Accessibility of knowledge is of upmost importance in our partner countries. Through an internet based platform, we offer an affordable access to a wide range of experts and expertise all over the world. As working means, GIZ established the website www.agriwaterpedia.info as a public, internet-based, multilingual knowledge platform. With the platform, we offer context specific best practices and lessons learnt as well as an online-based network for experience sharing.

The presentation will demonstrate the www.agriwaterpedia.info website in detail and guide the audience through the different layers and possibilities. Within our session, we like to trigger the exchange of interested experts to add on or exchange their knowledge in the network.

Keywords: Agricultural water use, climate change, expert's network, knowledge platform

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Poetry route

Resilience – Touching a Colourful Sky – Breaking the Mould of Linear Models of Innovation and Creating Innovative Learning Spaces for Social Changes of Resilient Small-Scale Farmers

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The world has become a confusing place. Agricultural production continues to grow, and absolute poverty worldwide is decreasing. Yet, hunger is increasing, and mostly so among the rural poor.

We can write a long story about how resilient small-scale farmers are, and how marginalised by the powers that be. But who's listening? While the Centre for Learning on Sustainable Agriculture (ILEIA) was raising this question, a group of students at Van Hall Larenstein University of Applied Sciences (VHL) was engaged in a course about Media Design for Social Change exploring the portrayal of social resilience. The encounter resulted in a beautiful series of poems and paintings that, put together, capture the idea of resilience in an entirely non-linear, intuitive way.

Resilience thinking helps us to avoid the trap of simply rebuilding and repairing the structures of the past, but instead anticipate, adapt, learn and transform human actions and societies for improved wellbeing in the lights of the unprecedented challenges of our interconnected and turbulent world. So far much of conventional models of intervention in agriculture and rural development policy neither gave attention to the ever changing global challenges, uncertainties and complexities of environment under which small scale farmers live nor acknowledges the importance of local knowledge's in rural areas. Rather, it is more dedicated to increase production by transferring hardware technologies. Social resilience could be conceived as a livelihood capital which requires due consideration in vulnerable rural contexts of unsustainability, insecurity, poverty and emic and etic processes of change.

We describe resilience of small-scale farmers from the perspective of communication and rural innovation and explore how complex issues can be unravelled and expressed through poems and other art forms. The paper argues that other innovative trajectories can be utilised to create spaces of learning and communication and thereby encourage or articulate social resilience.

Keywords: Poetry, social change, social resilience, spaces of learning

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