

# Tropentag 2008

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

## Competition for Resources in a Changing World: New Drive for Rural Development

### Book of Abstracts

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# Preface

In recent years the TROPENTAG has become the most important International Conference on development-oriented research in the fields of Food Security, Natural Resource Management and Rural Development in central Europe. Since 1999 it is convened alternately by a number of German Universities in co-operation with ATSAF and GTZ/BEAF, all of them are engaged in agriculture and forestry in tropical countries. The TROPENTAG provides an international platform for scientific and personal exchange for students, junior and senior scientists, and development practitioners alike. The increasing international interest in the TROPENTAG from a large and still growing audience - some 850 participants from 72 countries have registered so far - demonstrates its importance on the agenda of both, the development oriented scientific community and the implementing development organisations.

The TROPENTAG 2008, organised by the Centre for Agriculture in the Tropics and Subtropics of the University of Hohenheim, will be held under the conference theme “Competition for Resources in a Changing World: New Drive for Rural Development”.

After many years of public disregard, agriculture is back in the headlines. The conference aims to shed light on the opportunities, threats and challenges triggered by the ongoing boom in agriculture. Growing demand for food for a still rapidly increasing population in the South, an alarming decrease in available arable land, and the emergence of bio-energy production as a new powerful and competitive player have contributed to recent price hikes in agricultural commodities. This development increases the value of agricultural enterprises and stimulates investment in this long-time neglected sector. Better-off farmers and international companies will most likely benefit from the recent trends in agriculture, whereas resource-poor rural people, being economically unable to take part in the new drive in rural development, may be left even more vulnerable and dependent. Land degradation, increasing scarcity of water and negative impacts of climate change, which are intensively hitting the tropics and subtropics, may counteract potentially positive developments. The agricultural sector being a significant contributor to greenhouse gas emissions and one of the largest water users, also holds the key to alleviating emerging problems by developing more resource-efficient, productive, climate-friendly and sustainable land use systems.

The Tropentag 2008 will discuss the implications of the aforementioned issues on a global, regional, farm and field level, considering resource allocation and use, biodiversity and income generation.

To broaden the accessibility of the results of this venue the abstracts of all contributions are published both as hardcopies and on the Internet under [www.tropentag.de](http://www.tropentag.de).

Georg Cadisch, Ludwig Kammesheidt, Bärbel Sagi and Folkard Asch  
Organising and Scientific Committee of the TROPENTAG 2008

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# Economics

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# Economic development and policy

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## **The Competitiveness of Brazilian Rice in the World Market: A Comparative Advantage Approach**

ALCIDO ELENOR WANDER<sup>1</sup>, SYDÊNIA DE MIRANDA FERNANDES<sup>2</sup>, CARLOS MAGRI FERREIRA<sup>1</sup>

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Among cereals, rice represents a major source of food for an important part of global population. As rice world stocks fall and prices climb, the food security of many countries can be negatively affected. However, for rice exporting countries, new opportunities may arise from this new scenario, where currently only 7 % of total production is being internationally traded. New players may appear in the rice market while others may reduce their participation. Based on this assumption, this paper's aim was to analyse the international competitiveness of Brazilian rice considering the world market as well as some selected rice producing and exporting countries as potential competitors. As main producers in year 2005, based on the amount of produced paddy rice obtained from FAO data, China, India and Indonesia were considered; As main exporters in 2005, based on the monetary value of exports obtained from WTO data, United States of America, Uruguay and China were taken into consideration. For the analysis, the Revealed Comparative Advantage (RCA) Index was used. According to RCA-Index, a country would have a revealed comparative advantage and be competitive if the RCA-Index is higher than 1.0. The analysis considered the period from 1995 to 2005. The main findings were that, so far, Brazil has no comparative advantage in producing rice and exporting it to the world market. From the considered countries, in the past 10 years, Brazilian rice could only compete with Indonesian rice i.e., the RCA-Index used to be higher than 1.0. Thus, Brazil's participation in the world market depends on structural changes in the rice market as well as on issues related to cropping systems that may arise in the future.

**Keywords:** Comparative advantage, competitiveness, rice market

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## **Economic Transformation – Theory, Empirical Evidence and Lessons from Successful Developing Countries**

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Our research is motivated by encouraging signs of growth acceleration in Africa that may herald a new development era of rapid transformation. This paper provides an extensive literature review on development economics, empirical observations from successfully transforming countries and analytic narratives on Thailand and Mexico. We find that the traditional development theory is consistent with past experiences of countries that moved from low to middle income level. However, this theory needs to be broadened in the light of rising inequalities during transformation.

Successful transformation vitally depends on agricultural development and industrialisation strategies. An early withdrawal of attention away from agriculture slows down transformation and resulting inequalities have become a persistent development challenge. By-passing small farmers in the process of agricultural modernisation has marginalised a large group of the rural population. This has not only led to short term social tensions, but also made long-run poverty reduction and improvements in inequality an extremely difficult task, even after countries have reached middle income status.

Winner-picking industrialisation strategies and related policies have created big industrial sectors, but these sectors have often failed to establish close links with the rest of the economy. Increased inequality and the difficulties to make these “picked” sectors internationally competitive and to generate sustainable long-term economic growth are all painful lessons drawn from this type of transformation strategy. On the other hand, private sector-led manufacturing growth, which is more of a “home-grown” nature and starts from a realistic base, is likely to be more consistent with a country’s initial conditions and comparative advantage.

Unleashing agricultural and industrial growth potentials in Africa requires government action to significantly improve the business environment. Public investments in infrastructure and improvements of the institutional environment for doing business are critical. In agriculture, the most important policy action is the removal of urban-biased and industrial-biased policies in trade, marketing, taxes and many other macroeconomic aspects. The most important public investment is in rural infrastructure and agricultural research and extension. As in other countries, African farmers will use this opportunity to transform traditional agriculture and thereby contribute to the successful transformation of their economies.

**Keywords:** Africa, economic growth, inequality, transformation

## Mapping Poverty: How Many Different Geographic Profiles can we Produce? An Application to Latin American Small Area Estimates

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The study of the geographic distribution of poverty has gained considerable attention in recent times. Several methods have been developed and tested in different countries with the aim of producing disaggregated poverty incidence estimates that can be portrayed in maps. For the case of Latin America, countries such as Bolivia, Brazil, Ecuador, Guatemala, Honduras, Nicaragua, Panama, and Paraguay have joined these efforts and produced updated geographic poverty profiles. These profiles can serve as support for the identification of priority areas, the allocation of public expenditure, and for policy making. As well, they can aid in the formulation of hypotheses as regard causal factors of poverty and the validation of estimation results. Poverty maps are created by classifying poverty incidence estimates into groups that reflect various degrees of poverty. Several classification approaches are available and very often, they produce different geographic profiles. In spite of this, most of the current poverty mapping exercises lack of precise documentation about the classification approach used and their rationale. This work reviews alternative classification approaches and their implications for map display and interpretation. Using data from selected Latin American countries, the analysis begins with the exploration of the spatial trend observed in the poverty incidence estimates. Afterwards, alternative classification approaches are used for the creation of poverty profiles and compared for consistency with the observed trend. The results clearly show how clusters of certain degrees of poverty appear or disappear depending on the classification approach used and how certain profiles deviate from the observed trend in the unclassified data. It is strongly recommended that poverty map makers evaluate the consistency of their displays with the data trend in order to transmit their findings, and that the proper documentation of the mapping process is included for an adequate map interpretation.

**Keywords:** Choropleth map, classification method, Latin America, poverty incidence

## Time Allocation, Poverty and Gender: Evidence from Post-War Rwanda

KATI SCHINDLER

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This paper analyses the impact of gender on time allocation in a developing country context, using household survey data from Rwanda. Even though more than a decade has passed since the genocide, Rwandan society still bears the demographic impact of the conflict, which killed many more men than women. In the aftermath of the genocide, the share of female-headed households increased sharply and many women became the principal income-earner of their household.

The paper addresses these issues by analysing the determinants of time allocation on domestic activities, such as water fetching and cooking, and on market activities, including wage work and self-employment. This paper contributes to the literature in two ways. First, it extends the framework of gender indicators and accounts for interrelations between different indicators. More specifically, the paper compares the impact of 1) gender of head, 2) the regime of intra-household decision-making processes, 3) an individual's position within the household hierarchy, and 4) civil status. Second, this paper applies the analysis both to the unit of the household and of the individual.

Methodologically, the paper applies probit and tobit estimations and differentiates between the participation in a particular activity and the intensity of time allocated to an activity, expressed as shares of total time. This approach accounts for the selection into an activity.

Results reveal three issues. First, household composition has the most important effect on how men and women, but also male-headed and female-headed households allocate their time. The presence of adult males particularly increases household time spent in wage work — an important income source that insures household income against agricultural risks in rural areas. Second, household hierarchy and gender are interrelated as women heads do engage more intensively in domestic tasks. Given that domestic tasks contribute less to the household income this may explain the higher incidence of poverty among female-headed households. Third, more time is devoted to wage work if the decision-making authority is concentrated in the head. The findings of this paper make a strong argument for the provision of basic infrastructure which might particularly increase women's time shares in market activities.

**Keywords:** Gender, household, poverty, Rwanda, Sub-Saharan Africa, time allocation



# Knowledge, innovation and adaptation

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## High Demand to Find Pathways to Secure Food for Man

RALF SCHLAUDERER

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Last years showed declining reserves of major food stuff due to further increasing world population, limited land resources and declining yield increases. As a result food prices increased rapidly and released increased social problems which partly even led to riots, since people were not able to pay their daily food.

Forecasts show, that world population will grow from about 6.7 billions today to about 9.1 billions in 2050 - an increase of about 50 % or about 81 million per year. Already today it is estimated, that more than 800 million people do not have enough to eat day by day or seasonally. It has to be worried, that this number will increase, if there will be no basic advances in food production, storage and proceeding. The development will hit particularly the people who do already struggle to feed themselves and their families because of very limited resources and income.

An increase of food production by using additional land seems to be only possible on a limited scale. The major productive land resources are already used. Further extension of arable land will come across environmental issues such as sustainability of land use, limited water resources or erosion. On the other side increasing fuel prices made biofuel production economically more interesting and so an additional competition for land was generated.

To overcome this arising problematic situation and to be able to feed the increasing world population on a sustainable way, we do have to support research to increase our knowledge about these fields. We do need innovations in the different areas to improve food production and food availability on a sustainable way. And last but not least we do have to bring this knowledge and innovations to the people who need this information in a way, that they are able to adapt it into their daily live. It is not sufficient to have scientific solutions as long as “solutions” are not adapted by the people. We still need more information about the socio-economic forces improving or hindering the adaption processes in different regions. These fields, which were not in the focus of the international community in the last decades, have to be followed forcefully to overcome this serious emerging situation.

**Keywords:** Development strategies, food security

## Rural Knowledge Networks and Dynamics of Innovation: Lessons from Bolivia's Smallholder Agriculture

FRANK HARTWICH

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This contribution presents results from a study on how the inclusion of relational parameters describing connectivity and embeddedness in social networks affects a model that explains adoption of innovation among small farmers. Empirical evidence is derived from rural communities in four microregions in Bolivia that have used a set of innovations including improved seed varieties as well as new plant protection, harvest and post-harvest methods in the production of quinoa, a high altitude staple grain. A robust Tobit regression model was applied to analyse variation in levels of adoption depicted by the average degree of adoption across the diverse components of the set of innovations promoted in every microregion. Embeddedness in social networks was measured in terms of degree centrality of every farmer in the affiliation network, a term calculated from the count of ties between farmers and other change agents normalised by the maximum number of change agents each farmer could have been affiliated with.

Results show that neither one of the three factors, framework conditions, innovative capabilities and networking alone were able to sufficiently explain adoption of local farmers; however in combination the three factors could explain up to 45 of the variation in the adoption rates. The inclusion of the networking variable in the model improved the overall fit from 37 to 45 %. Degree centrality alone did not improve the overall explanatory power of the model; improvement of fit was rather achieved through including the frequency of farmer's interactions with a number of change agents such as technology transfer agents, development projects and NGOs, neighbouring producers, input providers, buyers and local authorities. This indicates that innovation processes are indeed of collective character. Interaction with a single extension worker or project agent is not enough; rather it is the simultaneous relationship with a range of change agents which does enable small producers to apply innovations on their farms. The results lead to the conclusion that development projects fostering agricultural innovation in regions such as rural Bolivia shall focus on knowledge and technologies that respond to the local capacities among smallholders and their endowment with resources.

**Keywords:** Adoption, Bolivia, rural innovation, social networks

## **The Declining Profitability of Litchi Fruit Orchards in Northern Thailand: Can Agricultural Innovations Reverse the Trend?**

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The profitability of litchi growing in northern Thailand has declined during the last 15 years. The potential substitution of seasonal field crops for litchi trees has created concerns about increased levels of erosion, pesticide use, and irrigation water demands. In response, researchers have been developing various technical innovations that could make litchi growing more profitable again.

The objective of this paper is to ex-ante evaluate four of these innovations: artificial flower induction to produce off-season fruits, village level fruit drying, improved shelf-life and fruit quality, and greater irrigation efficiency. These innovations were evaluated in terms of five indicators: profitability of litchi growing, farm household incomes, area under litchi orchards, irrigation water use, and the environmental impact of pesticides as based on the environmental impact quotient of pesticides (EIQ method). As some innovations (artificial flowering and improved self-life) are only at a research stage, assumptions were made about their likely costs and benefits.

The profitability of litchi growing and the four innovations was assessed through financial analysis. Although the results show that each innovation could increase profits of litchi growing, this is no guarantee for farm level adoption. For this, opportunity costs, resource constraints, risk aversion, and knowledge need to be taken into account. To do this, an integrated land use model was developed that used an agent-based modelling approach to capture the heterogeneity in opportunity costs between households and to capture the dynamics of innovation diffusion. The model was calibrated to the Mae Sa watershed area in Chiang Mai province. Located about 40 km northwest of the rapidly expanding town of Chiang Mai, the watershed has seen rapid economic development which has created various farm and non-farm alternatives to litchi growing. Farmers have increasingly left their litchi orchards unmanaged or have cut down trees to replace them with more profitable crops. The watershed is hence not representative for northern Thailand but could be a prospect for other areas in northern Thailand.

Using scenario analysis, each innovation is separately introduced into the model allowing a comparison of their effects. In addition, the innovations are introduced simultaneously to analyse their combined effect.

**Keywords:** Agent-based modelling, agricultural economics, ex-ante technology assessment, pesticides

## **Towards a Sustainable Landuse Option in the Bamenda Highlands, Cameroon: Implications for Sustainable Food Supply, Income Generation and Climate Change Mitigation**

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A land use option that can contribute to climate change mitigation and welfare improvement of poor smallholder farmers who cannot integrate traditional markets, but need alternatives for income generation, remains a challenge for researchers and policy makers in the Bamenda highlands. In a degrading agricultural landscape as such, where traditional cultivations and pasture have released quantities of greenhouse gases that are today significant in terms of their current impact and potential for long-term contribution to global warming, carbon sequestration projects, like agro forestry, can be an alternative. To verify this hypothesis, cost benefit analysis was employed. To estimate opportunity cost of land use change, the net present value of agroforestry was compared with those of pasture and traditional cultivations. Some indicators of profitability and cash flow viability (net present value, pay back, etc.) were used. Sensitivity analysis was used to simulate some salient conditions like interest rates, establishment costs and carbon prices. To complement these results, a rapid ecological services assessment was undertaken. This was to determine the relative contributions of the different options to environmental “viability”. All the options were found to be economically viable. However, agro forestry (NPV = USD 1361 ha<sup>-1</sup>, IRR=30 %, payback 4.5 years), though not as profitable as the pasture (NPV = USD 6829 ha<sup>-1</sup>, IRR=63 %, payback 2 years), appears to be the only option that can meet up with the current challenges. Opportunity cost is least (USD 2.09 ha<sup>-1</sup>) for a change from traditional cultivations to agroforestry than from pasture to agroforestry (USD 12.16 ha<sup>-1</sup>). However, land suitability analysis, education and precise silvicultural practices would be an asset.

**Keywords:** Cost benefit analysis, environmental viability, opportunity cost

## **Training Female Farmers as a Tool for Rural Development - A Review on Experiences from Bali, Indonesia**

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Over the last decades Bali's economy has been flourishing due to the growing tourism sector. However, the sector has experienced a sudden decline after the Bali bombing in 2002. This incident caused many rural communities to lose their extra income from the tourist sector and made them rely on agricultural activities again. As the tourist sector is steadily recovering in some regions, direct profit for the rural population is still minimal. New ways have to be found to provide them income possibilities.

Although women are carrying out most of the work in Balinese communities, decision making is still lying in the hands of men. Thus empowerment of women in rural regions is also a key issue which needs to be addressed.

The demand of fresh, high quality vegetables by tourists is a possible income source for rural communities. The "Bali Fresh Femal Farmers Partnership" (BFFFP) is a co-operation which was created to provide small farmers market access. A close network of local women with an input supplier, a sales company and horticultural experts was initiated, to ensure production and marketing of high-value products. The climate of the highlands of Kintamani, where the BFFFP is located, is highly suitable for growing vegetables. However, most farmers still restrict themselves to growing low profit crops, such as cabbage and onion. To enable the female farmers to produce high-value crops, such as bell pepper and various lettuces, practical and financial support was given in the beginning of the project.

Currently about fifty women are organised in small groups of ten farmers. Frequent meetings with all stakeholders along the production and marketing chain are held to ensure quality and marketability of the products. Adoption of improved production systems by the female farmers, to enable them to independently and continuously deliver the demanded vegetables to the tourist regions in a long run, is the target. Up to now still difficulties occur regarding amount and timing of fertilisation, as well as precise yield predictions. Therefore ongoing consulting and training is necessary. By increased expertise and money inflow local women experience a stronger position in the local community.

**Keywords:** Gender, market access, production chain, development

## Knowledge Transfer Systems in China: An Example of Vegetable Intercropping Systems in Hebei Province

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The North China Plain being East Asia's largest alluvial plain is of high importance to food security in China, accounting to one fifth of China's total food production. Highly intensive agricultural practices during the last decades let to a dramatic degradation of arable land, severely endangering sustainability. In recent years a steady shift from cereal production systems into vegetable production systems can be observed. As most vegetables have much higher water and nutrient requirements environmental degradation caused by vegetable production is many times over that of cereal production systems.

Intercropping, the simultaneous cultivation of two or more crops on the same field is widely practised in Hebei province. Intercropping can use environmental resources more efficiently, weed and pest pressure are lowered and the risk of crop failure is reduced. Intercropping can lead to higher yields and at the same time environmental degradation can be minimised by controlling erosion and leaching of nutrients. A qualitative inquiry in Hebei province was conducted, interviewing researchers, administrators, consultants and farmers on occurrence, methods, chances and constraints of vegetable intercropping. Semi-structured in depth interviews were used to examine where the ideas for the systems are generated, and how the dissemination is taking place. More than 60 hours of recorded interviews and numerous written down interview reports had been analysed.

In most cases the intercropping systems are developed by the farmers themselves, or their ancestors, and later are adapted by farmers inside the village and in neighbouring villages. Some systems, which proved to be successful are also picked up by the local and regional state extension service and are disseminated among farmers. Transfer of the systems to other extension stations inside and outside the province was also reported. Due to its interesting features, agricultural researchers also recognise certain intercropping systems practised by farmers. However, after being examined by researchers, improved systems are not redistributed to extensionists and farmers. Extensionists claim that "researchers don't know about farmers' problems" and that "they keep the results in their labs". On the contrary researchers state that most extension technicians lack of agricultural knowledge and "should be re-educated".

**Keywords:** China, knowledge transfer, vegetable intercropping

## Development of Agricultural Open Educational Resources through the Use of Wikieducator

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A challenge for agricultural education, research and development is the availability of technical and scientific information. Open Educational Resources (OER) - similar to Free/Libre Open-Source Software (FLOSS) - are becoming increasingly attractive and important as an alternative to professional textbooks and journals, especially in sub-Saharan Africa (SSA). The Commonwealth of Learning (COL) is adapting agricultural open educational resources (AOER) to expand agricultural education for improved livelihoods in SSA. COL created the WikiEducator ([www.wikieducator.org](http://www.wikieducator.org)) for collaborative:

- planning education projects linked with the development of free content,
- developing free content for e-learning,
- building open educational resources.

A “Wiki” is a website which anyone can use for publishing and editing online. COL’s WikiEducator uses the same free soft-ware that is used for Wikipedia. One can edit and modify content from anywhere in the world. Therefore WikiEducator is an excellent tool for international collaboration on free content development, such as AOER.

In June 2007, in collaboration with and at the World Agroforestry Centre (ICRAF), Nairobi, Kenya, COL conducted a workshop on AOER. The workshop was build around a toolkit ([www.wikieducator.org/\\_workshop\\_toolkit](http://www.wikieducator.org/_workshop_toolkit)) and included 23 collaborators from 10 countries, mainly from agricultural universities. Workshop goals were to:

- let participants have hands-on experience in using the WikiEducator and practice developing content,
- try out an online version of the training toolkit for fine-tuning and pilot testing.

Complementary subjects included e-learning, instructional design, learning objects, on-line learning resources, and copyright licensing options, specifically <http://creativecommons.org/licenses/by-sa>. Most workshop participants were not used to the development of educational content in an open manner. Some common fears addressed during the workshop were related to:

- loss of intellectual property rights,
- security of published content and risk of vandalism,
- lack of motivation and incentives for producing OER materials.

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Experiences with Wiki platforms show that these fears are not substantial.

This was the first COL-initiated workshop on agricultural education and Wiki-Educator in Africa. We expect that AOER and Wiki-Educator will be taken up by national, African (e.g. Forum for Agricultural Research in Africa - FARA) and international institutions (e.g. Consultative Group on International Agricultural Research - CGIAR).

**Keywords:** Commonwealth of Learning, e-learning, ODL, open educational resources



## **Technology-Mediated Open and Distance Education (Tech-MODE) for Agricultural Education and Improved Livelihoods in Sub-Saharan Africa**

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Globalisation, market liberalisation and worldwide food situation are threatening food security of the developing countries, which depend on millions of small farmers. Such farmers require access to information, learning and new skills to take advantage of the emerging income-generating opportunities (e.g. meat, milk, vegetables, fruits, flowers). They need relevant, useful, accurate and reliable information in a timely manner for their self-directed learning. This requires new ways of developing and delivering information. Technology-mediated open and distance education (Tech-MODE) - a combination of open and distance learning (ODL) with information and communication technologies (ICT) - has potential to satisfy such demands.

The Commonwealth of Learning (COL) wishes to identify opportunities for a complementary and catalytic role to expand the scope for Tech-MODE for agricultural education and improved livelihoods in sub-Saharan Africa. In 2007, COL undertook country case studies in eight Commonwealth countries from West, Central, East and Southern Africa: Nigeria, Ghana and Sierra Leone; Cameroon; Kenya and Uganda; Tanzania and Zambia; respectively.

An inventory of local institutions, facilities and capabilities for Tech-MODE included:

- Country status of agriculture, horticulture and livelihood;
- National ICT policies and strategies on agriculture;
- Institutions, facilities, capabilities, government support, and potential available to implement Tech-MODE in collaboration with COL;
- Recommendations and suggestions to COL.

Conclusions and recommendations:

- Agriculture is the engine of development. Agriculture contributes from 17 (Nigeria) to 49 % (Sierra Leone) to GDP. Labor force in agriculture extends from 60 (Ghana) to 85 % (Zambia).
- National ICT policies either exist or are in process. They may include education in general, but rarely reach agriculture specifically. ODL is well recognised, but rarely with emphasis on agriculture.
- Collaborators for Tech-MODE are available mainly on formal educational levels. A few international partnerships are in progress.
- Recommendations for consideration by COL and interested partner organisations fall into five categories: policy, infrastructure, socio-economy, capacity

building, and collaboration. COL may assist in identifying learning needs and opportunities, establishing linkages and partnerships, facilitating proof of concept studies, capacity building, training, development of Tech-MODE-based learning materials and models, monitoring, and following up.

**Keywords:** Commonwealth of learning, country studies, e-learning, Sub-Saharan Africa, Tech-MODE, distance-learning,

## Using SWAT to Evaluate Climate Change Impact on the Water Resources in the White Volta River Basin, West Africa

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In West Africa, availability of and access to freshwater has a strong impact on patterns of development in both rural and urban areas. Due to extreme temporal and spatial variability in rainfall, global climate change, land degradation and population growth among others, there is a serious threat to the sustenance of freshwater and subsequently the livelihood of the many rural poor in West Africa. Therefore, wise and effective management of freshwater sources in a river basin is necessary.

The GIS based, semi-distributed Soil and Water Assessment Tool (SWAT) model was applied to the White Volta River Basin to quantify the basin's water yield and to evaluate the impact of climate change on water availability. The White Volta basin is a major sub catchment of the Volta River Basin located in West Africa. The major riparian countries are Burkina Faso and Ghana. The main channel of the river has a total length of 1,140 km and drains a total land area of about 106,000 km<sup>2</sup>. The model was successfully setup, calibrated and validated using daily observed streamflow time series data for the period 1980–1999 with the first 6 years (1980–1985) used as warm-up period. The results showed that SWAT was very well able to mimic the hydrology of the White Volta basin. The streamflow, surface runoff and base flow were all well reproduced by SWAT.

To evaluate the impact of climate change on water resources in the White Volta basin, the calibrated SWAT model was used to simulate the future water resources based on the future climate series of the regional climate model MM5. This model has been adapted to station-specific climate data using the weather generator LARS-WG. Compared to the simulated present (1990–2000), the results of the simulated future water resources (2030–2039) show important increases in the annual streamflow, surface runoff and the baseflow.

**Keywords:** Base flow, climate change, modelling, streamflow, surface runoff, SWAT, White Volta river basin

## **Approaches to Modelling Vulnerability to Poverty in Rural Households in Thua Thien Hue Province, Viet Nam**

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Economic reforms have transformed Viet Nam into one of Asia's fastest growing countries which has achieved impressive progress on cutting poverty. The success of its agricultural sector remains a key factor for maintaining this positive trend since the majority of the population still lives in the countryside. Idiosyncratic and covariate shocks pose a threat to the rural economy and can cause households to fall back or deeper into poverty. However, positive shocks like the recent price surge for food crops also offer opportunities. Modelling the reactions of rural households to shocks presents a challenge. Several steps are necessary. Firstly, a good understanding of the Household's decision-making processes, his income portfolios and his coping capacity are needed. Secondly a good concept to build such models that incorporate vulnerability in the criterion function is needed. Thirdly, a good empirical data base is necessary.

This paper focuses on the third aspect, namely the collection of data and the formulation of respective household models which are typical for the farm household systems in Thua Thien Hue Province in Central Viet Nam. In this study primary data from 718 households were collected. Results of a descriptive analysis indicate that two groups of typical farm households can be identified: Those households who are exclusively engaged in own agricultural activities and those who are engaged in both own agriculture and off-farm employment. The first group accounts for a larger share of households in the mountainous areas of the province which is predominantly inhabited by ethnic minorities. Major shocks by which households were affected in a reference period of 5 years are unusually heavy rainfall, flooding and illness of household members. Shock-affected households applied different coping activities such as borrowing from different sources, taking up of additional occupation and adjusting their agricultural production portfolio. A considerable share of households did nothing when a shock occurred. The outcome of the study points to the importance of a more profound analysis of the effect of shocks on farm households and their risk coping behaviour.

**Keywords:** Viet Nam, vulnerability

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## Climate Change Impact Assessment and Adaptation Options in Vulnerable Agro-Landscapes in East-Africa

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By 2020 between 75 and 250 million people will be exposed to water stress due to climate change impacts. Coupled with expected increases in demand for food and other land based goods and services land use changes will occur, drastically threatening livelihoods of small-scale farmers. Rain fed mixed crop livestock systems of north-eastern and central Tanzania are likely to be most severely affected by these changes.

This project aims at assessing the regional impacts of climate change on agro-landscapes and environment in Tanzania (eastern Arc, Dodoma) and at designing adaptation strategies and practices for small-scale agriculture. Assessments on related land use sectors as forest, hydrology, nature conservation and biodiversity are additionally considered involving local partners and counterparts.

Driven by regional climate change scenarios, integrated agro-ecosystem models (including soil water and nutrient dynamics and soil-crop-atmosphere-management interactions) are used to assess combined climate change and management effects on crop production, water resources and soil fertility. These agro-ecosystem models are linked closely to hydrological models, which provide necessary boundary conditions such as groundwater level and get back the input from the root zone, e.g. surface runoff, seepage, erosion and nutrient leaching.

Complementarily, stakeholders can develop options of management practices in potential future agro-landscapes based on the same regional climate change scenarios. All three sustainability dimensions (social, environmental and economic) are targeted and discussed with decisions makers on the regional level. Stakeholder scenarios will be visualised and linked to the development of good agricultural practices.

Model outputs will be used to evaluate good practices for potential future climatic conditions. Stakeholder-based scenarios will be made compatible in an iterative process with model-based scenarios. Options for climate change adapted good practices embedded into region based scenarios of sustainable agro-landscapes are anticipated as key output of these exercises.

Rather than seeking climate-proof good practices for specific scenarios, this project will contribute to the development of farming systems and livelihood strategies that are robust across a range of possible future agro-landscapes. High emphasis is on the relevance for regional policy development.

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

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## **Economic Effects of Climate Change in the Middle Drâa Valley in Morocco**

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Irrigation water is essential for agriculture in the semi arid Drâa River basin in south-east Morocco. However, prolonged drought periods and effects of climate change will worsen the unreliable water supply situation in the future. Characterized by small palm tree oasis along the River Drâa, agriculture is mainly practised in form of subsistence farming through the cultivation of dates, cereals and fodder. Farmers have the choice of surface- and groundwater for irrigation, whereas the overuse of the later has lead to a decrease of groundwater tables and an increase of salinity rates during the last years. Implementing uncertainty in water resource management models has been an increasingly recognised tool to more realistically simulate river basin management. In this paper a hydro-economic river basin model is extended towards a stochastic modelling approach to incorporate the uncertainty of water supply. The model is an optimisation model which maximises agricultural net revenues over all oases under two main constraints: land and water. Both water quantity and water quality are considered for yield formation of seven major crops. On the basis of meteorological climate change scenarios from an interdisciplinary water research project, parameters of the water availability density function is calculated using maximum likelihood techniques. Based on these distributions, a random variable for water supply is introduced to simulate inflows into the system. Scenarios are simulated for one year with random reservoir inflows. Model results show that currently the probability of farmers to receive revenues below the existence minimum is around ten percent but this is likely to worsen in the future when water for irrigation becomes more scarce and unreliable depending on the assumptions of the climate change scenarios. Groundwater use for irrigation is increasing when surface water becomes scarce although groundwater is assumed to be more costly than surface water.

**Keywords:** Mathematical programming, Morocco, uncertainty, water resources

## Motivation of CSR Orientated Public Private Partnerships in Fisheries and Agriculture Development

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This paper analyses the possible contribution of private partners to development assistance realised through two instruments: Corporate Social Responsibility (CSR) and Public Private Partnerships (PPPs). As important topics in the field of development assistance, the paper draws on examples from the fisheries and agriculture sector.

A number of corporate social activities can be found in the reporting of multinational enterprises acting in developing countries, including implementation of human rights and fair working conditions in the supply chain, building human capital through education, and reducing pollution. These are not only interesting fields for a responsible corporate management, but also for development policy. As a result, many development agencies interpret CSR as the implementation of their aims at the company level and support this concept through different policies. However, there are also critics who believe the influence of CSR on development is overvalued. Potential problems are seen in the different motivation of companies and development agencies. Responsible acting companies must always be orientated on long term profitability. They will not be orientated on strategic aims of development assistance, even if the fields of CSR activities of companies and projects of development agencies may be similar. On the other hand, development agencies try to increase efficiency by partnering with profit-orientated companies in special designed PPP programs on the basis of their strategic plans. These aim at a sustainable implementation of development projects. This should increase the impact of development by allocating new financial resources and the use of skills and experiences of the private sector within development assistance projects. In practice many projects fail caused by organisational challenges, different expectations and unclear goals, created by the different motivations of partners.

This paper therefore will analyse the motivational structures of both partners, in order to identify the potential contribution to development assistance and possible limitations of CSR and PPP. In conclusion, a combination of these instruments - CSR - motivated PPPs - will be discussed to determine their potential to avoid problems and therefore increase the impact on development.

**Keywords:** Corporate social responsibility, corporate development responsibility, public private partnerships, fisheries, aquaculture, development assistance





# Small-scale farming and value chains

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## The Impact of El Niño Related Drought on Smallholder Farmers in Central Sulawesi, Indonesia: Who is Most Vulnerable?

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Crop production in the tropics is subject to considerable climate variability caused by the El Niño-Southern Oscillation (ENSO) phenomenon. In Southeast Asia, El Niño causes comparatively dry conditions leading to substantial declines of crop yields with severe consequences for the welfare of local farm households. In concert with global warming, the severity of ENSO events is forecast to increase in the future. Using an interdisciplinary modelling approach that combines regression analysis with linear programming (LP) and stochastic simulation, and integrates climatic and hydrologic modelling results, the objective of this paper is to assess the impact of El Niño on agricultural incomes of different types of smallholder farmers in Central Sulawesi, Indonesia, and to derive suitable crop management strategies to mitigate the income depressions.

We identify five farm classes by cluster analysis. Our LP model maximises their cash balance at the end of the time period most severely affected by El Niño. Main activities are the cultivation of rice, maize, and cocoa. Accounting for water supply as an input factor, external Cobb-Douglas production functions generate output according to the level of production intensity and predicted weather patterns. A major limitation of LP models is that they produce deterministic estimates of the expected outcome under a given scenario, hence failing to incorporate the risky nature of agricultural production. In our modelling approach, stochastic simulation accounts for variations in crop yields due to factors not captured by the production functions. Iterative model runs produce probability distributions of the model outcomes for each household class, rather than point estimates, whereby the downside risk of failing to achieve a specified minimum level of income is a particularly policy-relevant measure of vulnerability against ENSO-related drought. The results can contribute to the formulation of enhanced development policies by illustrating that drought-related crop management recommendations must be tailored to farm households according to their location, farming system, and resource endowment.

**Keywords:** ENSO, Indonesia, linear programming, risk management, stochastic simulation

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## **Interlinks Between Cash Crops, Food Crops, Food Security and Smallholder Farms in Western Kenya: Disentangling the Old Rural Development Fashion?**

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For several decades now, the notion about rapid population increase and the resultant influx of urban areas due to rural-urban migration has been a familiar theme in the development discourse of Sub-Saharan Africa. Due to the dependency of the majority of rural dwellers on agriculture for livelihoods, the best approach of enhancing rural development, so the argument went, was the increase in rural agricultural productivity and effectively the rural dwellers' purchasing power, leading to a reduction in rural urban differentials. In no region is such a scenario as explicit as in East Africa and particularly in Kenya. The various government policy programmes, for example the Special Rural Development Programme (SRDP) and the District Focus Strategy for Rural Development (DFSRD) were attempts to cement this policy.

With data of 182 sample farm households from western Kenya, the major objective of the research was to examine the interlinks between cash crops, food crops, food security and smallholder farms in a region characterised by continuous decline and subdivision of farm size. The data comprising of two equal groups of both tea farmers and non-tea farmers from 2007 production year was analysed by logit and log linear models for participation in cash crop farming, food security and household income determination.

According to the findings, households that engage in both on-farm and off-farm activities are less likely to experience food insecurity, compared to those engaging in only on-farm work. Such households are also likely to experience less intensity of food insecurity irrespective of the crop mix. Participation in cash crop farming is also likely to be undertaken by farm households also practicing off-farm work. Moreover, households engaging in both on-farm and off-farm activities achieve higher per area yields of the maize staple and/or the tea cash crop. Conclusively, declining farm size in western Kenya has a strong correlation to food insecurity.

As a policy recommendation, the research points out that the induced approach of considering agriculture as the engine and prerequisite for the transformation of rural economies on which other sectors should be systemically built needs urgent revisiting in terms of future research.

**Keywords:** Cash crops, farm size, food crops, food security, labour absorption, rural development

## **Integrating Small Scale Farmers to Regional Organic Markets: Issues, Opportunities and Constraints in East Mau Catchment, Kenya**

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In Kenya, just like in other developing countries, the character of the food system and nature of food policy is changing, with the supermarkets and other specialised outlets taking a leading role in marketing of agricultural produce, policy makers have also to focus on emerging issues with regard to food production, processing and marketing. As these changes occur, the gains are more likely to accrue to the more concentrated players who control the major agro-based and food processing systems. The small scale farmers are likely to be the losers due to a number of challenges and poor links of their production to the market. Against the backdrop of the expanding domestic and export markets for organic produce accelerated by changing global food systems, food, health and safety concerns, this study sought to identify the factors that influence the level of local market participation for small scale farmers in East Mau catchment. It was hypothesised that there is a relationship between the farmers' level of participation in the market and the state of infrastructure, level of transaction costs, level of trust and farm specific socioeconomic factors. A tobit model was used to analyse the factors that influence farmers' level of market participation. Results indicate that, infrastructure, transaction costs, level of trust, inconsistent production and low premiums were identified as some of the factors that mainly impede farmers from competitive participation in the market for specified food crops. We suggest that though it is important to target the ever growing export markets, there is need to empower the small scale farmers to fully participate in local and regional markets. The link between the organic farmers and specialised and non specialised outlets in the urban centres of Kenya is still weak. Primary data was collected through a household survey on a sample of 308 farmers in the study area between January and March 2007. Additional data was collected from focus group discussions with agricultural experts in the region.

**Keywords:** Market participation, organic markets, transaction costs

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## Health and Environmental Impact of EU Private Standards: Evidence from Kenyan Export Vegetable Growers

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The proliferation and enhanced stringency of food-safety standards represent potential barriers to producers in developing countries seeking to expand their trade in high value crops. Yet, they may also represent a catalyst for the upgrading and modernisation of production systems, which can help reduce hidden environmental and health costs. The specific objectives of this paper are to: (1) estimate the effect of EU private standards on pesticide related incidence of acute poisoning symptoms and its associated cost-of-illness and (2) explore impact of private standards on improved crop management practices as proxy for environmental benefits. To attain the objectives, a theoretical non-separable farm household model is used as a starting point. Based on the optimal health demand functions derived from the model's first-order condition, an empirical model is formulated and estimated. Farm level data were collected between August 2005 and September 2006 via a cross-sectional survey of 449 households of Kenyan export vegetable producers.

Results show that adoption of production standards like GlobalGAP significantly reduces pesticide ascribed incidence of acute poisoning symptoms and its associated cost-of-illness. *Ceteris paribus*, farmer's who adopt standards experience 78 % lesser incidence of acute illness and spent about 50 % less on restoring their health compared to non-adopter farmers. Although the health costs examined in this study are limited to treatments related to a few acute health impairments (which could be just a small part of the total health cost), they still account for about 86.4 % of the mean household pesticide expenditure per cropping season for non-adopters and 39.6 % for adopters. Likewise adoption of standards has a significant positive impact on environmental outcomes corroborating the view that standards induce changes in farm production systems in developing countries. Improved pesticide management practices entail less pesticide intoxication by farmers and farm workers, improved environment and efficiency gain. Generally this study strongly indicates that adoption of private standards can play a positive role, providing the catalyst and incentives for the adoption of safer and more sustainable production practice.

**Keywords:** Adoption, environment, export vegetables, GlobalGAP standards, Kenya, pesticide

## Organic Coffee, Fairtrade and Small-Scale Producers: Is Certification a Way to Reduce Poverty in Nicaragua?

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Coffee farmers and their organisations become increasingly aware of the potential benefits of participation in high-value chains. Alternatives to conventional coffee production and marketing systems have evolved over time, offering now certification for environmentally friendly production and fair marketing conditions. Certain production systems, such as organic or shaded coffee, require usually a higher labour but a lower capital input compared to conventionally grown coffee. The marketing of coffee through specialised market channels might be a viable alternative for poor farmers, as these tend to offer more stable and even higher prices. Current knowledge about welfare impacts of certification schemes on small-scale coffee producers is inadequate.

Our research investigated the effects of organic and organic-fair trade certification on small-scale coffee producers, organised in cooperatives, in northern Nicaragua. Cooperatives with conventional farmers formed the control group for the quantitative and qualitative analysis. The results of the qualitative research, consisting of various tools of the Participatory Research Appraisal applied to key-persons and producer groups are presented. Results show a divergence between public hopes regarding effects of certification schemes and reality. Certification schemes may increase welfare of small-scale coffee farmers but it cannot be taken for granted. The main reason for farmers to participate in certification schemes is the hope to achieve higher or more stable incomes than from conventional production. Current price differentials paid for certified coffee in the research region are not remarkably higher than for conventional coffee. This jeopardises producer's willingness to continue participating. Additionally, price differentials are judged to be insufficient for the investments needed in the coffee plantation, and for improving considerably the nutritional situation or the health status of producer families. Improvements in the living standard of a farm household are rather related to yield improvements, which are triggered by development projects investing in agricultural training and extension services. Since cooperatives are heterogeneous in the way they are structured, in their resource endowment and human capital, not all offer equal services and access to development projects. These differences have a far greater influence on the welfare of small-scale producers than the certification itself.

**Keywords:** Certification, coffee, cooperatives, fair Trade, Nicaragua, organic agriculture, small-scale producers

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# Climate change, food and agriculture (GTZ)

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## **Adaptation to Climate Change in Agriculture – Roles of Development Cooperation**

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Adaptation to climate change has become an important development cooperation issue, both at international policy level and on the ground where it must focus on strengthening adaptive capacity of societies and reducing vulnerability of the poor in particular. Developing countries, as a group, are the ones most threatened by the impacts of global climate change. This is true both because many of the poorest countries lie in regions where effects will be most damaging, and because their ability to respond to harmful changes is the most limited.

In agriculture, a critical expected impact of climate change is depression in major crop yields in tropical and sub-tropical regions. Africa may become the region with highest population of food insecure, up to 75 percent of world total by 2080. Arid and semi-arid lands are expected to increase by 5–8 %. On the other hand, many adaptation options, including changes in planting dates, tillage practices or adjusted livestock breeds in the short term or improved water management and irrigation systems and diversification in the mid to long term can help to adapt to a changing climate.

In consequence, development cooperation activities must consider carefully the expected impacts of climate change and build in appropriate adaptive measures.

Concrete tasks for development cooperation include support to integrate climate change concerns into decision-making and supporting mechanisms for risk management. This contribution discusses how these issues can be addressed based on experiences from three pilot projects:

- Application of cost-benefit analysis in supporting an adaptation strategy in the Indonesian water sector with a focus on rice production
- Developing index based weather insurance to adapt to increasing drought risks in agriculture in Mali
- Pilot application of climate proofing of development projects in a rural poverty alleviation programme in Viet Nam.

**Keywords:** Adaptation, Africa, agriculture, climate change, climate proofing, cost-benefit analysis, development cooperation, policy, risk management, weather insurance

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## Rising Food Prices - Causes, Consequences and Impact for the GTZ

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Since the end of 2007 one could observe worldwide an enormous rise in food prices. In many developing countries serious implications have become visible. Besides the low income food deficit countries also wealthier countries experience increasing inflation and problems with the balance of payments, social unrest and political instability due to high food prices in about 30 countries. Analysts fear that the achievements of poverty reduction in the past years may be lost and more than 100 million people may additionally fall below the poverty line.

There exists a broad consensus about the causes of the crisis. Important factors were decreasing stocks, failing harvests in important export countries, changing consumption pattern in populous emerging countries, the rise in fossil energy, fertilisers and transport. The declining investments in agriculture (private and public) have added to the situation. The effect of biofuel quotas are being discussed controversially and the influence of speculative investments are not yet fully transparent.

The international community has reacted swiftly and decisive. Under the auspices of the Secretary General of the UN a Task Force has been established that has developed a catalogue of measures. Most important is the fact that there is no blind actionism but the will to coordinate the efforts with the other actors.

For Germany BMZ has made available additional resources of approximate € 77 million for coping with the food price rises. In addition a number of extremely needy countries have been identified with an emphasis on subsaharan Africa. Those countries are to served first

This situation poses a number of challenges for the work of GTZ. The presentation will show how GTZ is dealing with these challenges give examples of concrete concrete.

**Keywords:** Climate change, economic policy, food security, investment in agriculture, poverty alleviation, rising food prices, social policy, water for food

## **Sustainable Production of Bioenergy: A Road for Market and Smallholder Oriented Rural Development for Poverty Alleviation**

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The demand for energy from biomass (bioenergy) and liquid biofuels is increasing all over the world. Drivers for bioenergy are the uncertainty of future domestic energy supply, the increasing demand for energy worldwide with sharply increased energy and oil prices as well as the need for reducing GHG (green house gas) emissions in order to achieve the targets defined in the global climate change policies.

Bioenergy is seen as an opportunity for enhanced market and smallholder oriented rural development in many developing countries where comparative advantages of bio energy production exist. Private investors and companies are increasingly acquiring land and prepare for large investments in industrialised monoculture oriented systems for bioenergy production in the rural areas of many developing countries. However, a comprehensive set of sustainability criteria needs to be fulfilled for the expansion of bioenergy in order to ensure its ecological effectiveness as well as to prevent ecological damages and to ensure that social standards and the right to food are maintained. These sustainability standards will become the requirement for access to the european markets and are supportive for fostering smallholder oriented bio energy value chain development.

This contribution will it will present results of an assessment of bioenergy potentials and the possible impact of a national bioenergy policy for bioenergy.

Furthermore it will outline the key elements of out grower concepts for smallholder focused bioenergy production systems for palm oil and sugar cane production and will briefly describe the costs and benefits for decentralised electrical grid and biofuels production systems based on the jatropa shrub (*Jatropha curcas*) and kapok tree (*Ceiba pentandra*).

**Keywords:** Bioenergy, bioenergy strategies, economic policy, impact of national bioenergy policies and targets , investment in agriculture, jatropa, kapok, poverty alleviation, rural economic development

## **Adaptation of African Agriculture to Climate Change - BMZ-Research Priority has Started!**

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Particularly Africa is affected by climate change. Extreme weather events such as droughts and floods are already occurring more frequently and with greater severity than in the past. The consequences are lower – or even total loss of – crops and livestock. Enhancing the capacity of the most vulnerable poor to adapt to climate change is going to be one of the main issues technical development cooperation is facing in the near future.

However, the changes differ locally and depend on natural conditions such as species and variety of crops and cropping systems, but also on political and socio-cultural factors. A precise understanding of these factors as well as their local and regional impact is essential to manage against climate change.

To develop measures of adaptation to climate change, the Federal Ministry for Economic Cooperation and Development (BMZ) assigned the Advisory Service on Agricultural Research for Development (BEAF) with the design of the research priority area “Adaptation of African Agriculture to Climate Change”. In summer 2007 the call for proposals led to the submission of 18 project suggestions. Eight of these were selected after close examination and expert appraisal: Five international agricultural research institutes (CIP, ICRISAT, IFPRI, ILRI, IWMI), two German universities (Göttingen, Hohenheim) and one of the Leibniz centres (ZALF) have received research funding totalling € 9 million for the programme, which is scheduled to run for three years.

The research priority is designed interdisciplinary and multi-institutional. There is a manifold network between the participating institutes and universities. Professional tasks range from climatology over classical agricultural disciplines – cropping systems, plant breeding, grazing management and agroforestry – to water management and policy research. Regional focuses are the Sahel belt countries in West Africa as well as Eastern Africa.

One of the main issues of the research priority is to involve local stakeholders to enhance their capacity as well as to feed their knowledge into the research approach. At least 3 either non-governmental organisations, farmer associations or National Agricultural Research Centers are participating in each project to assure an appropriate connection to the persons concerned.

**Keywords:** Africa, agriculture, agroforestry, climate change, climatology, cropping system, farmer association, food policy, grazing management, national agricultural research centre, non-governmental organisation, plant breeding, research, water management



# High-value supply chains and contract farming

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## Upgrading: A Path Towards Integration in Value Chains? Evidence from Small and Medium-Sized Producers in Honduras

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Analyses of upgrading from a value chain perspective pay particular attention to the ways in which value chain linkages facilitate or obstruct upgrading. Upgrading can be a precondition to get integrated in a value chain or a requirement to secure a position within the chain. Empirical research in a number of developing countries demonstrates that small and medium-sized producers in developing countries can learn and upgrade through the interaction with lead firms in the value chain even though local institutions have facilitated this process in several ways. Through small and medium-sized producers, there is the potential to link the poor to growth opportunities and reduce poverty. These local producers, in their interaction with local processors or exporters and international retailers have the possibility to acquire new skills and knowledge depending on the structure and dynamics of the value chain in which they operate. Focusing on this kind of interactions, the study explains how small and medium-sized producers in Honduras engage in upgrading and whether this had an impact on their profit. For the purpose of this study, three different agricultural value chains were analyzed. These chains were the traditional primary commodity chain (coffee), the plantation product chain (palm oil) and fresh produce chain (horticultural). The results indicate that the majority of the producers in the sample upgraded their products and internal processes. Producers in a high-trust relationship with their buyers were more likely to upgrade. A limited number of producers engaged in functional upgrading. Most of the producers were aware of the important role of standards. They affirmed that in the process of implementing and complying with standards, they have gained new knowledge and were convinced that they succeeded in securing a better position in the value chain. The results indicate that the form of coordination affects the upgrading opportunities of producers and their implementation and compliance with standards. In the coffee chain, coordination is loose and indirect; therefore upgrading was more difficult for producers to achieve. Horticultural and palm oil producers had more incentives to upgrade mainly because of the higher-trust relationship they were embedded in.

**Keywords:** Coordination, standards, trust, upgrading, value chain

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## **Contract Farming in Tobacco Production: Opportunity for Small-Holders? Comparative Study from North Sumatra**

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The paper presents results of the research focused on impact of tobacco cultivation, processing and selling on socio-economic situation of small-holders in three districts in central mountainous part of the North Sumatra province: Karo, Tapanuli Utara and Tapanuli Tengah. Tobacco cultivation has a long tradition in lowlands but in some mountainous areas small-holders recently uncover the tobacco ability to generate a regular negligible income. Farming system is there subsistence-oriented and highly specialised on crop production. Poor infrastructure and less developed mechanisation make these small-holders dependent on their own or local market products. Tobacco production became very popular among those farmers due to increasing demand by both local people (population growth, high unemployment rate etc.) and international trading companies. Research was carried-out during May and June 2006. Two different ways of production chain, which have been developed in the region, were investigated. The first one is naturally realised by the farmers: collection from the field, processing at the common place and transport to the market. The second one is based on the world-wide-spreading endearment of contract-farming even without properly developed infrastructure, market and social structure but with existing just one company setting the prices. Using PRA's methods, semi-structured questionnaires with tobacco growers and secondary data analysis from different statistical sources, relevant information were collected on total tobacco production, processing, purchasing price and credit and inputs access were supplemented by the area observation. Results show that despite of very similar social background (education, family status etc.) farmers under contract farming (Tapanuli districts) have faced more serious socio-economic oriented problems (fluctuation of cash-inflows, poor input supply, urgency of off-farm activities), further, the way of tobacco processing is inadequate and purchasing prices are considerably lower (US\$ 0.75–1.60 per kg) as compared with Karo district (US\$ 4.10 per kg). This could be explained especially because of the farmers' remoteness from each other and from the market, lower farmers' negotiating power in the time of signing the contract and less developed social capital in those districts what has a negative impact on higher income generation and inputs supply.

**Keywords:** Contract farming, North Sumatra, smallholders, tobacco, traditional market chain

## **Contract Farming as a Feasible Tool for Agri-Food Chain Development in Pineapple Production: Case Study of North Tapanuli**

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The research was carried-out in North Tapanuli regency, North Sumatra province during the May and June 2006. Majority of local population is extremely poor, living in rural areas, and practicing traditional agriculture techniques. Their poor living conditions have not been caused by low level of social development only, but also due to insufficient information on market opportunities, as the development process is now spreading into all parts of Indonesia. Thus, survey was aimed at monitoring of fruit production and trade, and ascertaining the overall living conditions of local farmers. Only areas of pineapple production were examined, as initial monitoring showed that in higher amount only this crop is cultivated. Data were gathered through observation, interviews, and questionnaires with farmers, traders, and representatives of local pineapple manufacturing company. Pineapple is cultivated only in five out of 15 sub-districts (Sipahutar, with 75 % of the production, Pangaribuan, Siborong-borong, Tarutung, and Garoga). Pineapples are sold directly on the field to traders and passed on within a network of traders until they reach local market or local export-oriented manufacturing company. Contract-farming is used as a method to obtain the production from farmers. Agreements are also set between a small number of traders and processing company. Economically weak farmers (average farm-size for growing pineapple is less than 1 hectare) are responsible only to grow the crop, and have stable incomes due to assured pineapple sales, while their transaction costs are reduce to minimum. Hence, they are more opened to adoption of more risky, high-value-crops such as pineapple, even under the situation the purchasing-prices are lower (700–1,000 IDR) in comparing to the local-market price (1,500 IDR). The research in this upland region proved that it is possible to create a functioning agribusiness activity, based on local production and labour force, with working supply chain also under local specific social, economical, and natural conditions. Such a process of emergence of small scale industries is optimal for sound economic development tendencies of rural areas, while the strong, but sensible support of local authorities is evident.

**Keywords:** Agri-food systems, contract farming, Indonesia, North Tapanuli, pineapple production, rural areas

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## Upgrading Opportunities for Small-Scale Farmers in Selected Coffee Value Chains in Nicaragua

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Coffee prices have fluctuating greatly over the past few decades. There have also been increasing differences between production and consumption with respect to prices, valuation of qualities, and product definition. Although certification schemes and standards have been applied widely, research is needed to identify income shares of small-scale farmers from certified and quality coffees and in terms of final retail prices. Although substantial symbolic rents can be obtained by marketing differentiated coffees, premiums are mainly captured in final stages of the value chain and thus do not benefit the producers.

This distribution of benefits can be related to governance structures in the coffee market which is characterised by buyer-driven chains giving more negotiation power to buyers in consuming countries.

Nicaragua has a high potential to participate in high value coffee markets because of its geographic and climatic conditions. Since its successful participation in the Cup of Excellence competition over the past few years, roasters increasingly appreciate Nicaraguan coffees as potential specialty coffees.

This research investigated the possibilities for small-scale coffee producers to enhance their position in high value coffee chains in the central and northern Nicaragua. It analyses the need for transparency and appropriate chain management to improve small-scale farmers' integration in value chain upgrading activities. Qualitative interviews have been conducted with actors internal and external to the chain.

Analysis showed that communication among different chain levels is limited by organisational factors that result in asymmetric information. Certification and processing activities such as cupping and labelling provide information on the product from the producers to buyers and consumers. Producers, however, lack information on market conditions, prices, quality premiums, and demand. This lack of information limits the ability of small-scale coffee farmers to successfully participate in value added activities and decreases their incentives to participate in certification and quality promotion programs. Enhanced knowledge transfer among chain actors could increase farmers' understandings of high quality coffee markets; and would provide them information on coffee attributes sought by consumers. The efforts of farmers to produce high quality products should then be rewarded by adequate prices, which until now is not the case.

**Keywords:** Coffee, governance, small-scale farming, transparency, upgrading, value chain analysis

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## Geographical Indications in Brazil: Possibilities for Small Farmers in the APA of Ibirapuita

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Agribusiness is an important sector to contribute the Brazilian trade surplus. The European Union and the United States are among the main destinations of agrofood products, taking part in 29.5 % and 13.7 % out of the exportations, respectively. The consumers, especially the Europeans, have presented themselves more demanding in what concerns farming products for human consumption, due to the nature of these products and the frequent food crisis. Thus, market segmentation based on information about the origin of the product and production process for differentiation and price attribution has become important, due to the fact that farming systems which are scale-based and linked to the production of commodities have become weakened beyond such markets. In this context, an alternative for development for certain regions is to consider regional/local specificities as factors that determine their identity, based on the concept of geographical indications. This scenario presents an opportunity for the small farmers located in the APA of Ibirapuitã. Historically, the region is linked to animal production, due to the fact that the natural pastures there found provide a good support for this activity, which has marked the tradition, history and culture of the Gaúcho. The natural environment, therefore, characterises certain intrinsically specific attributes for the products that are originated from it, being that an important aspect in Geographical Indications. Thus, the geographical origin system is an alternative of development through the territorial perspective. This approach allows the origin of a product and/or its production processes to be valued, and to convert them into a differentiation and value aggregation factor, besides guaranteeing the products identified according to pre-established parameters in what refers mainly to environmental, social and sanitary issues, as an alternative to the new barriers present in today's economical negotiations.

**Keywords:** Conservation areas, geographical indication, geographical origin, protected area, protected designations of origin

## **“Our Money Falls from the Tree”: A Value Chain Approach for Cashew Helps Farmers in Northern Benin Improve their Income**

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In northern Benin, cashew production is characterised by a large number of small-scale farmers with 0.5 to 2 hectares of cultivation area with diversified cropping systems. Cashew production is growing constantly in the last 15 years and raw cashew nuts are after cotton the second largest agricultural product for exportation. The cashew value chain is among the priorities of the national diversification policy since 2004. Main problems of the cashew sector in Benin are a low productivity per tree (1 to 2 kg per tree) due to a poor farm-level technical knowledge, a weak research support and limited access to extension services and other inputs. Processing of the raw nuts is still stagnating; only 3 % of the production is processed in Benin, the majority of raw cashew nuts are exported to India.

For the cooperation programme Conservation and management of natural resources (ProCGRN) cashew is one of the selected value chains with the objective to provide the rural population of the Atacora/Donga region in northern Benin a better benefit from sustainable cultivation of natural resources. Using a value chain approach (ValueLinks) on the national and regional level allowed to public and private actors in the cashew sector a participatory analysis of problems and opportunities in cashew production, processing and marketing. The programme helps farmers to increase the quality and quantity of their primary production using approved good agricultural practices. Producer groups on local and regional level are targeted to improve business linkages. Processing of cashew for the local demand and exportation is one of the opportunities especially for women to provide employment possibilities and added value in the value chain.

**Keywords:** Benin, cashew, primary production, processing, value chain approach

## Assessment of Different Value-Chain Upgrading Strategies for Litchi Farmers in Northern Upland Parts in Thailand

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Litchi cultivation is one of the most important income sources for small-scale farmers in the northern upland regions of Thailand. However, increasing productivity and trade liberalisation have led to a considerable decline of farm-gate prices that threatens the profitability of litchi cultivation. Neglect of the orchards, or cutting down litchi trees in the worse cases, are the ultimate effects. This change in litchi cultivation endangers sustainable land use and accelerates soil erosion. To avert such developments, supportive measures to find upgrading possibilities within the value chain of litchis that put the upland farmers in a more strategically advantaged position are required. Different upgrading strategies in comparison to the present situation of upland farmers are the focus of an ongoing field research in Chiang Mai province in northern Thailand. The overall objective is the assessment of different upgrading strategies to give recommendations about the most suitable alternative for upland farmers; meaning solutions that align high benefits with sustainable land use.

One upgrading strategy within the value chain is the production of higher quality litchi that can be sold to special “niche” markets rather than ordinary wholesale markets. Another strategy is upgrading production through the adoption of further activities in the value chain, in particular the case of litchi drying. Necessary equipment for the drying is foremost a drying oven, fuelled by either gas or wood. The intention of litchi drying directly by the farmers is a decoupling of the volatile fresh market and a takeover of an activity that offers additional benefits. It is believed both strategies can increase and sustain net-profits of upland farmers.

To assess these strategies, different value chains for fresh as well as dried litchis were analysed, including value chains with a focus either on exports or local markets. The analysis followed the value-chain-analysis approach where special attention is paid to organisational structures and contract type. The economic evaluation of different upgrading strategies was done by a cost-benefit analysis, with a special focus on investment and processing costs. Based on a strength- and weakness analysis of the present situation of upland farmers, adoption possibilities are critically discussed.

**Keywords:** Cost benefit analysis, litchi production, litchi drying, litchi oven, small-farmer-contracts, upgrading strategy, upland farmer, value chain analysis

## Effect of Contract Farming on Smallholders in Northwestern Viet Nam: The Case of Tea Production

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This study examines the effect of tea production on living standard of smallholders in northwestern Viet Nam. It is applied empirical analyses which focus on tea farming in northwestern Viet Nam and provide some of the most detailed information available on growers' returns and costs of tea production, and their livelihood. Here the tea production under different contractual schemes is considered as a tool for rural development and evaluated as a part of the whole livelihood and farming system.

The first objective of this study is to analyse the efficiency and comparative advantage of tea production under different contractual schemes of smallholders with state-owned, cooperative or private, and joint-venture tea processing companies. For this purpose the descriptive analyses have been conducted in order to generate a clear picture of the different marketing channels and contractual arrangements existing in the research area. In the course of the analysis several determinants of participation among different contracts could be identified. In addition, the efficiency analysis of existing different marketing channel has been evaluated in terms of production costs which competitive price is taken into account.

The second objective of this research is to investigate the importance of income from tea production by smallholder farmers to overall income and livelihoods. For this purpose the relative poverty status of the households has been estimated by aggregating living standard data using the verified approach. These results were then applied to compare the incidence of poverty among different contract groups. Moreover, the relation between the incidence of poor in the different production schemes and the socio economic characteristic of its participants is assessed in order to provide the information about necessary and sufficient condition between living standards of growers and participating specific marketing channel.

**Keywords:** Contract farming, efficiency analysis, relative poverty, tea production, Viet Nam



# Agricultural markets, transaction costs and rural finance

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## **Challenges and Opportunities for Market-Oriented Apiculture Development: The Case of Ada'A-Liben District, Ethiopia**

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Beekeeping has been practised in Ethiopia for centuries and currently the country is a leader in Africa in terms of volumes of honey and beeswax produced and traded. Ethiopia produces between 24,600 and 43,000 tonnes of honey per year, and is also one of the five biggest wax exporters with an average annual export estimated at 3,000 tonnes. In spite of the huge potential of the sector, production and productivity have been low due to poor quality beehives, lack of good bee management system, low quality of hive products and lack of skills by beekeepers. The objective of this study was to characterise the current beekeeping system, identify the constraints and provide solutions through the introduction of improved and market-oriented beekeeping practice using the value chain approach in Ada'a-Liben district as a case study site. Systematic and step-wise approaches were employed to assess the production system and implement the interventions. Interventions included improvements in production system, market assessment and institutional linkages between producers and stakeholders. The main activities were identification of pilot intervention sites, beekeepers mobilisation and group formation, capacity building through visits and training and constant demonstration and follow ups, as well as linking beekeepers to credit facilities and markets. During the last two years of the study (2005–07), 60 beekeepers received training, 4 beekeepers associations were formed in Yerer, Godino, Denkaka, and Adulala rural Kebeles and received certificates. During this time about 40 transitional hives (Kenyan top-bar) and 80 wooden framed hives (Langstroth) were introduced. In general, improvement in the management of apiary has been observed and the quantity and quality of honey produced have improved. This paper provides highlights of strengths and constraints of apiculture in Ethiopia and describes apiculture development potential and interventions done to improve the existing production system in Ada'a-Liben district. It presents the intervention strategies and the lessons learned in knowledge sharing, capacity building, market linkage, and beekeepers group formation for better production technologies, input supply, and marketing and credit facilitation. It also provides valuable information for scaling up of the lessons to other areas with similar potential for apiculture development.

**Keywords:** Beekeeping, Ethiopia, market-oriented, marketing, production

## **Transaction Costs and Banana Marketing in Southern Ethiopia: Implication for Enhancing Farm Income**

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A shift from traditional crop production to high value crops is considered as an important and alternative option in increasing smallholders' income and boosting rural development. Since high value agricultural products have higher market values than traditional ones such a shift is a recommended strategy in achieving development objectives. Smallholders in the southern Ethiopia region produce about half of the national fruit production. The production of fruits by small holders in the major producing areas is predominantly traditional. Market and institutional problems like high transaction costs, poor roads, and information asymmetry and market imperfections are detrimental for smallholders' market integration. High transaction costs, particularly, are major obstacles for smallholder market integration. Transaction costs in the form of information and search, bargaining and negotiation, as well as monitoring and enforcement costs are likely to influence smallholders' marketing behaviour. This study hypothesises that the level of income generated from banana sales in the Chamo-Abaya irrigated banana livelihood zone in southern Ethiopia is influenced by transaction costs. Regression analysis shows that the depth of marketing is significantly influenced by transaction costs. Transaction costs are mainly related to ownership of means of transport, access to communication, and access to main road. Membership in a cooperative, as a major institutional factor, also influences the depth of marketing. Results from a block-recursive regression analysis show that the level of income generated from selling banana is determined by the depth of marketing, the size of allocated land for banana and investment on farm inputs. The implication of the finding is that households with lower transaction costs, sizeable allocated land and adequate investment on farm inputs are expected to generate higher income from banana. Hence, investment in public goods such as roads, telecommunications and appropriate institutions, as well as farmer support services in terms of input supply and marketing information, may enhance farm income by and in turn improve the livelihood of the rural poor.

**Keywords:** Market integration, banana, Ethiopia, farm income, marketing, transaction costs

## **Social Performance Measurement of Rural Microfinance Institutions: Theory and Empirical Measurement**

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The rural microfinance industry has made great progress in financial performance measurement and evaluation in the past years. Now, there is increasing interest in developing a social performance measurement tool with common set of key indicators to go hand in hand with the financial performance indicators. The industry is moving from a predominant emphasis on financial sustainability to a renewed concern with social performance and the ‘double bottom line’.

The paper works on the premise that it is necessary to judge the performance of rural microfinance institutions (MFIs) in both social as well as financial terms. It attempts to create a framework for social performance measurement compatible with existing audit and management information system of a MFI by which management, donors and investors can assess the double bottom line approach of the institution.

The paper undertakes three stages: (1) existing literature is reviewed to examine the theory and concept of social performance; (2) selected ongoing social performance measurement initiatives is evaluated in terms of applicability across the industry, a MFI’s capacity, and stakeholders interest; and (3) empirical data from AMK (Angkor Microfinance) in Cambodia is analysed to draw on a practical measurement system for social performance.

Among others, measurement of social performance will: (1) help rural MFIs assess whether their products are adapted to client’s needs and whether the institution is contributing to increase the social situation of its clients; (2) encourage organisations to be more mindful of accomplishing their stated social mission and objectives especially now that more and more MFIs are transforming into banks; (3) allow rural MFIs to demonstrate social performance and transparency leading to donors and investors reallocation of funds towards socially-oriented MFIs; and (4) assist donors and investors of microfinance in making decisions about which institutions still need subsidies.

**Keywords:** Microfinance, social performance measurement

## Cashew Nut Almonds: Nutritional and Market Aspects

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Having the Brazilian Northeast as its origin, cashew trees (*Anacardium occidentale* L.) are being grown in tropical areas of Asia, Africa and America since several decades, for different purposes, considering its flower, fruit, timber and peel. From its fruits, the cashew nut almond is being largely used in human nutrition due to its favourable composition. This study presents information related to the composition in different fatty acids of cashew nuts almonds, and the human daily intake needs of those components and the contribution of cashew nuts almonds in its supply, as well as an analysis of its production and world exports during the last 20 years. The statistical analysis evidenced a disadvantage of Brazilian cashew nut almonds in the world market. As third world exporter of cashew nuts almonds, Brazil had a growth rate of 3.32 % ( $\pm 0.85$  %) in its exports while its main competitors Viet Nam and India, who were the first and second world exporter of cashew nut almonds, had export growth rates of 6.47 % ( $\pm 0.55$  %) and 12.35 % ( $\pm 2.91$  %), respectively. Considering the production amount, again Brazil is disadvantaged, with a growth rate of cashew nut production of 2.99 % ( $\pm 1.47$  %), while Viet Nam's and India's growth rate reached 12.25 % ( $\pm 1.33$  %) and 3.98 % ( $\pm 0.39$  %), in the same order. In Brazil, the commercialisation of cashew nuts (almonds and cashew nuts) is geographically and numerically dispersed. Additionally, the dispersed production of cashew nuts, the high concentration by middlemen and buyers at Brazilian processors and their traditionalism in keeping this market structures, partly explain the high commercialisation margins obtained by the actors. High commercialisation margins of middlemen in cashew nut market limit profitability to farmers as well as the high commercialisation margins at the cashew nut almonds level limit the profitability to cashew nut processors.

**Keywords:** Cashew nuts almonds, commercialisation, human nutrition, production

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## Brazil Nut Almonds: Nutritional and Market Aspects

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This paper presents information related to the composition of different fatty acids from brazil nut almonds and the human daily intake needs, as well as an analysis of its production, its growth rate during the last 20 years and its export. and the human daily intake needs. Having the Amazon Biome as its origin, brazil nut trees (*Bertholletia excelsa* H.B.K.) occur in several South American countries, like Brazil, Venezuela, Colombia, Peru, Bolivia and Guyana. The brazil nut trees provide food and timber. Its nuts contain 10 to 25 almonds each, which are used as food mainly in the Amazon region, but are also appreciated around the globe. Its timber is of high value for civil construction as well as for ship construction. The fruit of brazil nut contains high amounts of calories and protein. Additionally, it contains selenium that reduces free radicals, and many studies recommend it for cancer prevention. It is highly consumed by local population *in natura*, toasted, or in flours, sweets and ice creams. The shell of the brazil nut is very hard and its extraction requires high amount of energy. This nut is of economic importance for most states of the Brazilian Amazon, as 60% of the total production is exported *in natura* to Europe, Japan and the United States. Domestic consumption is limited to 5% of production. The statistical analysis evidenced a disadvantage of Brazil in the world market. As second world exporter of brazil nut almonds, Brazil has a negative annual growth rate of its exports (-6.01 %) while its main competitor Bolivia, who is the first world exporter of brazil nut almonds, has an export growth rate of 8.72 %. Considering production, again Brazil is disadvantaged, with a negative annual growth rate of brazil nuts production (-1.28 %), while Bolivia's annual growth rate reaches 5.10 %.

**Keywords:** Brazil nut almonds, commercialisation, human nutrition, nut production

## **Determination of the Potential of Micro-Financial Services in the Rural Community Kuito, Bié Province (Angola)**

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Microfinance was recognised as an effective poverty alleviation tool in many regions of the developing world. This study evaluates the potential of micro-financial service, their providers and demand for these specific financial products in the Bié province (namely community Kuito), an area of Angola that was mostly affected by the civil war. The survey was held under the patronage of the development project "Centre of Agricultural Education in Bié Province" (Angola) from the Institute of Tropics and Subtropics of the Czech University of Life Sciences Prague. In this physically and socially damaged area, several development organisations (Oxfam, Care, Concern, etc.) intervene in order to improve living conditions and empower women as well as to integrate the work of veterans. The primary data collection was carried out by co-operation with these organisations by interviews and questionnaires handed out among their co-workers and among selected households of community Kuito. The results clearly show evidence of strong need for stable input market, technical support, and consultancy for local farmers/entrepreneurs. From this point of view it is not the short money supply the only constraining factor of rural development. It also analyses the current status of organisations working in target area, their ability to provide these requested financial services and discusses their influence on the product or money market formation which is the prerequisite for stable income generation. Recommendation derived from the study suggests that it would be highly advisable to intensify the co-operation among organisations working in target area, local authorities' representatives and organisations providing foreign developing projects. Based on primary data, personal observing and qualitative interviews, this study evaluates the community Kuito as well as the Bié province has still not overcome problems caused by war and does not use its potential on such level which would attach the steady income generation throughout the year for all groups of local population.

**Keywords:** Angola, co-operation, income generation, microfinance

## **The Access of Microenterprises to Commercial Microcredit in Aceh Besar: Closing the Gaps**

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Access to credit has been a major instrument to promote microenterprises in Indonesia. However, many factors influence access to credit like education, gender, age, formal financial services and collateral. Poor women have not the same access to credit as men in many traditional societies. Moreover, formal financial sector has not been able to meet the demand for financial services by poor rural households because access to banking services is restricted in rural areas. Many studies proved that poor rural households have no collateral to offer against loans. Studies also stated that age of micro-entrepreneurs and education influence access to credit and share of income of microenterprises in their total household incomes.

This research aims to quantify the gap between the number of micro-entrepreneurs being assisted and the overall number who might need assistance, and to determine the effects of education, distance to microfinance institutions, age, gender, and ownership of standard collateral, on the accessibility of microcredit in research area.

A survey was conducted in 100 randomly selected micro-entrepreneurs living in Aceh Besar, Nanggroe Aceh Darussalam Province, Indonesia, by using formal questionnaires.

The result shows that only 10 % of microenterprises have already participated for borrowing from commercial microfinance institutions in research area. However 60 % of the microenterprises have an access to microcredit. Access to credit is significantly different between owners aged 25–34 years and owners aged 35–44 years. Other significant factors are the time needed to reach the Bank and the ability to provide collateral. Regression analysis will be used for further analysis.

**Keywords:** Access, credit commercial, micro-entrepreneur, microcredit

## Policy Changes for a Better Access to Credit for the Rural Poor in Viet Nam: From Theory to Practice

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Credit, especially micro-finance, is well known by scholars as one significant instrument for poverty alleviation in rural areas. In Viet Nam, an economic reform towards market-orientation since 1986 has helped to decrease the incidence of poverty but progress remains limited.

Research has shown that a shortage of credit has been a major constraint to the augmentation of economic activities of the rural poor and improvements in their living conditions in general. In mountainous regions of northwestern Viet Nam, where the incidence of poverty is particularly high, credit for rural development has mainly been provided by Viet Nam Bank for Agriculture and Rural Development (VBARD) and Viet Nam Bank for Social Policies (VBSP). These two state-owned banks have adopted far-reaching changes in their credit policies to enhance the access to formal financial services for the rural poor. However, so far there is a lack of understanding of the credit demand by rural clients in mountainous regions of Vietnam and the factors determining their access to credit. Moreover, it is unclear whether the financial products offered by VBARD and VBSP actually reach the rural poor, and whether they are used for investment activities or consumption purposes.

Against this background, the objectives of this paper are twofold: First, the policy changes in credit regulations for rural development since the reform period are explored, especially from the time of banking reconstruction towards market-orientation. Second, based on data collected in a random sample of 300 households in Yen Chau district, Son La province, the paper investigates demand for credit, credit worthiness, and determinants of households' access to formal credit using regression analysis. Apart from households' resource endowment also intangible assets such as social capital are considered as potential influencing factors.

We hypothesise that (1) credit policies, especially those particularly designed for the poor, are not targeted to the poorest of the poor, which means that ethnic minorities are often excluded from the preferable credit scheme; (2) the demand for consumption credit is not effectively met. Based on our findings we will derive recommendations regarding an improved design of credit products for rural clients in mountainous areas of Viet Nam.

**Keywords:** Credit demand and supply, micro-finance, rural credit, Viet Nam

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## **Market Participation of Small Scale Crop Farmers under Transaction Cost: Evidence from the Free State Province of South Africa**

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The paper analyses the factors determining the decision to participate in crop market and level of commercialisation of South African small scale farmers with a particular emphasis on transaction costs. Transaction cost differs among households due to asymmetries in access to assets, market information, extension services and remunerative markets. To achieve this objective an Agricultural Household Model incorporating transaction costs is designed and based on an Agricultural Household Survey that was collected from 200 households in all five districts of Free State province, namely Motheo, Lejweleputswa, Thabo mofutsanyana, Xhariep and Northern Free State, a Heckman selectivity procedure is employed. The results support previous studies that existence of transaction costs constrains households from selling. The result suggests that having a good road condition (access) and an increase in the arable land by a hectare will lead to an increase in crop sells by R<sup>3</sup>861 and R55 respectively. However, sells would decrease by about R997 for every additional household member in the household. The result also suggests an increase in off farm income by R1 and extension visits by 1 day lead to increase sales by R6 and R<sup>2</sup>3 respectively. The other positive factors include household education, ownership of vehicle or tractor and being a female farmer. The ownership of livestock, distance to nearest town and age were negative but only ownership of livestock was found to be significant in terms of influencing participation in crop markets. The study recommends the need for policy and institutions to support access to productive assets (such as land), markets and better infrastructure.

**Keywords:** South Africa, small scale crop farming, transaction costs

## **Lack of Liquidity and Financing Possibilities for Agricultural Family Farms in Azerbaijan: The Example of Mountain Grazing Systems in the Region of Gandja-Gasach**

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The structure of farms in Azerbaijan was extremely changed after the privatisation of land. The so long dominating state-owned big farms were replaced by small family farms. This development had sustainable effects on the production and also on the possibilities of financing farming.

The presented article aims to survey in an empirical analysis mountain grazing systems in the region of Gandja-Gasach with a particular focus on analysis of lack of liquidity and financial possibilities of these farms. The farms are typical family farms, which hire additional labour in form of herdsman. for their mountain grazing systems. They do own only little agricultural crop land and use the possibility to rent land in from the state. They use the land to practice the for them typical sheep and dairy production.

About 50 family farms were selected by chance and the respective family members were interviewed using standardised questionnaires to secure a representative analysis. The main objective of this work was to determine the financial and liquidity situation of these agricultural farms by using primary data.

Liquidity problems do exist particularly in the period of the purchase of feed and in the period of animal migration from winter to summer pasture as the analysis showed. Foreign capital is needed, since the own means of financing are short. The empirical analysis showed, that the access to formal credits is bad for the surveyed farms

High interest rates and additional costs for the application and documentation of credits are seen as major reasons for this situation. Banks and credit institutes do not provide higher credit amounts to the farms since securities and trust in the farm people is missing or they do ask for serious higher interest rates.

Therefore informal creditors do play a dominant role for providing credits to the farms. Informal creditors are relatives and friends, who do provide capital mostly for short periods and without interest. Credit users do thank the creditors by giving of natural means. Transition costs of these financing forms are very little, which will shown in the article.

The articles works out the importance of the informal credit sector for the family farms and gives hints on the need to further improve and strengthen the formal credit sector.

**Keywords:** Azerbaijan, farm families, liquidity, mountain grazing systems

# Resource allocation and household welfare

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## **Impact Assessment of Maskana Irrigation Project on Economic Situation of Farming Families in Northern Syria**

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Syria, like many countries in the Near East is characterised by a high population growth rate. This has led to increased demand for agricultural products. Farmers in Northern Syria compete for the scarce water resources. To increase agricultural production in this region, there is a need to increase water availability through improvement and expansion of irrigation. As a result, living standards of the target groups will be expected to improve.

The Maskana Irrigation Project in northern Syria was initiated in 1990. Many feasibility studies have been done aiming at extending the project to other areas. This paper focuses on development of future strategies that could improve the impact of the project on living standards of the farming families. These strategies were established based on problems identified by farmers during the survey and also from findings of previous analysis of the farming systems in the project area. Impact analysis of these strategies was done through simulation with static models at family level based on linear programming.

Testing and simulation of the strategies established the importance of vegetables production in improving farm and family income. The size of the herd also indicated an impact on family income. Results also indicated that with improved water availability, farm income would increase by more than 100 %. Implementation of the irrigation would lead to full utilisation of the available and underutilised production units such as capital and family labour in farming activities. Due to water scarcity, the farmers had actually diverted these inputs to off-farm activities. However, investment in increased water availability had a significantly positive impact on farm income up to a certain level of the cultivated land after which the impact was negative.

**Keywords:** development strategies, Syria, water scarcity

## **Implication of Migration for Family Welfare and Rural Development in East Java, Indonesia**

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Migration is a reaction to economic imbalances and decision making involves a negotiation of preferences, interests and alternative strategies. In Indonesia, international out migration flows still continue to increase in the future due to limited job opportunity. Whereas rural to urban migration provides a strategy for rural households to allocate their labour resources among areas to reduce risk and increase their income. This paper aims to identify and analyse the impact of rural to urban and international migration for family welfare and rural development in Malang Regency, East Java Province. It helps to identify factors which are essentially for design of policies and programs aiming to promote rural development.

The development of villages in Indonesia aimed at improving community welfare and decreasing the number of poor households. The main problem is to cope with the splitting of development into various sectors. In many cases, the development in land exploitation overlaps with other claims and interests.

In micro analysis, respondents spent the biggest part of the remittance to buy land, motorcycle, or to build house so that the share for educational expense tend to be small. Econometric result also shows the effectiveness of government's policy; those who received the government's aid tend to have big share on basic needs. Family who possessed a quite large land had problems with water because they lived located in a high place that clean water and well were difficult to find.

In macro analysis, the large number of schools had no effects to the elimination of poverty; it brought negative influence instead. A short-term subsidy from government that was given to each school had not been successful in lifting the people from poverty. The poor also had no access to the credit yet since the credit seems only given to those who would able to pay. The results shows the village's big dependency on the government. The development of village, which aims to the improvement of growth by increasing capital and social access, would lower the chance of migration.

**Keywords:** Family welfare, Indonesia, migration, rural development

## **Emigration of Labour Resources and its Impact on Farm Families: The Case in the Mid Hills of Nepal**

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With increasing economic liberalisation and globalisation the mobility of human beings have increased many fold. The number of people living outside their country of birth increased from 75 million in 1960 to 191 million in 2005 (of which over 86 million are migrant workers). In Nepal, in 2003–04, about 15 % of economically active male and 2 % females were involved in work migration. Migration has significant developmental impacts both on sending as well as receiving countries. For the sending countries, the positive impact is in the form of remittances. The major negative impact is the loss of labour resource. As per International Monetary Fund, the remittances received by the developing countries have surpassed the total developmental aid, which indicates the growing importance of remittances on development. In the year 2006, the total remittance received in Nepal was about US\$ 1.5 billion (about 18 % of the total GDP).

Nepal is an agricultural country with the contribution of 39 percent to the national GDP. However, the agriculture sector performance is determined by limited resources and constrained by structural weaknesses. In such a situation, the cash that rural agricultural households receive in form of remittance is of great significance not only for meeting household needs but also as investment.

To analyse the determinants of migration and its impact, a total of about 500 households were surveyed using a semi-structured questionnaire. Apart from household survey, the study also uses group discussion, key informant interview and secondary data sources. The study is conducted in two hill districts of Nepal and is focused on two major streams of international migration - namely, cross border migration to India and other countries.

The major destination of migrants is India but this portfolio is widening and Gulf countries are gaining popularity. The main reason for the increased migration is lack of sufficient opportunity in the country to meet the basic food and non food requirements of the households. Therefore, migration is perceived to have improved the household livelihood situation. The paper presents the major factors influencing migration decision and the impact of migration on farm families in the mid hills of Nepal.

**Keywords:** Farm families, labour-migration, Nepal, remittances

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## Income Composition and the Perception of Income Fluctuation in Rural Households: Evidence from Thailand and Viet Nam

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The concept of vulnerability to poverty continues to gain attention among researchers and practitioners of development because it better captures the dynamics and complexity of poverty as compared to the FGT (Foster-Greer-Thorbecke)-type poverty indicators. However measurement of vulnerability remains an issue because of the problem to choose appropriate vulnerability indicators the need for longitudinal datasets. In a DFG sponsored research unit (DFG 756) a comprehensive household survey drawing a representative sample of rural households in three provinces in Thailand and Viet Nam was conducted in 2007. A second survey wave that is presently underway to complete a panel data set for about 4,400 households, will establish a database suitable for advancing the vulnerability concept.

In this paper we investigate the composition of the household income aggregate. Comparison of total household and per capita income estimates to existing survey data like the Thailand household socioeconomic survey yields very close correspondence for Thailand and a reasonable correspondence for a more dated wave of the Viet Nam Household Living Standards Survey. While average household size does not differ very much between the two countries, incomes are more diversified in Thailand with a mean Simpson index of 0.53 and 0.48 for Viet Nam. The contribution of agriculture to total household income is only between 20–26 % in all provinces except for the province of Dak Lak, where coffee-production drives the agricultural income share above 45 %. On average of the three provinces in Thailand, remittances take a share of 13–19 %. In Nakhon Phanom, a province with relatively low per capita income, remittances are the 2nd largest contributor to household income. Subjective assessment of income fluctuation was obtained from the perception of the respondents on an ordinal scale. Interestingly perceived income fluctuation does not correspond closely with the income diversity indicator based on cross sectional data.

**Keywords:** Income diversity, rural livelihoods, Thailand, Viet Nam, vulnerability to poverty

## Understanding Vulnerability to Poverty of Rural Agricultural Households in Northeastern Thailand

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Vulnerable households are not only those who are currently poor, but also those who are exposed to risks to become poor in the future. Rural agricultural households are perceived as being exceptionally vulnerable due to limited ability to cope with shocks and higher risks triggered by susceptible agricultural sector but it can also provide possibilities to mitigate and cope with risks and shocks from other sectors. Understanding the decisive characteristics of rural agricultural households provides a better insight to property and more efficient poverty reduction. To deal with this problem, 970 households were interviewed in 2007 in Ubon Ratchathani in Northeastern Thailand. 90 % households surveyed engage in some form of own-agricultural activity. Particularly, about 6 % of the households surveyed depend solely on cropping and livestock production with support from remittances and public transfers, whereas 84 % of the households undertake on-farm activities simultaneously with off-farm, and/or non-farm activities, hence being seemingly better prepared to prevent vulnerability to poverty due to more diversified occupation. However, roughly 30 % of all agricultural households currently fall under the provincial poverty line and another 30 % earn less than twice the provincial poverty line. Therefore, about one third of agricultural households in the province are already caught under poverty and another substantial one third is subject to downside risk of slipping into poverty should an unexpected shock occur. For that matter, 70 % of agricultural households experienced at least one shock during the previous 5 years. The most common covariate shocks are flood and drought as well as idiosyncratic shocks of illness and death of household members. Regarding production area, half of the agricultural households engage primarily in cropping whereas the other half also raises livestock for commercial purposes. Approximately 60 % of agricultural households report agriculture as main occupation of at least 60 % of their active members. To construct a basis for behaviour modelling of rural agricultural households regarding effects of shocks and coping strategies, income, main production area and occupation are taken as criterion and 8 typical farm types are identified. Statistical tests show significant differences in household size, yield, subsistence and commercial production and land allocation.

**Keywords:** Household analysis, Thailand, vulnerability to poverty

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# Food security, food prices and institutional analysis tools

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## Current Regional Trends in Vietnamese Economic Relations

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The case of Vietnamese economy is rather specific, being a developing country of South East Asia that only recently joined WTO and is still high on the UNDP agenda. After 20 years of economic transition and institutional reforms it still struggles to acquire fully accepted status of a market economy. Well aware of its comparative advantages such as great natural resources and an abundant and inexpensive workforce, Viet Nam has been exploiting these to raise its exports, which generate an increasing flow of foreign income for economic growth and industrialisation. Over the past 20 years Viet Nam's export growth has averaged 20%. From around half a million \$ before the introduction of the Doi Moi policy, the total export volume of Vietnam reached \$44 billion in 2006.

With the "open door policy" starting in 1986 Viet Nam focused on "multilateralisation and diversification" of its international relations. In late 80's, Viet Nam had trade relations with 40 partners only. Since then Viet Nam has signed multilateral and bilateral trade agreements with over 80 nations. The country has been granted MFN status by more than 70 countries and territories, including countries and regions with large capital resources, markets and high technologies, such as the U.S., Japan, the EU and newly industrialised countries in East Asia. Viet Nam integrated in the regional ASEAN in 1995 and its AFTA zone and joined APEC in 1998. The SRV became member of WTO in 2007, which is a major step in cementing Viet Nam's economic transformation and integration into the world economy.

The international trade data show that each of the BTA's or regional agreements boosted Viet Nam's trade with the particular country or region, but not at the expense of already established trade flows. The trade increase often occurred right after signature of the agreement before actual implementation of trade liberalisation. It is possible to conclude that the regional integration of Viet Nam through trade and investment increase within the AFTA will continue. At the same time the transpacific link towards the U.S. will most likely further intensify and the above-standard relationships with the EU can be expected to keep at the pace.

**Keywords:** Integration, international trade, regionalisation, Viet Nam

## **The Role of Women in Rural Development Programs: The Case of Kecamatan Development Program in Indonesia**

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It has been widely accepted that rural poverty in Indonesia is caused by a low accessibility of capital. This low accessibility of capital is caused by a low rate of saving, and the low rate of saving is caused by a low income that could be generated by rural population. This phenomenon is called the theory of vicious circle of poverty. To cut the vicious circle, the government of Indonesia has been implemented a rural development program called Kecamatan Development Program (KDP). The programme offers revolving funds to be accessed competitively by a group of poor villagers. To gain the fund, villagers must organise themselves into groups. There are two kinds of group: Productive Economic Units (PEUs) that are membered mostly by men and Woman Micro Credits (WMCs).

It is found that KDP, implemented in East Java Province in Indonesia, has hit the targets, which are poor villages. The target precision is measured from physical condition of respondent house, which is strongly related to the respondent income. It means that the more lower the respondent income, the more badly their house condition. At micro level, KDP through its micro credit enables to create average additional income 10 % per year for its borrower.

This study observes a success of woman group (WMC) in making use of micro credit, and there is a strong Spearman relationship between frequency of the group meeting and the group default in credit. In the culture of rural society, especially in Indonesia, many women are strongly demanded to take care of their domestic problems, so that they feel expensive to leave their house (let alone their village) for a long time. This role enables rural women to interact each other intensively within their group, so that social coordination within them could be realised. For a rural woman with debt, running away from her group is more expensive than thinking seriously to pay her debt to her group.

**Keywords:** Rural development, women

## Impact of Land Reform Policy on Crop Production of Farm Households in the Northern Uplands of Viet Nam

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Poverty is recognised as a critical development problem and has been given highest priority on the international development agenda. Besides adverse climatic conditions and political instability, many rural people suffer from hunger simply because they are landless or, do not hold secure tenure. Therefore, there is a widespread belief that land reform is an important key to development, which could contribute to overcome poverty. Viet Nam conducted its land reform in the beginning of 1990s, including privatising farm land and legalising land market. However, at the micro level, lack of households' data has prevented empirical analysis on its impact on crop production on the one hand; its timely implementation is also a barrier to take such a needed analysis on the other.

The study focuses on farm households with the data collected in the northern Uplands, one of the poorest regions of Viet Nam in 1993, 1998, and 2006. Multiple econometric regression models for panel data were used to estimate the determinants of inputs and outputs of crop production of farm households. Because many households have more than one plot of land, and because most grow several crops simultaneously on a given plot, the analysis pertains to the aggregate volume of various inputs used by the households and to the aggregate volume of agricultural outputs produced. The implicit assumption is that each household uses the resources at its disposal optimally, so comparison of aggregate input and output volume over years across households are valid.

Results of empirical analysis show, that the land reform has positive effects, in terms of both land privatisation and land titling, on quantity of inputs used and outputs produced. The paper thus concludes that the land reform has a critical impact on crop production at household level. This could be used to explain the reduction of poverty rate in Viet Nam in the last decades and the change of Viet Nam from a net importer to a net exporter of food. However, further improvements of land rights are needed to promote crop production and land transaction among land users.

**Keywords:** Crop production, input, land reform, land transaction, output, panel data

## **Negotiation Support Tools: Linking Science and Policy**

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Presently, agriculture is facing new challenges in dealing with its mandate to maintain food security in a sustainable way and being able to adapt to changes of environmental conditions. The complex nature of agro-ecosystems with its broad range of sustainability issues related to policy interventions and technological innovations requires a dynamic and efficient approach to assess the various options to manage the landscape. Envisioning tools, such as simulation models in combination with scenario analysis, have been promoted and used to assess such complex interactions. Compared to traditional experimentation, use of adequate simulation models is cost effective and more efficient, at the same time enables exploration of fast dynamic changes and challenges. Models however, need to be adapted for their purpose in terms of scope, precision, data requirements and end user.

“Trees in multi-Use Landscapes in Southeast Asia (TUL-SEA): A negotiation support toolbox for Integrated Natural Resource Management’ is a project that aims to promote and equip local resource managers with cost-effective, replicable tools and approaches to appraise the likely impacts of new technologies and changes in market access on multi-use landscapes. The outcome of such an appraisal is important to support evidence-based negotiations of contentious issues (water conflicts, land use intensification, etc). The project, funded by BMZ/GTZ, runs in six countries of South-east Asia: China, Indonesia, Laos, Philippines, Thailand and Viet Nam. Within this project, a study is being carried out to appraise the use of simulation models by local resource managers and policy makers. The study particularly paid attention to their perceptions of simulation models, its results and its recommendations in terms of its salience, credibility and legitimacy. Results of a survey carried out in three countries and a methodological approach to quantify local resource managers’ and policy makers’ acceptance of simulation models will be discussed, and recommendations developed how the improve and increase acceptability and use of such negotiation support tools.

**Keywords:** Model acceptance, negotiation support tools, scenario analysis, simulation model

## Food Price Effects on the Food Consumption in Urban Areas: Case of Benin

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The recent worldwide increase of food prices is likely to deeply affect West African countries, particularly those that are importers of staple foods such as wheat or rice. In Benin, for instance, prices for rice increased by 50 percents between 2007 and April 2008, for maize by 67 percents, and milk powder by 22 percents. This article examines the consequences of the price increases for consumption and calorie intake by households in urban areas of Benin. In particular, it deals with the food substitution induced by the rise of food prices per household. The study focuses on urban areas as they are more exposed to price changes of tradable commodities.

The analysis is going to be based on a survey on food consumption that has been carried out in 2008. The study will enumerate the extent of price effects on food consumption patterns regarding quantity, origin and quality. Quantities consumed will be aggregated to the calorie intake per household and individual while. As to the origin of food, we will distinguish between imported and domestic food. The quality aspect will be addressed by the type of food consumed such as meat, vegetables, legumes, cereals, oil which have different energy and protein contents. The following hypotheses will be tested:

- Rising food prices lead to significant reductions in the consumption of individual food items.
- Rising food prices reduce the consumption of imported staple foods.
- Imported food will be substituted by domestic food.
- Consumption will shift from meat consumption to cheaper staple foods.
- Overall calorie intake will be reduced.

Beyond these analyses, measures taken by official actors and donors to tackle the food shortages will be discussed.

**Keywords:** Benin, calories intake, food consumption, food prices, food substitution

## **Inter-Village Differences in Formal and Informal Institutions Governing Access to Land and Natural Resources in Central Sulawesi (Indonesia)**

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Of high conservation interest are the mountain forests of the Indonesian province of Central Sulawesi that include conservation core areas of the global Wallacea biodiversity 'hotspot'. The investigation was prompted by the observation that deforestation rates appeared to differ more strongly between villages around Central Sulawesi's Lore Lindu National Park (LLNP) than could be explained by differences in the individual characteristics of the village households as assessed by quantitative village censuses. Our results are abstracted from 3\*10 semi-structured, qualitative interviews with key informants from the leading groups of autochthonous and migrant households.

Village A is characterised by powerful local institutions, mainly controlled by the Council of Traditional Leaders (Lembaga Adat). The council is responsible for land allocation in the community forest which is completely located inside LLNP. The formal village leadership had successfully negotiated "traditional" - i.e. restrictive - use rights from the LLNP administration for the community forest. The Lembaga Adat grants permissions for the extraction of timber and NTFP such as rattan. Immigration by members of other ethnic groups is strictly discouraged, e.g. by restricting land purchases.

In migration dominated village C, Buginese from South Sulawesi are, on average, substantially more prosperous than the autochthonous households mainly due to more effective cacao cropping. Autochthonous as well as Buginese interviewees agree that a widespread laissez-faire attitude on natural resource use prevails. Each household is regarded as responsible for itself. Virtually without institutional restrictions, Buginese migrants as well as some better-off local households acquire land via purchase from poorer, local households. The land-stripped local households, in turn, acquire new land by - technically illegal - clearing of primary forest inside LLNP.

Village B is to some degree similar to village A. The Lembaga Adat regulates access to the community forest (here: outside LLNP) which is granted only to autochthonous households. In contrast to village A, land transactions are not restricted, however. Therefore, similarly to village C, Buginese migrants and better-off local households tend to acquire land via purchase from poorer, local households. Groups of autochthonous, partly land-stripped households prepare new agricultural land via conversion of uphill community forest.

**Keywords:** Deforestation, Indonesia, migration, open access resources, qualitative analysis, village institutions

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# Economic development and policy: case studies and others

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## **Socio-Economic and Cultural Aspects Affecting the Nutrition of Children under Age of Five in the Rural Area of Sudan**

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In Sudan, more than 60 % of the population live in rural areas lacking the basic services and over-burdened by poverty particularly woman and children. This study was carried out in three villages of Al-Fau rural area. The community mainly consists of farmers of semi-nomadic nature who own different sizes of herds and agricultural land; they are the farmers of the Arabic pedigree. The rest of the community are workers from western Sudan and were brought from their original areas to enhance the nomad settlement strategy of the Sudanese government in the mid seventies. Various techniques and sampling methodologies were done to collect the relevant data about socio-economic cultural status and nutrition of children under age of five. These data gathering techniques include questionnaire, in which information was collected about socio-economic status of the family, level of education, occupation and age of parents were recorded. Income level of the family was assessed. This was done by recording the members of family and the facilities available such as refrigerator, television, telephone, transport, land holding, occupation and other sources of income. Women were asked about the social norms affecting mother and child nutritional and health status, as well as the feeding habits of the children.

The results revealed that most of the community members practice subsistence farming and the area suffers as all other rural areas from seasonality, physical weakness and sickness. It is also found that only 20 % of the children's families have their own farms, 36 % have their own livestock and 44 % have both. Moreover, it was recorded that all markets of the studied area were very poor lacking fresh vegetables and fruits with some handcrafts and other commodities, which attributed to the low purchasing power, since most of the families depend on their storage which consist of sorghum, milk and dried okra. In addition to the illiteracy (76.7 % of the mothers and 54 % of the fathers), the lack of nutritional diversity were found the main reasons for nutritional anaemia for 65.3 % of the children.

**Keywords:** Children under 5, cultural aspects, human nutrition, socio-economic analysis, Sudan, nutritional diversity

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## **Do Certification Schemes Influence the Role of Nicaraguan Women in Small-Scale Coffee Production Systems?**

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Coffee sales constitute the main income for 25 million families in East Africa, South Asia and Latin America. In mountainous regions of Guatemala, Nicaragua, southern Mexico, southern Colombia and Ecuador coffee is the most important sector. Yet, these areas remain among the least developed ones in Latin America. In Nicaragua, the second poorest country in Latin America, coffee contributes 25 % to total exports, and provides employment to 13 % of the population. Although women participate in the coffee production, they have in general little economic, social or political power in this process or in their communities. Despite intensive research on coffee production systems, little is known about the situation of women in small-scale coffee production systems in Latin America.

Our research evaluated organic and organic-fairtrade certification schemes, by looking at gender roles and impacts of certification on small-scale coffee producers. Seven cooperatives in northern Nicaragua were chosen and individual and group discussions with women and men, with and without certification, were carried out.

Results showed in general no difference between certified and conventional producer groups regarding the status, behaviour and role of women within the household and coffee production system. Also, the living conditions of women do not differ significantly between them. Irrespective of the certification, most married women do not own land because land titles are registered in the husband's name. Labour division is usually quite strict and women tend to work more hours than men. Women are afraid to speak in public, often because their educational level is very low. In combination with the burden of domestic tasks, many women are not very involved in cooperative activities and do not occupy leadership positions. In all observed cooperatives, neither women nor men usually know to whom the cooperative sells their coffee.

**Keywords:** Coffee, cooperatives, fair trade, gender, Nicaragua, organic certification

## Impact of Off-Farm Income on Nitrogen Use – Case Study Results from the North China Plain

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Income from off-farm activities plays a major role for rural households with 48 % of rural labour in China being engaged in both agricultural and non-agricultural activities. Cash income from off-farm activities and reduced family labour available for farming might affect cultivation patterns.

Therefore, this paper focuses on the impact of the income structure on the application of fertiliser based on cluster and regression analysis using data from a survey of 340 farm households in the North China Plain (NCP). To review trends in the agricultural sector in the study region over time, a data set of the Research Center for Rural Economy (RCRE), covering the period 1986–2006 for Hebei province, is analysed with descriptive methods. To validate the impact of farmer's perceptions regarding fertiliser quality on their actual fertilisation behaviour results from qualitative interviews combined with measurements of the quality of fertiliser samples are presented.

Results show that the NCP is characterised by high levels of nitrogen application and a resulting nitrogen surplus. No difference in means of nitrogen input and nitrogen balance between farms with and without off-farm income as well as between farms that have farming and those having off-farm activities as main income source is found. In addition the analysis of the RCRE data reveals that the proportion of full-time farmers is declining and the share of off-farm income rising. Farmer interviews revealed that a rising share of farms is managed by older people; because the younger generations are engaged in non-agricultural activities. During the interviews farmers indicated that they mistrust (fertiliser) sellers. This observation can be seen as another critical point according the effectiveness of the functioning of the agricultural sector in China. Future research has to focus on the effects of off-farm income on the efficiency and sustainability of Chinese farming practices, especially with respect to fertiliser. Policy makers need to be aware that a prevalence of small-scale, part-time farm structures, like in the NCP, could have negative impacts on the economic and natural resource base of Chinese Agriculture.

**Keywords:** Agrarian change, China, fertiliser use, migration policy, off-farm income, rural development

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## Evaluating the Economics of an Improved Taungya System with Teak in the Ashanti Region in Ghana

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Land use of the Ashanti Region in Ghana is characterised by traditional small-scale subsistence farming of annual crops as well as by industrial production of timber on tree plantations. However, yields of both land use practices are constantly jeopardised by the occurrence of wild fires and soil degradation due to slash-and-burn activities of local farmers.

By joint efforts the Institute for World Forestry of the Federal Research Institute for Rural Areas, Forestry and Fisheries, Hamburg, together with a Ghanaian timber plantation company and the German Foundation for Forest Conservation in Africa aim at improving the unsustainable manner of conventional land use practices. A viable approach of creating an economically and ecologically sustainable basis for mutual benefits of all stakeholders is the implementation of an adapted version of the Taungya system, the tree “outgrower” programme. Thus, seedlings of teak (*Tectona grandis*) are put at the disposal of farmers living around the plantations while necessary skills to simultaneously cultivate them with their staple crops are taught in workshops. Additionally, farmers are provided with genetically improved material of fruit trees (orange, mango, oil palm, cashew) to be grown as a “green fire belt” at the boundaries of their cultivation areas. Bearing responsibility for preparation and maintenance of the sites, farmers are granted full possession of all yields (crops, fruits, timber) which allows them to open up a perpetual source of income based on a diversified range of products. In return, the timber company has the right of first bid for the harvested wood.

One crucial pillar for a successful implementation of the tree “outgrower” programme is its economic impact. Therefore, an ongoing study will compare the costs and benefits generated by the traditional and the improved land use systems for both local people as well as timber industry. It will furthermore reveal key factors for economic returns and thereby offer opportunities to improve the efficient use of resources.

**Keywords:** Agroforestry, cost benefit analysis, Ghana, taungya, teak

## **Socio-Economic Changes in Tsunami Affected Villages in the District of Aceh Besar, Indonesia**

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An earthquake followed by Tsunami has devastated the coastal regions of Aceh, Indonesia, on the 26<sup>th</sup> of December 2004. The total damage in productive sector was estimated at USD 1.2 billion and 80 % occurred in the agricultural sector, whereas 62 % of Acehnese community worked in agricultural sector. This research aims to assess (1) the rehabilitation of infrastructure, (2) the rehabilitation of damaged land, and (3) the change in employment structure. It helps to identify success and weaknesses of the rehabilitation measures.

A village survey was conducted in 32 randomly selected villages in the district of Aceh Besar between September and December 2007. The village headmen were asked to answer questions concerning village structure, farmland management, infrastructure availability and employment before and after the Tsunami.

In the research area, the rehabilitation focused more on non-agricultural infrastructure. 59 % of the housing area and 62 % of the roads have already been reconstructed, whereas only 12 % of the paddy fields and 17 % of the upland fields have been rehabilitated. Moreover, the number of villages with a functioning irrigation system decreased from 38 % to 9 % after the Tsunami. Employment in the agricultural sector decreased from 69 % before the Tsunami to 55 % after the Tsunami. Within agricultural sector, employment in crop and fishpond farmer decreased significantly after the Tsunami while outside agriculture, employment in services and construction increased significantly. Due to the concentration of employment in agricultural sector, rehabilitation processes should focus on this sector to give a chance for agriculture community to increase their income opportunities.

**Keywords:** Agriculture, rehabilitation, tsunami

## **The Priority Vegetable Products Based on Efficiency Resource Allocation in Upland Areas of Indonesia: Designing Agriculture Policy Pattern**

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Nowadays, the integration of markets worldwide provides unparalleled opportunity for rural development and food security. Removing barriers to trade and competition opens up new markets for vegetables as main agricultural products in Indonesia. It also provides new opportunities for attracting high investment on Vegetable Farming System (VFS) into Indonesian economies. Moreover, local government agricultural policy should support the development of vegetable products which have competitiveness in the global market.

Based on above explanation this study attempts to present the priority vegetable products in order to promote vegetables as specialized, competitive and high value products. Specifically, the objectives of the study were firstly, to evaluate the current local government policy for priority vegetables and secondly, to rearrange the best priority vegetable products based on efficiency resource allocation in upland areas of Indonesia.

The priority vegetable products from the study sites is discussed with the importance of agro-ecological zone in achieving efficiency resource allocation, economic scale, government policy and sustainability with holistic and integrated conditions as defined by the Analytic Hierarchy Process (AHP). Determination of priority vegetables product were carried out at certain potential areas based on the production history as well as potential development.

Related with the analysis of priority vegetable products prepared by the local governments, the selected vegetables in each area were as follows: potatoes, cabbages and tomatoes in Pangalengan; potatoes, cabbages and chillies in Kejajar; and potatoes, cabbages and carrots in Berastagi. These results should be address as new policy patterns in Indonesia in order to equip vegetable products in upland areas to compete effectively in the global economy. Concretely, this means shaping a policy which allows Indonesia agriculture to specialise in what it does best, not only adapting to technological changes, but really driving the priority vegetable products. The policy must prioritise investment in research and development, so facilitating the ability of vegetable products to constantly innovate. They should added resources into education and training, facilitate investment in the constant up-grading of the infrastructures and ensure that unnecessary red tape is cut so that the regulatory environment in Indonesia is more conducive to do VFS.

**Keywords:** Efficiency, local government, policy, priority, resource, vegetables





# Plant systems

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# Integrated pest management

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## Overview of ICIPE Research Activities

CHRISTIAN BORGEMEISTER

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Over two-thirds of Africa's population comprises small-scale farmers, on whose productivity their own socio-economic development, as well as the nutritional security of the urban dwellers, relies. Moreover, smallholders contribute up to 50 % of the fruits and vegetables exported from Africa. Therefore, the management of arthropods, which greatly constrain the growth and output of small-scale farmers, is a major factor in enhancing Africa's development.

A complex of indigenous and invasive borers species ruins between 20–40 % of cereal yields, an amount that would be enough to feed 27 million people in the continent. Storage pests, such as the larger grain borer, can inflict losses of up to 90 % in maize. The horticultural industry, one of the fastest, and most dynamically growing businesses in Africa falls prey to a plethora of pests, including fruit flies, which ruin up to 50 % out of some fruit varieties. In addition, disease vectors, in particular blood-feeding insects and ticks, which transmit debilitating or fatal diseases, threaten livestock, on which many people in the continent rely for their every day survival.

Bearing in mind that majority of small-scale farmers cannot afford synthetic pesticides, which are in any case often harmful to people and the environment, icipe addresses the complex arthropod-related challenges through the development of affordable, environmentally-friendly, and sustainable strategies. icipe's regional stemborer biocontrol project has brought down the pest populations by as much as 70 %. The Centre's programmes to control pests of beans, brassicas, tomatoes and a range of horticultural crops, is helping to improve the nutrition and health of smallholders, while at the same time supporting them to comply with strict export regulations for their produce.

In the case of livestock, ICIPE's has focused on the control of the tsetse menace through the development of repellents, attractants and traps, tailor-made for different African communities including pastoralists such as the Maasai. In pilot field studies, these approaches have shown a 70 % reduction in the prevalence of trypanosomiasis, the deadly tsetse-transmitted disease. icipe's research is designed to harness indigenous knowledge, build institutional capabilities and empower communities to exploit the continent's tremendous potential.

**Keywords:** cereal, fruit, ICIPE, indigenous and invasive pests, livestock, management of arthropods, vegetable

## Biological Control of the Diamondback Moth, Reduced Pesticide Use and Impact on Farmers' Health in Crucifer Production in Kenya and Tanzania

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Previous assessments of classical biological control (BC) of the diamondback moth concentrated on the impact of the BC agent, *Diadegma semiclausum*, on production costs, yield and revenue in cabbage production in Kenya and Tanzania. Results showed that BC led to a reduction of pesticide use and increased revenue for farmers who did not use pesticides. Farmers who use pesticides as well as having the BC agent established do not maximise the full benefit of BC due to a negative interaction between the two control strategies. This paper expands the impact assessment to the human health dimension of cabbage farmers first and then extends to kale producers.

The health assessment is based on a random sample of 1250 cabbage farmers from Kenya and Tanzania; the extension covers 249 randomly sampled kale farmers from Kenya. Both surveys capture the production with and without the presence of the BC agent. The analysis is conducted by using a non-linear zero-inflated Poisson regression model.

Results in cabbage production show that the BC agent reduces the incidence of pesticide-related acute illness symptoms within a household by about 20 %, all other factors being equal. Use of more toxic pesticides (as per WHO definition) as well as not washing hands after application increase health problems. Surprisingly increased use of protective clothing increases health symptoms, too. However, this is supported by the literature and explained by e.g. inappropriate material for protective clothing. Preliminary results indicate a higher positive health impact of the BC in kale production since the crop remains longer in the field and thus relies on a higher number of pesticide applications.

In sum, the findings show that by assessing only the direct financial impact of a BC program, the overall impact is underestimated. Findings further stress the need to assign an economic value to such indirect non-financial impacts of an intervention. From a development perspective findings indicate the need to increasing farmers' knowledge on appropriate production systems, which maintain the BC, appropriate handling of pesticides and personal hygiene after spraying.

**Keywords:** Biological control, East Africa, economic impact assessment, health impact, horticulture, pest management

## Classical Biological Control and Access and Benefit Sharing Regimes

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Based on the assumption that biodiversity is better protected if benefits from its sustainable use accrue to its owner, the Convention of Biological Diversity (CBD) introduced two principles. Firstly, countries have sovereign rights over their biodiversity and thus the right to determine ownership, and secondly, 'Access and Benefit Sharing'. Access to biodiversity should be facilitated provided that Benefits arising from sharing are equitably distributed amongst the involved parties.

These sensible principles are confronted with high expectations of a 'green-gold-rush', i.e. high and direct monetary benefits, which has led to complicated, seemingly stalling, negotiations under the CBD. There is therefore a call for a legally binding international regime against a backdrop of many countries implementing their own legislations on ABS, mainly in expectation of a company developing product which generates monetary benefits over many years.

Clearly, this is not the case in the activities of Classical Biological Control, where natural enemies are established by public research institutes, and in essence, contributing to a public good for all.

Conflicts arise from this mismatch of expectations, in terms of speed of research and biocontrol needs, and documentation, which is felt particularly painful by the biocontrol community as they very much work along the lines of the CBD to the benefit of all. Further, there are international regulations and good practices already in place such as those in the IPPC, suiting the increasing application of biocontrol.

The CBD further assumes a bilateral mechanism for Access and Benefit sharing, e.g. a country holding a certain species and company or research institute demanding this species. However as many species are distributed over many countries, a multilateral approach is probably more appropriate, such as the one applied in the ITPGRFA.

This talk is to inform a wider scientific public on the issue arising from the ABS regulations and to encourage it to participate in the CBD process. We can only change the situation when we actively approach the decision-makers and national focal points for the CBD/ABS negotiations.

**Keywords:** access and benefit sharing, classical biological control, convention on biological diversity, natural enemies

## Progress on *Striga* Mycoherbicide Research: Time for Scaling-Up?

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*Striga* spp. are presenting severe constraints to cereal and legume production in semi-arid regions of Sub-Saharan Africa. An integrated approach to *Striga* management is required for which biocontrol represents a crucial component. *Fusarium oxysporum* f.sp. *strigae* (isolates Foxy 2 & PSM197) are virulent and potential biocontrol agents against *S. hermonthica*. Extensive research aiming at facilitating and enhancing their field application has been carried out since the last decade. In terms of safety, the isolates are highly host specific to the genus *Striga* only, and do not produce any mycotoxic compounds that present health risks, and therefore their use pose no threat to humans or mammals. Genetic characterisation of these isolates has shown that these isolates are similar and having unique DNA sequences that enabled them to be classified as a new *forma specialis strigae*, which could ensure their bio-safety and thus greatly improve the acceptance of their use as mycoherbicides. Massive production of inoculum of these isolates was optimised based on simple, and low cost methods using locally available agricultural by-products. For practical use, the isolates were developed into Pesta granular formulation or delivered as seed treatment technology. Both delivery technologies showed compatibility and great potential and efficacy in controlling *Striga* under both controlled and field conditions, as well as maintaining excellent shelf-life after one year of storage that would be sufficient for their use under practical conditions of storage, handling and delivery. Integration of these mycoherbicidal products (granular and seed coating) showed synergy and enhanced field efficacy with *Striga*-resistant sorghum and maize cultivars, some co-coated fungicides, and demonstrated excellent control efficacy of *Striga* and improved crop performance in West Africa. Thus, these isolates are fulfilling all necessary requirements for being potential mycoherbicide candidates for scaling up to support and enhance the existing *Striga* control measures at farm level in Sub-Saharan Africa. Strategies about how to utilise these progresses to formulate successful integrated *Striga* control methods adoptable and applicable by subsistence farmers will be proposed.

**Keywords:** Bio-safety, fungicides, *Fusarium oxysporum*, integrated control, weed biological control, pesta, seed coating, shelf-life

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## Transaction Costs Analysis of Hired Labour Use in Pest Management: The Empirical Study of Fruit Trees Farming in Thailand

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Pest management is one of important activity in fruit trees farming. Having a look at the detail, it shows that pest management activity involves sort of tasks with distinct attributes. Depending on the strategy being employed, a set of tasks may vary from one to the other farms. Calendar based spraying strategy, for instance, may involve simple tasks such as pesticides spraying, while the others, such as IPM strategies, may consist of wide range set of tasks from simple to the more complex ones. This paper reports empirical investigation of the effect of pest management tasks on the likelihood of hired farm labour employment using transaction costs economic framework. It is argued that the hired farm labours are not randomly assigned to perform pest management tasks, but rather to the tasks that are easier to monitor, applied repetitively, and do not require specific skills. Accordingly, the main hypothesis we derived is that pest management tasks labeled as IPM strategy is most likely to be performed under farm labour organisation comprised largely of family labours. The results are summarised as follow: **(1)** The conditional probability of the form of farm labour organisation shows that **(i)** pest monitoring seems likely to be family labour business, **(ii)** pest management tasks labeled as IPM strategy is more likely to be performed under farm labour organisation comprised largely of family labour, and **(iii)** the use of hired labour seems likely to be under supervision of family labour. **(2)** Estimates of probit model of durian farming furthermore confirm that the attributes of pest management task is the most important factor determining the likelihood of employing hired farm labour in pest management. However, the estimate of probit model of tangerine farming cannot provide statistical evidence similar to durian farming model due to the less variation of pest management tasks applied by tangerine farm household.

**Keywords:** Fruit trees farming, hired labour, pest management, transaction cost economics

## **Contribution of *Pseudomonas proradix*® and *Bacillus amilolyquefaciens* FZB42 on Healthy Plant Growth of Tomato Affected by Soil Sickness**

YUSRAN YUSRAN, MARKUS WEINMANN, GÜNTER NEUMANN, VOLKER RÖMHELD, TORSTEN MÜLLER

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The use of antagonistic microorganism in biological control of root disease is becoming an important alternative or supplement to chemical pesticides. At present, an increasing number of commercial products based on plant growth promoting rhizobacteria (PGPR) is becoming available world wide. Many of them contain strains of *Pseudomonas* spp., *Bacillus* spp., etc. Some biocontrol strategies have been proposed for controlling root pathogens, but practical applications are still limited. This is largely due to the lack of unequivocal answers to key questions concerning the relationship which the biocontrol agent may establish with the plant, and the mechanisms by which it may directly influence the pathogen or indirectly influence the plant's own resistance. Further, single studies have shown the potential of beneficial rhizobacteria to interact synergistically with indigenous, site specific and adapted arbuscular mycorrhiza fungi (AMF).

Single tomato seeds of two varieties (Money maker and Hellfrucht hillmar) were cultivated in pots containing 50 g substrate (Einheitserde Type P). Then, the two weeks-old seedlings were transplanted to bigger pots containing 1 kg replant disease soils/sand mixture (3:1). Fertilised with 100 N, 50 P, 150 K, 50 Mg, 0,06 Fe mg kg<sup>-1</sup>. *Pseudomonas proradix*® (Sourcon Padena) ( $1,5 \times 10^{10}$  cfu l<sup>-1</sup>) and *Bacillus amilolyquefaciens* FZB42 (Rhizovital ABiTEP®) (100 g l<sup>-1</sup>) or none of both were applied by root dipping.

Soil inoculation with Proradix® and FZB42 significantly improved the root and shoot biomass production of the two tomato varieties growing on pathogen-infected soil. Roots of both tomato varieties were not only healthier but also showed a significantly higher colonisation by arbuscular mycorrhiza fungi (AMF), indicating that the AMF infection potential in the soils was not generally low but rather suppressed directly by pathogens or indirectly as consequence of poor root development. The concentration of macro and micronutrients in tomato shoots was higher in the Proradix® and FZB42 treated plants when compared to the untreated control. The result obtained suggest an important role of rhizosphere interactions for the expression of bio-control mechanisms by inoculation with effective *Pseudomonas* and *Bacillus* strains independent of simple antagonistic effects.

**Keywords:** *Bacillus*, indigenous AMF, *Pseudomonas*, soil-sickness, tomato

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## Relationship Between Prevention of Early Damage of Insect Pests and Cotton Yield in Sudan

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Seed treatments promote seedling establishment, help ensure yield and reduce quality losses due to many pests and diseases. Protecting cotton plant from the attack of early-season insect pests and diseases is of prime importance to ensure a healthy and strong establishment of this strategic crop. The present study tried to measure the susceptibility of cotton flea beetles (*Podagrica* spp.), as indicator of early insect pests, to some single and/or mixtures of pesticides as a preventive control measure against early season pests of cotton in Sudan. Two field experiments were planned in the study using a number of seed dressers and two varieties of cotton (Barac 67 B and Barakat 90). Visual counts in the field were used to evaluate the effects of seed dressing treatments. Counting shot holes resulting from Flea beetle adults feeding assessed flea beetle damage. Results showed that using the ant microbial bronopol alone did not prevent flea beetle damage. Treatments containing imidacloprid significantly reduced damage in the experiments, but not 10 weeks after sowing in field experiments. The relationship between damage caused through early flea beetle damage and reduction in yield was measured through simple regression analysis. The regression analysis indicated that the correlation coefficient measured between early damage (30 days after sowing) and yield of cotton can be used to explain third of the variability in yield. However the correlation coefficient was lower when the damage was recorded later (60 days after sowing). The relationship between damage and yield was found to vary between the two varieties tested.

**Keywords:** Cotton flea beetle, cotton yield, *Podagrica* spp., Sudan

## Quarantine Management on Fruits and Vegetables Eliminating Millipede Infestation Caused by *Spinotarsus caboverdus* (Diplopoda, Odontopygidae)

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The demand for a good quality of native fruits and vegetables with export potential from Santo Antão Island is increasing, due to a developing tourist market. Unfortunately there is a high infestation with the millipede *Spinotarsus caboverdus*. The infestation and damages on fruits and vegetables on the field appear also during the storage period.

The objective of this research is to develop a management for fruits and vegetables against quarantine pest, *Spinotarsus caboverdus* (Pierrard). The effective treatment is necessary for vegetables and fruits, which will be exported from Santo Antão Island to other islands of the archipelago of Cape Verde. We look for the effective treatment, without negative influence on the treated vegetables and fruits, low-cost and without environmental consequences.

All tests were conducted with naturally infested products with millipede. The effect of each treatment on the infestation and the quality of products was observed.

Moderate heat of 40°C and 45°C was used to eliminate live millipedes on fruits and vegetables. Effectiveness of these two temperatures was applied during 18 hours. At 45°C and 18 hours duration the mortality of *S. caboverdus* was 100 %.

In a second way hot water immersion at 40°C and 45°C with duration of 20 minutes was also investigated for lethal effect on millipedes. The mortality of millipedes at 45°C after 20 minutes was 100 % too.

In a third case it was tested an ambient water immersion at 25°C of fruits and vegetables with different time of immersion of 10, 15 and 20 minutes. The objective of using ambient water immersion was to turn out of the millipedes from the products. In results of these test 20 minutes at 25°C are enough to push out 100 % of millipede from the crops.

The investigation shows, that the millipede infestation can be eradicated in the post harvest phase of vegetables.

**Keywords:** Post harvest treatment, *Spinotarsus caboverdus*

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## Allelopathic Effect of Intercropping with Marigold and Common Rosemary on Tomato Early Blight Disease Development

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In order to evaluate the allelopathic effects of intercropping with marigold and common rosemary on tomato early blight disease development Intercropped systems promote biological diversity, improve the use of natural resources, diminish the risk of crop losses and can provide barriers to the spread of plant diseases. Medicinal plants can grow in intercropping. Common Rosemary (*Rosmarinus officinalis*) and Marigold (*Tagetes erecta* L.) are multipurpose crops with remedial, ornamental, medical and pharmaceutical uses, and reported antimicrobial properties. Tomato early blight, caused by *Alternaria solani*, is perhaps the most common leaf disease in this crop and is considered one of the main diseases affecting tomato production in Iran. In this experiment, we evaluated the effects of marigold intercropped with tomato (*Lycopersicon esculentum* Mill.) and Common Rosemary (*Rosmarinus officinalis*) on *A. solani* on tomato leaf damage in farm condition. Results showed that intercropping with marigold and common rosemary induced a significant ( $p < 0.05$ ) reduction in tomato early blight caused by *A. solani*, by means of two different mechanisms. The first mechanism was the allelopathic effects of marigold and common rosemary on *A. solani* conidia germination. The second way was by altering the microclimatic conditions around the canopy, particularly by reducing the number of hours per day with relative humidity  $\geq 92\%$ , thus diminishing conidial development. The third mechanism was to provide a physical barrier against conidia spreading. When intercropped with tomato, Common Rosemary plants worked also as a physical barrier and promoted reductions in the maximum relative humidity surrounding the canopy, but to a lesser extent than marigold.

**Keywords:** *Alternaria solani*, common rosemary, *Rosmarinus officinalis*, early blight, intercropping, microclimate, Marigold, *Tagetes erecta*, tomato, *Lycopersicon esculentum*

## **The Consequences of Defoliation of Gum Arabic Tree (*Acacia senegal*) by Tree Locust (*Anacridium melanorhodon melanorhodon*) for the Gum Producers: A Case-Study in North Kordofan State, Sudan**

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Gum Arabic is one of the main crops produced in the traditional rain-fed agricultural sector of Sudan. It is a non-timber forest product harvested from gum Arabic tree (mainly *Acacia senegal* var. *senegal*). Gum Arabic provides on average 12% of the gross domestic product of the country and accounts for about 15 - 10% of the income of the gum producers and other farmers in the gum belt across Sudan, respectively.

The most serious pest of gum Arabic tree is the tree locust *Anacridium melanorhodon melanorhodon* Walker. A study conducted in North Kordofan State focused on the estimation of the degree of defoliation by outbreaks of the tree locust and on socio-economic consequences for local gum Arabic producers. Moreover the study tries to cover the reactions of the local gum producers on tree locust outbreaks and the possibilities for compensation of the (financial) losses.

Defoliation of gum Arabic tree by the pest resulted in a loss of yield connected with a reduction of the benefits to the local communities practicing gum production as one of the main activities. The study showed highly significant differences in crop yield before (183.88 kg ha<sup>-1</sup>) and after (105.73 kg ha<sup>-1</sup>) tree locust outbreak. The pest reduced the per hectare benefits from gum production from 292.6 to minus 21.2 Sudanese Pound (SDG). In addition, tree locust outbreak leads to a delay of the tree tapping time from October to January/February due to the effects of the pest on foliage of gum Arabic tree.

The study was considered to be base not only for policy makers to avoid the economical losses but also for more research work concerning the ecology of the insect and the strategies of control.

**Keywords:** *Acacia senegal*, gum arabic, tree locust, *Anacridium* spp.

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# Abiotic stresses - characterisation, effects and management concepts

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## Getting the Most Out of Scarce Water: Adapting Dryland Cereals to Forthcoming Agricultural Transitions in Sub-Saharan Africa

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Times of major economic or environmental change cause change in agriculture. During such periods, new technologies such as crop varieties are needed, and research has the opportunity to make substantial positive impact. Such was the case during the green revolution in much of the world (except large parts of SS-Africa). A new period of agricultural transition is now coming up caused by several major changes that are a threat and, under certain conditions, an opportunity for Africa: climate change and associated variation of rainfall patterns, population growth, and rising prices of fossil fuels. All three contribute to rising grain prices on the world market which in turn aggravate food security problems. This is potentially disastrous for the urban poor, but not necessarily bad news for farmers. A new wave of intensification is likely, and along with it, the conversion of subsistence into commercial farming systems.

SS-Africa's vast savannahs are the continent's potential bread basket wherever political stability enables development of sustainable, commerce driven intensification. What are the crop adaptations and what are the crop ideotypes that need to be developed to foster such development? This paper presents some old, recent and new hypothetical breeding strategies for sorghum and maize for drought prone environments in West Africa, and discusses them in the light of the expected agricultural transitions. It describes summarily how drought escape, avoidance and tolerance mechanisms might be combined with desirable agronomic traits to provide best fit changing climate and production systems and objectives. On this basis, the author identifies physiological, genetic and agronomic research issues that should be tackled urgently because, once again, applied science may lag behind the rapidly changing reality on the ground.

**Keywords:** Agricultural change, Sub-Saharan Africa



## **Balanced Fertilisation – A Prerequisite for a Sustainable Improvement of Crop Yield and Quality in Developing Countries**

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In developing countries, the plant nutrient input into agricultural systems by organic and mineral fertiliser is often low and thus limiting crop yield. In Africa, so-called nutrient mining results in nutrient loss of up to 100 kg nutrient ha<sup>-1</sup> year<sup>-1</sup>. Nutrient mining (esp. P and K) has become a serious problem for crop production not only in Africa but also in many Asian countries. In these regions, the most widespread used fertiliser is urea, which is often applied in large quantities. Generally, in most of these countries, N is used in higher quantities as compared to P, K, Mg and micro nutrients. Consequently, soil fertility along with water, another serious threat for crop production in developing countries, will be negatively affected by nutrient imbalances. This nutrient imbalance has a number of detrimental effects on crop production: decrease of area productivity (yield/ha), decrease of N efficiency (*i.e.* less crop output per kg N used), lower plant resistance to pests and diseases and a lower product quality in terms of mineral content, vitamins and others. Nutrient imbalances and the use of large quantities of N-fertiliser also results in negative environmental effects associated with N, such as nitrate leaching and N<sub>2</sub>O-emission. Moreover, the lack of micro nutrients (first of all Zn) has led to lower crop yield but also to nutritional problems for consumers. Today, Zn deficiency is regarded as one of the most serious causes for malnutrition of children. This is reflected by special Zn promoting programmes of the FAO, Bill Gates Foundation and other organisations.

In the present study, we show results from various field trials carried out in India and other Asian and African countries showing the detrimental effects of unbalanced NPK fertilisation on crop yield and on soil fertility. Our results indicate that K improves water use efficiency and nutrient availability in soils, that Mg improves assimilate production and translocation in the plant and that S improves plant resistance. We show the practical relevance of balanced fertilisation and economic benefit for some crops against the background of increasing fertiliser prices.

**Keywords:** Crop quality, fertilisation, nutrient cycling, nutrient mining, soil fertility

## Drought Resistance of Mixed Pine-Oak Forest Species in the Sierra Madre Oriental, Mexico

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Mixed pine-oak forests are exposed to extreme environmental conditions where water availability is a limiting factor and climatic change makes the conditions for plant grow even more acute. In addition, unsustainable management contributes to the acceleration of forest degradation and deforestation in great parts of the mountain due to anthropogenic stresses like forest fires, agricultural, silvo-pastoral and silvicultural activities, why natural regeneration and reforestation are difficult. The response of ecosystems to such climatic and anthropogenic stresses will depend in part on the drought tolerance capabilities of the individual species. In order to develop and apply sustainable management or reforestation programs, detailed knowledge about the physical condition of tree species and their capacity to respond to a dynamic environment is an important precondition. The objectives of our study were to assess and quantify how seasonal plant water potentials ( $\Psi_w$ ) and osmotic potentials ( $\Psi_s$ ) are related to soil water availability and evaporative demand components in four tree species (*Acacia rigidula*, *Juniperus flaccida*, *Pinus pseudostrobus*, and *Quercus canbyi*) under natural drought and non-drought conditions in the Sierra Madre Oriental. All species showed high predawn and low midday values that declined progressively with increasing drought and soil-water loss. During the dry period, juniper and oak had the lowest  $\Psi_w$  and  $\Psi_s$  while *A. rigidula* maintained relatively high values. However, *J. flaccida* and *Q. canbyi* recovered high water potentials during the wet months indicating their capacity to overcome drought. *A. rigidula* had a wide range between predawn and midday  $\Psi_w$  during the dry season suggesting drought resistance.  $\Psi_w$  was positively correlated with soil water content for *Q. canbyi* and *J. flaccida*, and between 30 % and 47 % of temporal variation in predawn water potential ( $\Psi_{wpd}$ ) was explained by soil water content.  $\Psi_s$  was correlated with climatic variables for *J. flaccida* and *Q. canbyi*. Finally, *A. rigidula*, *Q. canbyi*, and *J. flaccida* had better capacity to withstand drought than pine, and are considered as suitable candidates for reforestation programs on dry sites in the Sierra Madre Oriental in Mexico.

**Keywords:** *Acacia rigidula*, drought stress or resistance, *Juniperus flaccida*, Mexico, *Pinus pseudostrobus*, *Quercus canbyi*, restoration, Sierra Madre Oriental, water- and osmotic potential

## **Squeezing More Crop from Each Drop – An Interdisciplinary Approach to Crop Improvement in Drought-Prone Environments**

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Improving crop yields in rain-fed environments will be central to food security in a climate-changed world where rain, temperature and drought will be increasingly erratic. Yield improvement in such environments based on selection for yield per se has been slow due to large genotype by environment interactions ( $G \times E$ ). In this paper, we present an interdisciplinary approach to crop improvement that links physiology with plant breeding and simulation modelling to enhance the selection of high yielding, drought-tolerant varieties for the water-scarce environments.

In a series of field experiments in Queensland, Australia, we found that the yield of CIMMYT wheat line SeriM82 ranged from 6 to 28 % greater than the current adapted cultivar Hartog. Physiological studies on the adaptive traits underpinning this advantage revealed that SeriM82 and Hartog differ in root architectural traits. In large soil-filled chambers, SeriM82 had a narrower root system architecture and extracted more soil moisture per soil volume, particularly deep in the profile, late in the growing season when marginal water use efficiency (WUE) is high. To quantify the value of these adaptive root traits, we conducted a simulation analysis with the cropping systems model APSIM for a range of rain-fed environments contrasting in soil water-holding capacity in southern Queensland using long-term historical weather data. The analysis indicated a mean relative yield benefit of 14.5 % in water-deficit seasons and that each additional millimetre of water extracted during grain filling generated an extra 55 kg ha<sup>-1</sup> of grain yield.

Further root studies of a large number of current Australian and CIMMYT wheat genotypes in small gel-filled chambers revealed that wheat root system architecture is closely linked to the angle of seminal root axes at the seedling stage - a trait which is suitable for large-scale and cost-effective screening programmes.

Overall, our results suggest that an interdisciplinary approach to crop improvement based on identification of physiological traits conferring tolerance to drought stress, evaluation of drought-adaptive traits in the target population of environments using simulation modelling, and development of efficient screening methods is likely to enhance the rate of yield improvement in rain-fed crops in a changing climate.

**Keywords:** APSIM, root characteristics, simulation modelling, water use efficiency, wheat

## Ozone Pollution and Rice Production in Asia: Significance, Physiological Response of Rice and Development of Tolerant Genotypes

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Surface ozone concentrations have been rising in many Asian countries in recent years due to environmental pollution accompanying economic development. Ozone is an air pollutant that is formed in the earth's troposphere as a consequence of photochemical reactions of precursor gases such as nitrous oxides or volatile organic compounds. Ozone causes visible leaf damage ("bronzing") and negatively affects plant growth by hampering photosynthesis. Rice yield reductions up to 15 percent due to ozone pollution have been estimated in areas where ozone level exceeds 80 ppb, which is frequently the case in India and China. A powerful strategy to prevent such yield losses is the development of tolerant rice varieties. We therefore aim to identify genetic factors associated with ozone tolerance in rice, and to understand the underlying physiological mechanisms. We carried out experiments using three week old rice seedlings and exposing them to 100 ppb ozone for 14 days. Dry weight development and visible leaf damage (leaf bronzing) were used as tolerance indicators. We assessed genotypic differences for tolerance to elevated ozone, and identified quantitative trait loci (QTL) in a mapping population derived from contrasting parents Kasalath (a tolerant *Indica* landrace) and Nipponbare (an intolerant modern *Japonica* variety). The effects of QTLs were confirmed using chromosome segment substitution lines. This approach yielded three conclusive QTLs: two QTLs were associated with leaf bronzing and one with dry weight. We then carried out experiments with substitution lines aimed at identifying the physiological basis underlying these QTLs. Results suggested that leaf bronzing was strongly associated with the ascorbic acid status, whereas dry weight reductions were related to photosynthetic carbon assimilation. In ongoing experiments we now intend to obtain a more detailed understanding of the physiological processes underlying tolerance QTLs. We investigate whether photosynthesis under ozone stress is limited by stomatal regulation or by biochemical limitations such as Rubisco activity, and whether contrasting genotypes differ in this regard. The potential application of these results for the development of ozone tolerant rice varieties and its contribution to food security in Asia will be discussed.

**Keywords:** Genetic resources, oxidative stress, ozone, photosynthesis, QTL, rice

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# Cropping systems

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## Competing Claims on Natural Resources: the Role of (Plant) Science

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Competing claims on natural resources become increasingly acute, with the poor being most vulnerable to adverse outcomes of such competition. A major challenge for science and policy is to progress from facilitating univocal use, to guiding stakeholders in dealing with potentially conflicting uses of natural resources. The development of novel, more equitable, management options that reduce rural poverty is key to achieving sustainable use of natural resources and the resolution of conflicts over them. Here we describe an interdisciplinary and interactive approach for: i) the understanding of competing claims and stakeholder objectives; ii) the identification of alternative resource use options, and; iii) the scientific support to negotiation processes between stakeholders. Our aims are to contribute to develop new interdisciplinary methods, to design new options and conflict resolution among multiple groups of stakeholders, and to develop policy interventions that simultaneously improve livelihoods and the sustainable use of natural resources. Research is being conducted in southern Africa, a region characterised by heterogeneous and highly dynamic resource uses. A comparative approach is used to examine the different drivers of resource use dynamics and the interacting claims of multiple stakeholders on these resources. The methodological approach not only seeks to describe and explain resource use dynamics and competing claims, but also to contribute actively to negotiation processes between stakeholders operating at different scales (local, national, regional and global). It will explore alternatives that can contribute to more sustainable and equitable use of natural resources, and, where possible, design new technical options and institutional arrangements. In this paper I will specifically focus on the role of research on plant production systems within the broader debates on livelihoods of people in marginal areas and exploitation of natural resources.

**Keywords:** Alternative resource use, livelihoods

## Resources Use Optimisation in Main Food Legume Crops Production in River Nile State (RNS) of Sudan

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In Sudan, the tenants have embraced numerous crops in order to intensify production in an attempt to improve home food security and income. Seasonal legume crops are regarded as essential crops within the crop combination in RNS namely, faba beans, kidney beans and chick peas. They are a major part of the daily diet for the Sudanese. Moreover, they play an important role in sustaining the productivity of the farming systems through the fixation atmospheric nitrogen. The RNS is considered as one of the main supplier of legume crops to the country. The crops are commonly produced under pump irrigation from the River Nile. The production of seasonal legume crops in the State are faced by numerous constraints namely inefficiency of resource use, low level of productivity and high cost of production. The paper aims to optimise the available resources use in Winter seasonal crops vis-a-vis food legume crops production. It was on this basis that a paper was prepared out in RNS to establish resource combination levels that maximise gross margins from food legume crops that commonly grown within the combination. Primary data was collected by using structured questionnaire for (70) randomly selected respondents. A linear programming technique through the General Algebraic Modelling System (GAMS) programme was used to assess the optimally combining resources in seasonal legume crops. The model results revealed that tenants would get higher returns by allocating more resources namely land, water, labour and capital to the food legume crops production. Higher net benefits would be from food legume crops production and least from exclusion them. The RNS tenants should therefore, be guided on how to optimally and efficiently utilise their resources and be encouraged to grow food legume crops that give production and yield advantages, earn high returns and contributed significantly to farm sustainability and alleviates malnutrition in RNS.

**Keywords:** Food safety, resources use optimisation

## Impacts of Technological Change on Crop Residue Management and Livestock Feeding in the Indo-Gangetic Plains

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The slow-down in yield growth of rice and wheat in the Indo-Gangetic Plains of South Asia has been linked to soil degradation. Conservation Agriculture based Resource Conserving Technologies have been identified as suitable interventions. Especially zero-tillage in winter wheat has already found wide-spread adoption in more progressive areas of northwestern India and is actively promoted elsewhere. However, year-round zero-tillage systems demand more residue retention in the form of mulch than conventional systems to improve soils. This might affect livestock feeding, which relies heavily on residues as the most important feed component over most of the year, with wheat straw being preferred in the Northwest and rice straw in the East. Results from smallholder farming systems surveys indicate the importance of harvesting technologies, mainly the increased use of combine harvesters for both cereals, in regard to availability and management of residues. In contrast to traditional manual harvesting and stationary threshers, combine harvesters spread straw over the field making it more difficult to collect the straw for feeding. Thus, machines for collecting wheat straw from the field and chopping it are becoming popular, indicating the continued importance of straw as livestock feed. Still, many farmers burn the remaining stubble and mulch during land preparation even when using zero-till drills. This indicates that currently farmers are not yet satisfied with the prevailing technology when seeding into significant residue amounts. While the mechanisation of cereal harvesting is a major determinant of changes in straw management, the level of residue retention in wheat fields as mulch is further influenced by the availability and perception of suitable zero-till seeding technology. In regard to straw feeding, the use of straw collection machinery implies additional costs and presents trade-offs in terms of straw recovery and quality, but so far there is little evidence that this has altered feeding patterns.

**Keywords:** Conservation agriculture, crop-livestock interactions, India, residue management



## **Natural Resource Management and Food Security in the Alaknanda Basin of Garhwal Himalaya, India**

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This paper examines the natural resources conditions and food security in the Alaknanda Basin of Garhwal Himalaya. The availability of natural resources in the forms of flora, fauna, water, soil, and feasible agro-ecological conditions is abundant; yet, these resources are not utilised optimally. Furthermore, irrational exploitation and over utilisation of natural resources has resulted in considerable amounts of soil erosion, nutrient loss, and environmental degradation in the highlands and silting of river beds causing floods, loss of property and life in the lowlands. Agriculture is based upon the centuries old practices, carried out mainly on the narrow patches of terraced field, and dominated by intensive cereal farming. The outcome from the cultivation of cereal crops is not sufficient for food security and even the populace struggle for availing two times meal at several times. Forest resources are abundantly found as above 60 % land is covered by forest. Similarly, the region is rich in terms water resources. The Alaknanda and its sub-systems provide abundant freshwater. Enhancing and diversifying livelihood options from the available natural resources such as cultivation and off-season vegetables, medicinal plants, apiculture, and fruits according to environmental conditions, slope aspects, and elevation, forest based non-timber products, promotion of eco-tourism as plenty of natural, cultural, and historical places are located here, and construction of small scale hydroelectric plants, will secure livelihood. The main objective of the paper is to identify the availability of natural resources and their optimal utilisation, which could maintain food security. Data were gathered mainly from primary sources and participatory observation method was used for discussion of data.

**Keywords:** Cereal farming, food security, Garhwal Himalaya, natural resource management

## Evaluating Crop Substitution: An Empirical Approach Involving Sugarcane, Soybean, Beef and Corn

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With the objective of evaluating the relationship between the relative use of Brazilian agricultural areas in the production of soybean, beef, corn and sugarcane as a function of relative prices and other economic constructs, we fit an econometric model in the Cobb-Douglas family. The empirical exercise is of importance in actual Brazilian context, where drastic changes are envisioned for the agricultural profile of the country, in response to the potential world increase in demand for bio fuels and the likely increase of the area cultivated with sugarcane. We observe that during the period (1994–2005), soybean and corn prices dominate the prices of the other products. Important variations of relative prices were only observed for the pair soybean-corn. The statistical analysis indicates that an increase of 1 % in the relative price of soybean relative to sugarcane implies an expected increase in area of 0.01 % in favour of soybean. In regard to the relative areas of pasture and sugarcane as a function of the relative prices of beef/sugarcane we did not find a clear increasing linear relation. Relative to the coefficient of corn/sugarcane one can infer that an increase of 1 % in the relative price of corn in relation to the price of sugarcane, would lead to an increment of 0.05 % in the area planted with corn relative to sugarcane. For the relationship between soybean and pasture we estimate that a 1 % of increment in the relative price of the soybean in relation to the price of beef leads to an increase of 0.06 % in the planted area of soybean in relation to the area of pasture. For the combination soybean-corn we infer that a 1 % of increase in the relative price of the soybean in relation to the price of the corn will cause a significant increase of 0.94 % in the relative area in favour of soybean. It is concluded from the analysis, in general, that there is not enough past evidence to infer significant changes in crop areas relatively to the status quo in regard to changes in relative prices.

**Keywords:** Beef, corn, sugarcane, soybean, substitution effects of crop areas, substitution elasticities

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# Organic matter, microorganisms and organic farming principles

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## ***Rhizobium* Systemically Suppresses Root Colonisation by the Arbuscular Mycorrhizal Fungus *Glomus mosseae* in the Rhizobial Non-Host Plant Barley**

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Rhizobial bacteria and arbuscular mycorrhizal fungi (AMF) can form mutualistic symbioses. Both symbionts improve the nutritional status (nitrogen and phosphorus) of their host in exchange for assimilates provided by their host and thus, promote the growth of many crop plants.

Whereas more than 80 % of all land plants are hosts for AMF, the host range of *Rhizobium* is limited (leguminosae). In legumes it has been shown that application of Nod-factor to one side of a split-root system or pre-inoculation of one side of a split-root system with *Rhizobium* systemically suppresses AM root colonisation on the other side.

In the present work, we tested whether a similar effect can be observed with the non-legume barley (*Hordeum vulgare* L. cv. Xanadu). Application of nod-factor to one side of a split-barley root system systemically reduced AM root colonisation on the other side. Application of one of the following mutant rhizobia strains (NGR234.GMS, NGR $\Omega$ rhcN, NGR $\Delta$ NodABC and NGR $\Delta$ NodD1), which are completely or partially deficient in nod factor production, to one side of a split-barley root system, resulted in a similar systemic reduction of AM root colonisation as observed with nod factor.

In presence of rhizobia the levels of salicylic acid (SA), an endogenous molecule in plant defence, were increased in barley roots.

Our results indicate that rhizobia are perceived by non-legumes in a similar way as by legumes and similar regulatory mechanism are activated. There are at least two different perception ways: one is activated by nod factor whereas another is Nod factor independent.

**Keywords:** Arbuscular mycorrhiza, *Rhizobium*, nod factor, barley, systemic effect

## **Yields of Organically Produced Vegetables in the Cool-Dry and Hot-Wet Season in Tropical Taiwan**

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Information on potential yields of organic vegetables grown under tropical climatic conditions is important for researchers to evaluate the opportunities and constraints of developing organic vegetable production systems in the tropics. Decision makers in agriculture also benefit from knowing about the conditions under which organic production can be a viable alternative to conventional production systems.

In 2006 and 2007, we conducted variety evaluation experiments to gain preliminary results on yield potential in several economically important vegetable crops under organic farming conditions in tropical Taiwan. In these on-station experiments, we achieved high yields and good quality under organic farming conditions in the open field. Results indicated that marketable yields of cucumber (up to  $85.9 \text{ t ha}^{-1}$ , 20–25 times hand picked dependent on variety), sweet pepper (up to  $45.6 \text{ t ha}^{-1}$ ), and tomato (up to  $57.6 \text{ t ha}^{-1}$ ) were similar to the marketable yields achieved in previous AVRDC field experiments using conventional farming techniques. However, the yield potential of the vegetables was dependent on variety, transplanting date and growing season. For example, the yields of sweet pepper transplanted in November (cool-dry season) compared to March (hot-wet season) are lower in our field experiments may be due to suboptimal temperatures, which can weaken the plants' growth and natural defense mechanism against pests. In contrast, the total (up to 70.9 %) and marketable (up to 59.9 %) yield of tomato was greatly reduced when transplanted in March (hot-wet season) compared to October (cool-dry season), a phenomenon usually also found in conventional production systems. Tomato entry PT4727 of determinate growth type bred at AVRDC reached also in the hot-wet season an acceptable total ( $65.3 \text{ t ha}^{-1}$ ) and marketable ( $40.8 \text{ t ha}^{-1}$ ) yield. PT4727 combines both virus resistance and presumably heat tolerance, two important traits necessary for successful tomato production during the hot-wet season.

The relatively high yields achieved on-station with superior varieties under favourable growing conditions in tropical Taiwan may encourage farmers and agricultural stakeholders to consider organic farming approaches as a viable alternative to conventional farming systems, and may prompt more institutionalized research on organic farming in tropical countries.

**Keywords:** Cucumber, sweet pepper, tomato, transplanting date, variety,

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## **Increasing Income by Improving Marketing Strategies for Small-Scale Organic Vegetable Farmers in Tanzania**

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There is a growing demand for organic agricultural produce in and from Africa, leading to income generating opportunities for farmers all over Africa. This includes vegetable produce. Despite the rise in demand, the domestic market for organic vegetable produce has not been developed. Small-scale farmers who do practice organic agriculture in Africa find export markets in the US and the EU more attractive than domestic markets. However, it is risky for small-scale farmers to rely solely on the export sector. Domestic and regional markets in Africa can be good fallbacks.

No detailed research has been conducted on organic vegetables for the African market. Most research has been geared towards export opportunities for East Africa. Local NGOs that teach small-scale farmers organic agricultural practices do not explain to farmers how to efficiently market their organic produce. There are numerous constraints in the supply chain from the farm gate to the consumer.

This project assesses constraints in the supply chain to explore better marketing strategies for small-scale organic vegetable farmers in order to improve their income. The project has collected data from a questionnaire survey in northern Tanzania in February-March 2008 of more than 200 small-scale organic vegetable farmers, about 50 wholesalers, middlemen, and retailers in the intermediary sector, and more than 200 consumers on aspects of organic vegetable production such as volume, prices, uses, transportation to the market, marketing difficulties, selling points for the main products, main customers, awareness of organic vegetables by market supply chain actors and consumers, and consumers' willingness to pay for organic vegetables. The consumers were chosen by stratified sampling (by income and location), mainly at supermarkets and organic shops, latter additionally in Dar-es-Salaam.

**Keywords:** domestic markets, marketing strategies, organic agriculture, organic vegetables, small-scale farmers, Tanzania

## **IFOAM's Comprehensive Information Package on Development Options for Countries with an Emerging Organic Sector**

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In various countries and regions where the organic agriculture sector is emerging, governments as well as private-sector organisations and institutions are looking for competent advice on how to develop the sector. In November 2003, IFOAM's Government Relation Committee organised an informational event in Bangkok for official government representatives from Asian countries who were working on national standard-setting and national regulations. The interest was substantial, and a lack of comprehensive information and knowledge about the most important procedures and challenges was obvious.

Within the frame of the I-GO II program, IFOAM is supporting the development of emerging organic sectors in Developing Countries. Besides the establishment of IFOAM Information Points in selected regions, the objective is to facilitate the development of emerging organic sectors through the provision of a comprehensive information package. This information package includes recommendations on possible options for governments, the private sector, development agencies and consultancies on how to achieve a sustainable development of the sector. The recommendations are the result of analytical cases studies, reflecting experiences from various countries, selected to show different situations in different stages of development with variations regarding market conditions, regulations, political framework, structure of the organic sector, and geography. Each case study is analysed with a focus on the following topics:

- Best practices for organic policy development
- Market development:
  - Standards, regulations and certification
  - Consumer awareness
- Role of and relationship between different partners, esp. in public-private partnerships
- Extension and training

As an additional element of the information package, guidelines for the whole process of developing the emerging organic sector have been developed. Publications addressing all aspects of this process are being made available through a new online resource on the IFOAM website.

**Keywords:** Development options, extension and training, market development, organic agriculture, policies, public private partnerships

## Analysis of the Costs of Organic versus Fair Trade Certification in a Smallholder Association in Brazil

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Organic Farming and Fair Trade are two agricultural production systems that have shown to be a valuable alternative for smallholders to gain access to international markets, as both systems are well adapted to low-input agriculture and allow for group certification.

This case study explores the potential of Fair Trade and organic certification in a Brazilian smallholder association and is carried out as a part of the project Family Agriculture, Agroecology and Markets of the Konrad-Adenauer-Foundation. It focuses on assessing the economic profitability of the two types of certification by calculating the profit margin of cashew production. As a secondary objective, this study lays the groundwork for setting-up an Internal Control System (ICS) within the association, by identifying Critical Control Points (CCPs).

Data on the production system and the involved costs along the cashew value chain are gathered by interviews with (1) selected producers to account for different production systems, (2) owners of the processing units and (3) key persons from the administration of the association. Thus, the profit margin can be calculated at each link and finally for the cashew value chain. The interviews will also serve to identify CCPs within the production. Additionally, certification agencies, practitioners and extension workers are consulted to further disclose costs and challenges related to the certification.

As a result, four scenarios are presented; business-as-usual without any certification, organic certification, Fair Trade certification and both organic and Fair Trade certification. The costs and benefits that are induced due to changes in the production of cashew vary from one scenario to the other. Thus the association can choose from one of the presented scenarios, which, considering the unique conditions of all its members, seems to be economically and organisational most favourable. Finally, this study will address the challenges faced during certification, especially during its early stage.

**Keywords:** Fair trade, family agriculture, group certification, internal control system, organic agriculture, profit margin, low-input agriculture



# Post harvest technology and quality - a neglected relation

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## Analysis of Current Practices of Litchi Drying in Small Scale Industries in Northern Thailand

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Among the top litchi (*Litchi chinensis*) producing nations is Thailand, where litchi revenues are significant for local economies as well as the national economy on the global stage. Growers there are mostly small holders in the North, where marketing is almost exclusively under the control of middlemen and processors. Litchi is a highly perishable and seasonal crop requiring post-harvest preservation. It is generally sold fresh, with canning as the most common preservation method.

Drying is a practical conservation technique only recently applied to litchi in Thailand, where both wood- and petrol-fuelled cabinet dryers are used. Unsaturated markets for dried litchi offer great opportunity for expansion, but lack of appropriate knowledge hinders development. So far, current operations have not been optimised concerning performance, product quality and consumer acceptance.

This study proposes guidelines for the optimisation of the current litchi drying systems via inventory and comparative analysis of drying facilities in the greater Chiang Mai area. Semi-structured questionnaires were applied to investigate the procedures, equipment, and scale of facilities. Monitoring of the processing procedures and drying conditions, including temperature, relative humidity, air pressure, air velocity, and energy consumption provided a technical performance evaluation of the facilities. Analysis of final product samples, including colour, moisture content, water activity, pigments, vitamin C and sugar content provided quantitative quality measurements. A sensory evaluation was also applied to assess consumer acceptance of the products. The retrieved information, organised in a database, allows for the characterisation of the litchi drying sector in northern Thailand. The guidelines for optimisation were obtained by correlating the documented drying procedures with the final product's physical, chemical and sensorial attributes.

**Keywords:** Dried product quality, drying system optimisation, fruit drying, moisture content, sensorial evaluation

## Evaluation of Processing Parameters for Hot-Air Drying to Obtain High Quality Dried Mushrooms in the Mediterranean Region

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Mushroom is an important commodity in the Mediterranean region and appreciated for its delicacy, nutritional and medicinal characteristics. In Greece, approximately 1150 species of fungi have been identified as mushrooms and at least 400 species have shown various degrees of edibility. In mountain and hilly areas, mushroom foraging followed by picking, cooking and eating is not only a recreational habit but also a source of a seasonal income for the local population. Owing to Mediterranean climate, the seasons are wet with mild temperatures in spring and autumn favouring suitable environmental conditions for fungal growth. Specifically, Epirus and West Macedonia regions located in northwestern Greece have a large potential of various wild-growing mushrooms for production and consumption. However, fresh mushrooms are highly perishable commodities with short shelf life and their commercialisation becomes difficult. Among the various techniques employed for the preservation of mushrooms, drying seems to be an effective approach to enhance storability and ensure distribution.

The aim of this study was to investigate the drying behaviour of mushrooms and to evaluate the effect of drying parameters on quality in terms of colour, texture and rehydration capacity. Prior to drying, button mushrooms were soaked in a solution of 0.25 % potassium metabisulfite and 0.1 % citric acid for 5 min at room temperature. Treated mushroom slices were dried in a through flow laboratory dryer at Hohenheim University in Stuttgart, Germany under industrial drying temperatures (30/60°C, 60° C, 80/60°C and 80°C) maintaining 10.0 g kg<sup>-1</sup> of absolute humidity and 0.9 m s<sup>-1</sup> of air velocity. Trials were carried out at 15 and 20 g kg<sup>-1</sup> absolute humidity maintaining a temperature of 60°C to examine the effect of relative humidity. The results indicated that the air temperature and slice thickness were significant factors affecting the drying characteristics of mushrooms. Quality was negatively affected by higher temperatures and duration of the drying process. Stage drying at 30/60 °C showed improved quality characteristics. Additionally, hot-air dried samples were compared with those dried by freeze drying and the combination of microwave-vacuum and hot-air drying. Freeze drying gave superior quality products while the combined technique produced a unique texture property.

**Keywords:** Mushroom, hot-air-drying, quality

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## **Drying of Lemon Balm (*Melissa officinalis* L.) using Stepwise Process Control**

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In this work the method of stepwise drying of medicinal plants is presented as an alternative to the conventional drying that uses a constant temperature during the whole process. The objective of stepwise drying is the decrease of drying time and energy saving. In this process, apart from observing the effects on saving process time and energy, the influence of the different combinations of drying phases on several characteristics of the product is considered. The tests were carried out with *Melissa officinalis* L. variety citronella, sowed in greenhouse. For the stepwise drying process different combinations of initial and final temperature (30/40°C, 30/50°C, 30/60°C, 40/50° 40/60°C, 50/60°C, 50/30°C) are evaluated, with different transition points associated to different moisture contents (20, 30, 40 % and 50 %) of the product during the process. To determine the colour changes a Chroma-meter® device is used that carries out the colourimetric evaluation of colour coordinates and colour differences by means of the CIELAB colour space, in accordance with the norm DIN 6174. As reference for the colour change the measurement of the colour of the fresh product is used. The CIELAB coordinates of the reference colour is compared with the coordinates of the colour of the product after being exposed to the stepwise drying process. Drying curves were obtained to observe the dynamics of the process for different combinations of temperature and points of change, corresponding to different conditions of moisture content of the product. 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 commercial value.

**Keywords:** Drying process, lemon balm, medicinal plants, *Melissa officinalis*, stepwise drying

## Drying Kinetics and Colour Change of Mango Slices as Affected by Drying Temperature and Time

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Thin-layer drying behaviour of mango slices (var. Kent) was investigated in a laboratory scale dryer, using heated ambient air temperatures of 60, 70 and 80°C at a constant air velocity of 1.5 m/s and 3mm slice thickness. Besides the effects of drying air temperature on the drying characteristics, drying time and quality of dried products were determined. Drying curves obtained from the experimental data were then fitted to three well-known semi-empirical thin-layer drying models (Lewis model, Page model and Henderson & Pabis model). Model constants and coefficients were determined by nonlinear regression method. All the models were compared according to statistical parameters. Among the drying models investigated, the Page model satisfactorily described the drying behaviour of mango slices. The effective moisture diffusivity varied from  $4.97 \times 10^{-10}$  to  $10.83 \times 10^{-10}$  m<sup>2</sup>/s. Results indicated that drying took place in the falling rate period. The results have shown that, increasing air temperature causes shorter drying times. The combined effect of drying temperature and time on colour and re-hydration ratio were also evaluated. The colour was measured from the surface and expressed in the Hunter L\*a\*b\* system. Moreover, the total colour change ( $\Delta E$ ), chroma (colour saturation), hue angle and browning index (BI) were determined. L\* and b\* parameters were found to decrease as affected by drying temperature and drying time, whereas a\* parameter increases. Results also indicated that drying time has significant effect on colour change and rehydration ratio. The lowest total colour change and highest rehydration ratio were obtained at drying air temperature of 80°C then 70°C and finally 60°C with drying time of 3, 5 and 7 hours, respectively. In contrast to common practice, drying at elevated air temperature (80°C), instead of 60°C for a longer time, was optimal, since significant colour changes of mango slices were not observed. Moreover, at increased temperature, drying time was considerably shortened from about 7 h to 3 h, resulting in significant extension of drying capacity.

**Keywords:** drying models, mango, re-hydration ratio, thin-layer drying

## **Integration of Calneem Oil and *Habrobracon hebetor* (Say) (Hymenoptera: Braconidae), a Parasitoid of Pyralid Moths, against *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae) in Stored Rice**

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The worldwide growing demand for 'clean food' and better ecological approaches to pest control has been the stimulus for further research into the use of neem extracts to control stored pests. Calneem is a new commercial product that was extracted from the neem tree (*Azadirachta indica*). It is an oil extract from pure neem seed kernels collected, crushed and used in Ghana against stored product pest insects. Calneem is a biopesticide produced and marketed in Ghana by AQUA AGRIC Community Projects (AACP). Experiments were carried out in the laboratory to assess the compatibility of calneem oil and the parasitic wasp *Habrobracon hebetor* against *Corcyra cephalonica*. 50 ml of cracked rice were placed in 1 l glass jars and 20 last instar larvae of *C. cephalonica* were added. 10 freshly emerged adults of *H. hebetor* were introduced into all the glass jars. Treatments comprised control grain without neem, grain treated with only neem, grain treated only with *H. hebetor* and grain treated with neem and *H. hebetor*. The calneem oil was applied as mixture in which the oil was dissolved in water using soap as emulsifier. It was applied at four contents (0.5 % v/v, 1.0 % v/v, 2.0 % v/v and 3.0 % v/v) Each treatment was replicated four times. The openings of the glass were sealed with a piece of cloth and rubber band and then placed in a growth cabinet (temperature 25°C and 65–70 % relative humidity). Progeny emergence was recorded in all the different treatments after 3 weeks. In the samples that were not exposed to neem and *H. hebetor*, out of the 20 larvae of *C. cephalonica* almost all developed into adults. The calneem dosages and *H. hebetor* significantly reduced the emergence of *C. cephalonica* in all the treatments compared to the control. Generally, the combination of neem and parasitoids was not more effective compared to one of these two treatments alone. The scope of the presented results will be discussed.

**Keywords:** Calneem oil, *Corcyra cephalonica*, rice, stored product pests

## Experimental Results of Essential Oils Extraction from Herbs using Solar Energy

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With the increasing population and industrialisation, there is need to cut down the load of fossil fuels and to reduce environmental pollution. A large part of industrial process heat lies from low to medium temperature range which can be supplied by solar energy. The promotion of small scale agro-based industries by using innovative solar collectors can open new landmarks in rural development especially in tropical countries. The results of solar distillation are involved in “LILAC” project to promote agro-based industries. Essential oils are used in medicines, food, fragrances, perfumery and cosmetics and their extraction from herbs is one of the medium temperature agro-based industries that can play a vital role in promoting agriculture and farmer’s living standard. Scheffler concentrator was used for solar distillation system. The system was installed at solar campus, University of Kassel, Witzenhausen to avail fresh supply of different herbs. The system comprised of a paraboloidal type primary reflector ( $8\text{ m}^2$  aperture area), secondary reflector ( $0.343\text{ m}^2$ ), steel boiler, condenser and Florentine flask to separate the essential oils from hydrosol. Scheffler concentrator tracks the sun beam radiations by simultaneous rotation about two axes to focus on a stationary receiver. The solar distillation system was also equipped with Pyranometer and thermocouples to record real time data. The paper describes the development and experimental results of solar distillation system. In the first phase of the research, several trials were made to evaluate the performance of the system. Within the solar radiations range of  $700\text{--}800\text{ W m}^{-2}$ , the receiver temperatures were recorded between  $300\text{--}400^\circ\text{C}$ . Several water boiling tests were conducted in sensible and latent heat range at different column heights to test the system suitability for distillation of essential oils. In the average range of solar radiations of 739, the average power was found to be 1.58 kW and distillation system efficiency was found to be 26.79 %. Different herbs like melissa, peppermint, lavender, fennel seeds, cumin, basil and cloves buds were used for solar distillation. The results of solar distillation were found similar to laboratory results showing that solar distillation can be successfully used for extraction of essential oils.

**Keywords:** Essential oils, hydrosol, Scheffler concentrator, solar distillation



## Investigation of Optimal Thermal Parameters During Distillation of Essential Oils from Herbs

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Essential oils and aromatic plants have long been used throughout the world in foods, fragrances, perfumery, cosmetics and medicines. In the last decade, these potent natural remedies have gained enormous popularity in industrialised countries particularly in the multi-million-dollar aromatherapy business. Different methods like distillation, cold expression and solvent extraction etc are used for essential oils extraction. Out of all these methods, distillation methods have advantage of extracting more refined essence of the plant materials and herbs by evaporating volatile material. Due to complicated and sensitive thermal processes, distillation techniques are only limited at commercial scale. The main object of the paper is to develop simple and best methodologies for easy adaptation of these techniques. The trials are involved in the “LILAC” project investigations and possibilities to promote small scale agro-industrial processing. The laboratory apparatus comprised of electric heater of 250 watts, round glass boiler having 2 liters capacity, glass still tube, condenser and Florentine flask. The laboratory experiments were carried out with the help of insulated glass distillation unit. In each experiment, 100 gram of the herb material was used. The energy consumptions of different herbs for water and steam distillation were determined with the help of energy meter. The optimal thermal and physical parameters were recorded for different herbs. The process curves for different medicinal, culinary herbs were also drawn against different energy levels and compared. The heat energies required to extract one ml of essential oil of cloves buds, fennel, cumin, melissa, patchouli, cassia, orange peels, lavender, peppermint were found to be 0.19, 0.75, 0.50, 4.44, 4.01, 2.22, 4.15, 2.95, 3.33 kWh respectively. It was also concluded that fresh herbs gave better extraction results with comparatively low process heat requirement. Consequently, these results are helpful in adaptation of distillation technology at commercial scale.

**Keywords:** Aromatic plants, cold expression, essential oils, solvent extraction

## Utilisation-Orientated Harvest Time Decision: A Chance to Enhance the Marketability of Fresh Longan Fruits

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For farmers in northern Thailand, fresh longan fruits (*Dimocarpus longan* Lour.) play a key role in income generation. However, due to their high perishability, the profit is often unsatisfactory, with sale being limited to local markets and some export within Asia. To avoid decay and browning, pre-treatments like sulphur fumigation are commonly used, but make the product less suitable for international markets. Farmers must consider sustainable fruit production and quality aspects to improve income security through enhanced marketability of fresh longans and access to more distant export markets.

Customers from different markets request diverse sensory qualities for dessert fruits, which differ from quality standards for fresh fruits at processing facilities. Required shelf-life is depending on distribution and storage times needed. Since postharvest ripening of non-climacteric fruit is impossible, the production of high-quality longans mainly depends on the selection of proper raw material and harvest time decision.

The aim of this study was to investigate the levels of utilisation-orientated quality and shelf-life that are achievable through proper physiological maturity without any further postharvest treatment.

Longan fruits cv. Daw were obtained during harvest season 2007 from a research orchard in northern Thailand. Five harvesting dates at regular intervals were chosen, covering the whole harvest period. The maturity-depending initial fruit quality was evaluated on each harvesting day for fruits of different size categories. For monitoring of shelf-life, all samples were stored for 21 days at 5 °C and 90 % RH. A broad range of outer and inner fruit quality parameters was regularly monitored, in addition to physiological and chemical indicators of senescence and decay. Irrespective of harvest maturity, high perishability became evident by rapid changes in peel properties, as observed after 3 days of storage. Further size-depending quality changes were noticed after 8 and 13 days, respectively. Different stages of fruit decay and senescence were detected for the longans of diverse maturity after 21 days. This information makes utilisation-orientated harvest time decision more reliable for farmers and serves as basis for the development of innovative concepts necessary for an appropriate postharvest handling of Sapindaceae fruits.

**Keywords:** Fruit quality, longan, picking maturity, postharvest, ripeness, shelf-life

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## **Host Specificity of *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae* Isolates from Mango, Papaya and Rambutan and their Response to *Trichoderma harzianum***

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Anthracnose (*Colletotrichum gloeosporioides*) and stem end rot (*Botryodiplodia theobromae*) are the two most prevalent post harvest diseases that contribute significantly to post harvest loss of Papaya, Mango and Rambutan in Sri Lanka. The problem is compounded by the home garden system of horticulture practised in Sri Lanka. The objective of this study was to test the ability of these pathogens to cause disease by cross infection between crops and to provide information that would facilitate an integrated non chemical means of controlling post harvest loss due to disease. Thus *C. gloeosporioides* and *B. theobromae* were isolated from respective disease carrying mango, papaya and rambutan fruits. Pure cultures of each isolate were maintained on Potato Dextrose Agar at 28°C. The antagonistic effect of a local isolate of *Trichoderma harzianum* was tested via *in vitro* bio assays against the above isolates. Host specificity trials were conducted on mango (var. Karthakolomban) and papaya (var. Red Lady) at the 10 % – 25 % stage of maturity and rambutan (cv. Malwana special selection), at full ripe stage. Cross inoculation potential of isolates was confirmed by testing the ability of the respective organisms to produce characteristic disease symptoms when inoculated onto each of the above host tissue. Lesion diameter was recorded over 5 days with fruits incubated at 28°C ± 2°C. *T. harzianum* was observed *in vitro* to be antagonistic to all isolates of the respective anthracnose and stem end rot causing pathogens. While the three *C. gloeosporioides* isolates produced disease lesions on all hosts, respective isolates were observed to produce larger lesions (diameter 2.9cm – 5.8 cm) on their original host compared with the alternate hosts (diameters 1.1 cm – 2.6 cm ). However, the three *B. theobromae* isolates were equally effective in causing stem-end rot on the three hosts examined.

**Keywords:** *Colletotrichum gloeosporioides*, *Botryodiplodia theobromae*, host specificity, mango, papaya, rambutan, *Trichoderma harzianum*

## Study on Drying Cloves (*Syzygium aromaticum*) using Greenhouse Effect Solar Dryer Integrated by Biomass Energy

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A study on drying cloves (*Syzygium aromaticum*) was conducted in Bogor, Indonesia, in November, 2008. The purpose of this study is to evaluate the performance of GHE-hybrid dryer applying greenhouse effect mechanism and biomass energy to improve drying air temperatures, and electricity to force the drying air. The GHE-hybrid dryer tested is a deep bed crop dryer represented by 10 series of thin layers covered by polycarbonate sheet. The dryer is supported by 2 axial fans and a biomass stove. The biomass stove is equipped by 99 baffles functioning as heat exchanger. For each drying batch of 1 cm thickness, the drying capacity is 144 kg of cloves. The temperature of drying air from the collector varied between 28 and 52°C and cloves could be dried in 42 hours (6 days) where drying process was run intermittence during the day. Drying chamber temperatures varied in average between 36 to 46°C. The different temperatures among 10 layers were from 3 to 12°C. Air velocity found in drying chamber was in range of 0.04 to 2.09 m s<sup>-1</sup> by average of 0.68 m s<sup>-1</sup>. Thermal efficiency is found about 15 %, and drying efficiency is around 23 %. Based on the cloves initial moisture content of 71.32 %, the energy specific found was 16.79 MJ per kg of evaporated water. The energy input was dominated by the use of biomass energy (75 %) since the research was conducted during the beginning of rainy seasons. Solar energy contributed about 15 % and electricity shared about 10%. It was estimated that due to the variation of temperatures, air velocity, and humidity in the drying chamber the final moisture content wet basis varied highly from 0.2 % to 19.2 %.

**Keywords:** Biomass energy, cloves, solar dryer, greenhouse effect

# Crop quality

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## Response of Cane Quality to Some Management Measures under Northwest Sennar Conditions, Sudan

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Field experiment was conducted at Northwest Sennar Cane Farm, Sudan during season 2003–2004 to evaluate the effect of soil type, cane-cultivars and phosphorus fertilisation on cane quality. Dinder and Hagu soil series cultivated with CO-6806 and CO-527 cane cultivars, fertilised with 4 levels of P were the treatments applied to the experiment. The treatments were laid in split-split plot design. Pol %, brix %, purity and fiber percentages were the quality parameters tested against the 3 factors and their combinations. The effect of soil type on pol % was found to be significant ( $p \leq 0.05$ ) at 12 and 13 months crop age where as the cane cultivar had a significant ( $p \leq 0.05$ ) on pol % at 10, 11 and 12 months crop age. The effect of treatments on pol % was significant ( $p \leq 0.05$ ) at 10 months crop age. The interactions of the three factors had no significant effect on pol% and brix % at the 4 tested ages. At 13 months age the highest brix % (22.32 %) was obtained by CO-6806, Hagu soil and OP interacting conditions. As for fiber % the soil type was found to have a significant effect ( $p \leq 0.05$ ) on fiber % of cane and the lowest fiber % was achieved by OP treatment, Hagu soil and CO-6806 cultivar interacting conditions.

From the indications of this study we can conclude that cane quality parameters are significantly affected by cane management which is not contained in our sugarcane research programme. Based on this it is recommended to include the response of cane quality together with tonnage to different cane management.

**Keywords:** Sudan, sugarcane fertilisation, sugarcane quality

## Optimising the Use of Near Infrared Reflectance Spectroscopy (NIRS) to Predict Nutritional Quality in Cowpea (*Vigna unguiculata*) Leaves for Human Consumption

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In eastern Africa, reliable laboratory services are scarce and relatively expensive. Near infrared reflectance spectroscopy (NIRS), as a non-destructive, rapid mass screening technique, has shown an impressive throughput of analyses, once robust calibration equations are developed. Legume leaves like those of cowpea (*Vigna unguiculata*) are very popular as leafy vegetables in eastern Africa. A calibration equation for crude protein (CP) was developed within the framework of the ProNIVA project (Promotion of Neglected Indigenous Leafy and Legume Vegetable Crops for Nutritional Health in eastern and southern Africa) largely financed by the German BMZ. The available equation was based on 107 samples selected from a broad spectrum of accessions from Tanzanian environments. The present study addresses the optimization of NIRS to perform analysis of nutritional parameters (*i.e.*, CP) in a range of cowpea accessions grown under different experimental environmental conditions in East Africa and compare them with locally grown varieties in farmers' fields and those sold in selected Kenyan and Tanzanian markets. In total, 561 samples representing a wide range of environments in Tanzania and Uganda as well as genotypic variation (10 accessions in addition to about 10 landraces) were scanned using a FOSS 6500 spectrophotometer. Sample processing involved sun-drying and freeze-drying, while milling was done using a standard lab grinder and a coffee grinder. 167 samples were selected for reference analysis and to expand the existing calibration set of 107 samples, based on their spectral characteristics, with a 26 PCA-Factor-model using WinISI II version 1.50 software. The obtained calibration set of 274 samples was expanded with a further 20 samples (10 with the highest and 10 with the lowest CP content), which were selected from the remaining 394 samples. A modified partial least-squares (PLS) regression with cross validation was used to confirm the equations and identify possible spectral outliers (H-value >3, where H is the Mahalanobis distance). The calibration equation obtained permits determination of CP content in a broad range of cowpea leafy vegetable originating from typical East African agro-environments. This will save resources for laboratory analysis while obtaining reliable values for nutritional quality of cowpea leaves.

**Keywords:** African leafy vegetables, calibration equation, cowpea, crude protein, eastern and southern Africa, multi-location trial, NIRS, nutritional quality, *Vigna unguiculata*

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## Nutritional Characterisation of Passion Fruits, Pineapple and Mangoes in Tanzania

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Fruits are considered important as cash crops that have good development prospects and substantial impact on the incomes for majority in Tanzania. Fruits contain several health-promoting factors including fiber and high concentrations of phenolic acids, flavonoids, vitamins, and minerals. Phenolic acids and flavonoids, although not essential for survival, may over the long term provide protection against a number of chronic diseases. Minerals play a vital role in the maintenance of human health.

The present study intended to evaluate nutritional parameters, which play a role in quality evaluation of organically grown mango (*Mangifera indica* L.) cv. "Dodo", yellow passion fruit (*Passiflora edulis* f. *flavicarpa*) and pineapple (*Ananas comosus* L.) cv. 'Smooth Cayenne' to meet local and international market standards. Special focus is given on compounds that contribute to human nutrition, such as total phenolic and mineral contents.

Mango juice was characterised by the highest concentration of phenolic contents in 100 ml juice (2.80 mg) followed by pineapple (2.52 mg) and passion fruits (2.11 mg). Passion fruits were characterised by the highest phosphorus content per 100 g dry matter (23.71 mg), mangoes (11.84 mg) and pineapples (7.1 mg). Potassium content per 100g dry matter was also significantly highest in passion fruits (1537.99 mg) compared to mangoes (926.72 mg) and pineapples (801.92 mg). Iron content per 100 g dry matter was significantly higher in passions fruits (2.72 mg) than in pineapples (1.06 mg) and mangoes (0.69 mg)

Pineapples fruits have higher contents of calcium in 100 g dry matter (72.2 mg) than mangoes (62.08 mg) and passion fruits (41.37 mg). The content of magnesium per 100 g dry matter was also higher in pine apple fruits (1331.05 mg) compared to passion fruits (1084.96 mg) and mangoes (774.45 mg). Manganese was also significantly higher in pineapples fruits (69.92 mg) than in mangoes (1.33 mg) and passion fruits (0.5 mg).

Mangoes, passion fruits and pineapples consumed as fresh and juices are good source of phenolic compounds. Passion fruits and mangoes are good source of phosphorus, potassium and iron, while pineapples are good source of calcium, magnesium and manganese.

**Keywords:** Mangoe, minerals, passion fruits, pineapple, total phenolics

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## Root Yield and Nutritional Quality of Carrot Cultivars from Myanmar and Germany as Affected by Different Nitrogen Levels of Organic and Mineral Fertilisers

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Use of chemical fertilisers is a critical factor limiting carrot production by poor farmers in Myanmar due to their high prices and generally farmers use their own landraces by the application of organic manures. However, the knowledge of the local landraces as well as their responses to the different organic manures, e.g. certain yield and quality, is of great importance. The pot experiment was conducted at the section Quality of Plant Products of the Georg-August University Göttingen, to investigate the root yield and nutritional quality parameters of chosen carrot (*Daucus carota* L.) cultivars exposed to the different nitrogen levels of mineral and organic fertilisers. In the split-split-plot experimental design with three replicates, three kinds of fertiliser (mineral fertiliser, farmyard manure (FYM), and compost) were allocated to the main-plots, and the nitrogen levels ( $N_1 = 60$ ,  $N_2 = 120$ , and  $N_3 = 180 \text{ kg ha}^{-1}$ ) to the sub-plots. Cultivars from Myanmar (Mogyo, Pawedaung, and Srup) and Germany (Fly Away and Purple Haze) were set as sub-sub-plot factors. Percentage of premature flowering as well as root yield was significantly influenced by genotype along with the kind of fertiliser. Carrot cultivars from Myanmar were bolted up to 56 %, while none of German cultivars were bolted. German cultivars were more susceptible to the kind of fertiliser and achieved higher yield by mineral fertilisation. The highest total carotenoids contents were observed in cultivars from Myanmar at  $N_2$  and  $N_3$  levels applied in form of FYM fertilisation. The highest total antioxidant capacity was found in cv. Purple Haze regardless the nitrogen levels and kind of fertiliser. Significantly highest amounts of nitrate contents were observed in cv. Srup supplied with mineral fertilisation. Pawedaung cultivar was most sensitive to the N levels, i.e. the higher the N rate, the higher the amount of nitrate content in all types of fertilisers. Generally, higher yields as well as better nutritional quality were found in German cultivars. However, the highest total carotenoids content as a very important parameter of human nutrition was observed in Myanmar cultivars by the application of FYM at  $N_2$  and  $N_3$  levels. These results could be part of recommendation to the farmers in Myanmar.

**Keywords:** Carrots, mineral fertilisers, organic fertilisers, nitrogen levels, nutritional quality

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## Protein Quality Improved Waxy Maize Varieties for South East Asia

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Waxy maize (*Zea mays*) is an important food source among ethnic minorities in South-East Asia. The soft grains are very popular for preparing traditional dishes such as porridge or for the direct consumption of the ears as a vegetable. The cultivation of waxy maize takes place mainly in marginal regions in a micro-scattered way. In waxy maize, starch basically consists 100 % of branched high-molecular amylopectin; this trait is controlled by the recessive allele of the waxy gene (*wx*, located on chromosome 9).

Waxy maize contains reduced amounts of essential amino acids such as lysine, tryptophan and threonine. This represents a major problem in regions where animal protein is scarce and expensive and maize represents a major food source, often leading to infant malnutrition.

QPM (quality protein maize) arose from a mutation controlled by the recessive opaque-2 gene, which leads to a reduction in the synthesis of the highly indigestible storage protein zein and in an increase in the levels of lysine and tryptophan.

The main goal of our project is the development of protein quality improved waxy maize of acceptable agronomic and organoleptic properties, and well adapted to marginal regions of South-East Asia.

The way to achieve this goal will consist of the introgression of pre-selected QPM material into pre-selected waxy maize material, which was collected from several ethnic minority groups in Viet Nam, Thailand and China. The introgression of QPM into waxy maize will rapidly be achieved by the *in vivo* gynogenesis technique, a method which allows the rapid gain of double-haploid, and therefore, homozygous lines. For this step, the *in vivo* gynogenesis inducer lines RWS and RWK76 from University of Hohenheim will be used. Double recessive (*wx* and opaque-2), double haploid lines will be selected according to their agronomic and organoleptic characteristics, and will serve as core material for the production of experimental varieties

**Keywords:** Inducer lines, *in vivo* gynogenesis, opaque2, waxy

## The Molecular Basis of Flowering in Longan

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Longan (*Dimorcarpus longan* Lour.) is a commercial fruit crop mainly cultivated in subtropical countries of Southeast Asia. In Thailand, longan flowers from late December to late February due to flower inducing climatic conditions with a relatively dry and cool (<18°C) environment throughout the natural period of flower induction from mid November to mid December. However, the application of potassium chlorate (KClO<sub>3</sub>) can induce off-season flowering within 20–30 days even so climatic conditions may not be suitable. Thus, this chemical offers a unique opportunity not only to improve the irregular bearing behaviour of longan but also to use it as a potent inducer of longan flowering all year. It is hypothesised that an alteration in the hormonal status triggers the programmed sequential morphogenetic events and turns the switch from vegetative to reproductive bud meristem. Specific genes, coding for hormone biosynthesis and/or flowering will therefore be up-regulated, temporarily or spatially, with the transition to flowering in tree crops. Several genes involved in the switch from vegetative to floral bud meristem have already been identified and characterised in *Arabidopsis*. Some of the molecular basis in this flowering process has been shown to play a similar role in other annuals. A central protein in this process is flowering locus T (FT), which trigger flowering once it accumulates to high levels in plant tissue. We attempt to identify the molecular basis of flower induction in Longan by expression patterns of genes that encode for proteins similar to *Arabidopsis* flowering genes. Six-year-old potted longan trees were grown at Chiangmai University, Thailand conducted to compare the effects of KClO<sub>3</sub> application on flower induction in between longan and litchee trees. Six-year-old potted longan trees were grown in Horticulture station, Faculty of Agriculture. Potassium chlorate was applied at 15 g pot<sup>-1</sup> to fully mature plants as soil drench in April 2008. Samples for RNA extraction from terminal buds and leaves were collected 6 times at 7 day intervals following application. Eight degenerate primers of FT (FTDEG) were designed by using five highly conserved regions of *Arabidopsis thaliana*, *Vitis vinifera*, *Citrus unshiu*, *Oryza sativa* and *Hordeum vulgare*. Four of the FTDEG primers were successfully amplified in Longan and fragments were subsequently cloned and sequenced.

**Keywords:** Degenerate primers, flowering locus, longan, off-season fruit

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## Experimental Determination of the Influence of Color Type and Environmental Factors on the Concentration of Secondary Metabolites in the High Andean Plant Maca

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Maca (*Lepidium meyenii* Walpers, also known as *Lepidium peruvianum* Chacón) grows best in the central Peruvian and Bolivian Andes between 3,800 and 4,500 m a.s.l. The persistent interest in this plant is based on its assumed fertility effects. These effects are reported to vary between maca colour types, and our preliminary study indicated that these types also might differ in potentially biologically active plant secondary metabolites. These include macaene, macamides, glucosinolates, campesterol and beta-sitosterol. The present study aimed at determining the influence of the factors colour type, soil type and planting history on the concentrations of the above mentioned compounds of maca hypocotyls in a controlled study. In the planting experiment, four colour types (yellow, red, violet and lead-coloured) were cultivated at two soils/locations (Ultisol/Alpacayán, Department of Pasco, Perú, and Vertisol/Patalá, Department of Junin, Peru) at 4,200 m.a.s.l. At each location two terrains were chosen (untouched or cultivated with maca in the 2–3 previous years). The harvested plant material (n=4 per colour type, location and terrain) was lyophilized, milled and analysed for the above mentioned metabolites, and data was subjected to analysis of variance considering all factors. The interactions were not significant. Color type had a significant influence on the concentration of macaene, macamides and the aromatic, indole and alkylthioalkyl glucosinolates, but not for the sterols and olefine glucosinolates. Across both locations and both terrains, lead maca (not analysed in the preliminary study) had the highest concentrations of glucosinolates, primarily due to higher contents of aromatic and indole glucosinolates. Violet maca exhibited the highest alkylthiolalkyl glucosinolate content, red maca showed the highest macaene and macamides content, while yellow maca was low in most metabolites, especially macaene and macamides. The glucosinolate content was higher in Patalá, and the macaene, macamides and beta-sitosterol content was higher in Alpacayán. The terrain had a significant effect on campesterol concentration only. The present results confirm the large importance of the colour and soil type and, to a lesser degree, of previous cultivation of the site on maca's metabolite composition thus explaining its variable effects on fertility reported.

**Keywords:** Beta-sitosterol, campesterol, glucosinolate, *Lepidium meyenii*, macamide, plant secondary compounds

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## Variation in Chemical Composition of the Hypocotyle of Maca (*Lepidium meyenii* Walp.) cultivated in Czech Republic and in Peru

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Maca (*Lepidium meyenii* Walp., Brassicaceae) is a Peruvian crop cultivated in the Andes mountains for its hypocotyl that is used exclusively for medicinal purposes. According to folk beliefs, Maca is an aphrodisiac which enhances sexual drive and female fertility in humans and domestic animals. These beliefs have been sustained by various experiments in rats and in men. Maca has been reported to be rich in amino acids, glucosinolates and alkaloids macamides, which are probably responsible for the aphrodisiac effects and therefore the main quality markers in Maca.

The nutritional value (relative contain of macamides, fatty acid composition and energetical value) of three samples of Maca of Peruvian origin was compared to one sample of Maca cultivated in Czech Republic. The plant material was obtained from commercial sources except the sample that was grown on an experimental field of the Czech University of Life Sciences Prague. Although the growth period of Maca in Czech Republic was approximately the same as in Peru, the yield of bulbs was much lower than in samples of Peruvian origin. All the samples were prepared by extraction and repeated percolation in petrolether and analysed by RP-HPLC with DAD detection. The macamides and fatty acids were tentatively identified by retention time comparison on Agilent Eclipse XDB–C18 column and UV spectra matching. Bound fatty acids were determined as methylesters after alkaline hydrolysis using gas chromatography. Gross energy was determined using calorimetry.

There was a significantly lower concentration of macamides in the sample grown in Czech Republic compared to the Peruvian samples (4–9 times lower). The same was found for free fatty acids, linoleic acid and linolenic acid. The gross energy of Maca averaged 1740 kJ pro 100 g and was similar in all samples as well as the composition of bound fatty acids. The analysis showed that Maca cultivated under the climat condition of Czech Republic is similarly rich in energy as Maca cultivated in Peru, but it contains significantly lower concentrations of bioactive macamides and free fatty acids.

**Keywords:** Fatty acids, *Lepidium meyenii*, macamides, nutritional value

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## ***Artemisia annua* ANAMED, a Medicinal Plant for Malaria Treatment: A Study on Growth Performance and Artemisinin Content under Tropical Highland Conditions of SW Ethiopia**

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Worldwide approximately 300 million people are affected by malaria. Previously extremely widespread, malaria is now mainly confined to Africa, Asia and Latin America. The problems of controlling malaria in these countries are aggravated by inadequate health structures and poor socioeconomic conditions. The situation has become even worse over the past years with an increasing resistance to the drugs normally used to combat the parasite causing malaria. Alternatives are therefore urgently required. *Artemisia annua* contains artemisinin in leaves and flowers, a sesquiterpene lactone effective against drug resistant malaria. The World Health Organisation (WHO) recommends an Artemisinin based Combination Therapy (ACT). A tea based therapy is also available, which is favoured by low income population as it is less expensive. A new strain – *Artemisia annua* ANAMED – adapted to tropical conditions was introduced to southwestern Ethiopia in 2001, a malaria prone area. This study aimed at assessing the growth performance of A-3 and changes of its artemisinin content as affected by environmental conditions. Therefore, field trials were established during October 2006 and July 2007 at three locations in the Gamo Gofa Highlands of SW Ethiopia. Sites varied in altitude, climate and soils. *Artemisia* performance was monitored by monthly collecting plant samples to determine plant growth and variations in artemisinin content. Artemisinin was determined by using the High Pressure Liquid Chromatographic (HPLC) method. Results indicated strong environmental impacts on crop growth, dry matter production and artemisinin synthesis. An altitude of 2,200 m a.s.l. with a minimum and maximum temperature of 17.3 and 24.5°C led to a better performance (dry leaves: 2.9 vs. 1.4–1.7 t ha<sup>-1</sup>; artemisinin: 1.07 vs. 0.57–0.91 %) than higher elevations (2,600–2,900 m a.s.l.) and lower temperatures (8.4/18.3 and 10.4/16.3°C). It was also observed that a lower but well distributed rainfall (480 vs. 850–1050 mm) found at the lower elevation was also favourable for *artimisia* growth. This information is valuable to identify potential sites suited for A-3 cultivation. Thus, it may foster its promotion in Ethiopia and other countries, leading to an improved health situation of the rural population in malaria prone areas and contribute to income generation for small scale farmers.

**Keywords:** *Artemisia annua*, artemisinin, crop growth, environment, malaria treatment, medicinal plant

## Can we use Mid-Infrared Spectroscopy (MIRS) for Quantifying Artemisinin, an Antimalarial Compound of *Artemisia annua*?

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In the tropics malaria kills one person every 20 seconds. This disease is caused by four species of the genus *Plasmodium* - protozoan parasites - transmitted by the female *Anopheles* mosquito. *Plasmodium* has become resistant to most of the presently available antimalarial drugs. Currently, resistance to malaria drugs is spreading and new treatments are urgently required. *Artemisia annua*, an in China for more than 2000 years well known medicinal plant seems to provide an alternative option. Artemisinin, a sesquiterpene lactone, is one of its various active agents and is effective against the plasmodium. It is part of the WHO artemisinin-based combination therapy (ACT), recommended since 2001. In addition, a treatment with tea based on *Artemisia* leaves has proved to be successful in 80 % of treated cases according to ANAMED (Action for Natural Medicine). For quality control, a rapid method to detect artemisinin content in plants is highly desirable as artemisinin content strongly varies within plant and among varieties. Currently employed methods are high performance liquid chromatography (HPLC) with electrochemical detection, recommended by the World Health Organisation (WHO), and an indirect measurement using gas chromatography (GC). Alternatively, we tested if Diffuse Reflective Fourier Transform Mid-Infrared Spectroscopy (DRIFT-MIRS) can be considered as a novel and fast option to determine artemisinin content in plant materials. For this study, the artemisinin content of 20 plant samples was measured with HPLC and MIRS. Pure artemisinin was used to identify corresponding MIRS reflectance peaks and regions. Due to the characteristic intrinsic chemical structure of artemisinin characteristic peaks could be detected by MIRS. Both HPLC and MIRS measurements were subsequently linked to produce a Partial Least Square Regression model for artemisinin quantification. The artemisinin content of unknown samples was well predicted by this model. Estimating 20 other plant samples with HPLC and MIRS showed a high correlation of artemisinin content ( $r^2=92\%$ ) between the two methods. Thus, MIRS is considered to be a fast and viable alternative method with flexibility in application while requiring only small amounts of samples.

**Keywords:** *Artemisia*, artemisinin, malaria, mid infrared spectroscopy

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## Partitioning of Non-Structural Carbohydrates in the Fruiting Cape Gooseberry (*Physalis peruviana* L.) Plant

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Cape gooseberry (*Physalis peruviana* L., Solanaceae) originates in the Andean zones and as a semi-woody perennial plant grows half-wild between 1,500 and 3,000 m altitude from Colombia to Chile. Although in Colombia it has become the second important export fruit, scarce information exists about the carbohydrate partitioning in cape gooseberry. However, carbohydrate partitioning plays a major role in plant productivity and later might play a signalling function during plant pathogenesis. Seed propagated ecotype 'Colombia' was kept in a greenhouse (22°C, 75 % RH) in 2.5 l black plastic containers in washed quartz sand and triple irrigated daily 300–500 ml per pot with a Wuxal solution (8:8:6 (N:P:K)), while Ca and Mg were taken from tap water. Plants were pruned up to one main vegetative stem with two generative leaders leaving the lateral generative shoots with the first node. Dry matter (DM) partitioning during initial plant growth showed the highest accumulation rate in roots during first 20 days, whereas at a later stage of development shoot DM gain was higher and leaf DM gain lower than in the roots. Sixty days after transplanting, plant parts were analysed for glucose, fructose, sucrose, and starch. As in other perennial plants, roots were the greatest carbohydrate pool for starch. Root sucrose content was lower than in the vegetative stem and the lower part of the reproductive axes. At 5–15 cm of the vegetative stem base 6.4 % starch, 1.4 % monosaccharides and 5.3 % sucrose were found, indicating that this lower organ is also important for starch accumulation and, especially, for sucrose transport. In the two reproductive axes, starch contents were much higher in the base part than in the apical one; the same relation was found in leaves. Monosaccharid content was highest in the apical stem position with 8.2 %. In contrast, apical positioned 10 days old fruits had maximum starch levels (11.6 %), possibly, of primary starch from own photosynthesis, whereas mature basal fruits (60 days) accumulated principally sucrose (27.7 %) and monosaccharides (21.2 %). Whereas in vegetative plant parts glucose contents were 51–69 % higher than those of fructose, in fruits their contents were nearly the same ones.

**Keywords:** Carbohydrate partitioning, *Physalis peruviana*

## **Risk Factors for Malnutrition of Rural-to-Urban Migrant's Children (<5 years) in Comparison to Urban Children in two Kindergartens in Beijing, China**

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**OBJECTIVE:** To investigate risks factors that influence the health- and nutritional status of rural-to-urban migrant- and local children in Beijing.

**METHODS:** Assessment included height, weight, MUAC, dietary intake and a questionnaire to explore family background and (breast) feeding practices. 103 migrant- and 108 local children and their mothers were recruited.

**RESULTS:** Migrant children are more likely to suffer from mild/moderate (<-1 SD) stunting (30.1 % vs 12.0 %), underweight (28.2 % vs 9.3 %), and wasting (22.3 % vs 3.3 %) than local children while local children had a higher prevalence of mild/moderate (>+1 SD) overweight (14.8 % vs 9.7 %). Migrant girls are at higher risk than local girls for mild/moderate stunting (37.5 % vs 18.8 %), underweight (33.3 % vs 12.5 %), and wasting (27.1 % vs 4.2 %). Local boys have a higher prevalence than migrants boys of overweight (20 % vs 12.7 %), and local girls are also more likely than migrant girls to be overweight (8.3 % vs 6.3 %). According to 24-hour dietary recalls, migrant children lack age-specific energy intake and fall short of micronutrients like calcium, iron, zinc, potassium, vitamin B2 and folic acid. The calcium and folic acid intake of local children also did not reach age-specific recommendations. Migrant mothers were younger ( $28.1 \pm 3.6$  vs  $30.7 \pm 3.2$ ,  $p < 0.05$ ), received less education (3.9 % vs 46.3 % attended higher education) and had more children ( $1.2 \pm 0.5$  vs  $1.009 \pm 0.09$ ,  $p < 0.05$ ) than local mothers. Migrant families had lower income ( $715.6 \pm 508.8$  vs  $1580.2 \pm 834.7$  RMB per person/month,  $p < 0.05$ ), and lived in smaller rooms ( $7.7 \pm 6.1$  vs  $23.6 \pm 8.9$  m<sup>2</sup>,  $p < 0.05$ ) often without private water pipe and toilet. For both migrant and local children, initiation of breastfeeding was delayed up to 3 days after birth, more than half of the newborns received pre-lacteal feedings. The duration of exclusive breastfeeding ( $4.7 \pm 3.1$  vs  $4.3 \pm 2.8$  months) as well as total duration of breastfeeding ( $15.1 \pm 6.0$  vs  $14.4 \pm 5.4$  months) was short in comparison to WHO recommendations.

**CONCLUSION:** Migrant children (especially girls) are a risk group for undernutrition while local children (especially boys) are more likely to be overweight. Feeding habits, dietary intake and family factors strongly influence nutritional status of migrant and local children.

**Keywords:** Migrant children, infant feeding, nutritional status, dietary intake, kindergarten, China, Beijing

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## Development of a Multipurpose Pan for Date Processing

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In almost all countries where date palm is a traditional cultivation part of the dates are harvested for processing and main products are paste and syrup. Syrup is widely produced at a household level, while industrial processing is mostly done in big plants: an intermediate technology, allowing to produce syrup in a hygienically and controlled way is missing or not affordable by smaller producers.

After the experience gained in projecting and setting up a small scale date processing plant in the Iraqi Province of Dhi Qar, the author designed a multipurpose pan that can be used for rehydrating of dry dates, juice extraction and vacuum concentration for syrup production.

The main objective for carrying out this study is to provide single or associated smaller date farms with a mean for processing directly part of their dates, to obtain a healthier and more hygienic product and with lower energy input compared to what they could achieve with traditional methods.

The pan consists of a cylindrical body with a heating sleeve in the lower part and an airtight lid with an outgoing pipe for air extraction or juice circulation. This multipurpose pan is quite simple and inexpensive, taking in account the different operations that it performs, and can be produced in different sizes.

A first 80 liter prototype, capable of producing about 15 liters of syrup for each batch, has been manufactured to test and evaluate its performances and used first to rehydrate dried dates imported from Iraq and after to extract juice from them and then concentrate it. At first empiric exam and after an organoleptic test of the syrup, the pan proved to be capable to perform satisfactorily these operations and has been added to the equipment of the above mentioned date processing plant, so it will be used in a more intensive way in Iraq during 2008 harvest. In the while other tests are ongoing to measure main working parameters and define the best way of use.

**Keywords:** Date palm, syrup, processing, vacuum concentration, rehydration

## Effects of $\text{KClO}_3$ and Water Deficit on Flowering and Growth Characteristics of Longan

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Longan is one of the most important subtropical fruit crops in Thailand, both in terms of crop yield and export volume. In 1998, Thai longan farmers began to apply potassium chlorate ( $\text{KClO}_3$ ) for inducing off-season flowering and soil drench is most effective method. Nowadays fresh longan fruits are available in domestic markets almost all year round. However, irrigation management is critical for off-season longan production that falls into the rainy season. Due to high relative humidity, high soil moisture and also low light intensity the percentage of flowering is greatly reduced when compared to on(dry)-season production.

The objective of this study was (1) to study the time-dependent hormonal changes in various plant tissues following the application of  $\text{KClO}_3$  and (2) to determine whether total carbohydrates may be limited under off-season fruit production system and by establishing three crops in two years. The experiment was carried out at the Lampang Agricultural Research and Training Center, northern Thailand, and consisted of 64 two-year-old longan trees (cv. Daw) randomly assigned to four treatments; well-watered  $\pm \text{KClO}_3$  and water deficit  $\pm \text{KClO}_3$ . All trees were grown in lysimeter containers with a capacity of 150 L and treated with  $\text{KClO}_3$  in November 2007.

It was found that in water deficit and full irrigation treatments approximately 90 % of all buds flowered at 25–27 days after the application with  $\text{KClO}_3$ , whereas both treatments without  $\text{KClO}_3$  application did not flower. The efficiency of photosystem II (Fv/Fm), leaf net  $\text{CO}_2$  assimilation rate, transpiration rate and stomata conductance were reduced in all treatments except when full irrigation was applied. Leaf chlorophyll content was not significantly different between the treatments.

The change of plant bioregulators such as indole-3-acetic acid (IAA), gibberellins ( $\text{GA}_{1,3,20}$  measured as  $\text{GA}_3$  equivalents), and the cytokinins isopentenyladenin / isopentenyladenosin (iP/[9R]iP) and trans-zeatin/t-zeatin riboside (Z/[9R]Z) were determined in leaves, bark, wood and terminal bud and results will be presented at the Conference. Treatment effects on carbohydrate concentration, dry matter production, fruit yield and quality in longan will be determined destructively at harvest in June 2008.

**Keywords:** Carbohydrate, *Dimocapus longan* L., longan, leaf photosynthesis, Thailand

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## Effect of Mulberry Leaves of Different Varieties on Growth, Development and Cocoon Characters of Silkworm (*Bombyx mori*)

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Five mulberry plant varieties viz. BSRM-56, BSRM-57, BSRM-58, BSRM-59 and BSRM-34 were used to evaluate the effects of these varieties on larval and cocoon characteristics of silkworm (*Bombyx mori* L.) at Bangladesh Sericulture Research and Training Institute, Rajshahi during June – July, 2007. Silkworm larvae were under gone five larval instars on leaves of mulberry varieties and different larval characteristics: larval weight, larval length and larval breadth were collected in different growth stages. After rearing period the fifth instar larvae were transferred into mountage (Chandraki) for spinning and producing cocoon. The cocoons were then harvested and different cocoon characteristics like cocoon weight, shell weight and shell percentage and others characters like pupal weight, effective rate of rearing were collected. The results showed statistically significant difference among different varieties on larval and cocoon characteristics. The higher performance was observed by feeding the variety BSRM-34 in respect of 10 mature larval weight (40.500 mg), single mature larval length (7.660 cm) and breadth (0.980 cm), single cocoon weight (1.397 mg), shell weight (0.180 mg) and pupal weight (1.220 gm) while the average performance was recorded by feeding the variety BSRM-57 and BSRM-59 and poor performance was showed by feeding the variety BSRM-56 (in case of larval characters) and BSRM-58 (in case of cocoon characters) in respect of these characters as well as silk yield. These results indicated that the leaves of different mulberry varieties have statistically variable effect on larval and cocoon characteristics as well as silk yield, means silk yield varies with leaves of mulberry varieties.

**Keywords:** Cocoon, larvae, mulberry, pupae, silkworm

## An Evaluation of Native West African Vegetables

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Vegetables are a vital constituent of the West African diet, and traditional vegetable species are highly important yet many species of African native vegetables are poorly known, being used only locally. Native West African vegetables have in the past and presently been paid too little or no attention both by local, national and international research institutions. Seemingly, many local inhabitants in the West African region appear not to have deep scientific knowledge on the values possess by native vegetables species in their vicinity. By so doing, they sometimes turn to prefer the cultivation and consumption of exotic vegetable species rather than native ones-unconsciously or consciously rendering unexploited native vegetable species to extinction.

This research was purely a desk work research; focusing on the works of other authors with the prime aim of generating with analysis a list of native West African vegetables in terms of medicinal, nutritional and economic values. First, all the vegetables were identified based on local or regional origin, common name, scientific name, botanical family and types (leafy, root, legume or fruit vegetable). Second, the identified vegetables were then evaluated based on their nutritive, economic, and medicinal values. To this effect, a total of twenty three native West African vegetables were identified and analysed with respect to the different information sources. For example, in terms of medicinal properties, a vegetable like “Egusi” (*Citrullus colocynthis*) was found to have ribosome-inhibiting properties, potential as a therapeutic agent for HIV/AIDS... Also, nutritionally, the leaves of “Eru” (*Gnetum africanum*) species were also found to constitute an important source of protein, essential amino acids and mineral elements. It can be concluded from this research that, although native West African vegetables are not well known and documented, the few that have been identified and analysed within the scope of the current research prove to have profound nutritional, economic and medicinal potential which if well exploited would possibly open up new markets for the global commercialisation of native West African vegetables likewise, encourage the local and global cultivation, consumption and conservation of many other native West African vegetables-especially orphan species.

**Keywords:** Indigenous African vegetables, West African vegetables, vegetables native, under-utilised crops



## Cowpea (*Vigna unguiculata*) Variety Mixtures to Optimise Vegetable Leaf and Seed Yields and Stability in Central Tanzania

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Cowpea (*Vigna unguiculata*) is among the top three or four African indigenous leafy vegetables used in many parts of Africa. Both seeds and leaves of cowpea have excellent nutritional value that may contribute to feed resource-poor communities and, thereby, reduce malnutrition especially in Sub-Saharan Africa. Despite its importance, however, as leafy vegetable cowpea is ignored and has received little attention in research and development. This study was conducted within the project "Promotion of Neglected Indigenous Leafy and Legume Vegetable Crops for Nutritional Health in Eastern and Southern Africa" – *ProNIVA* (largely financed by the German BMZ). Four previously investigated promising cowpea varieties plus one local variety were tested as different mixture components at different locations through participatory research. The objective was to evaluate variety mixtures in different environments in optimizing and stabilizing cowpea leaf and seed yields as compared to pure variety production. Selected cowpea varieties included determinate and indeterminate as seed and leafy types, respectively. Established mixtures and their corresponding components were intercropped with maize (Situka M1) as the typical practice applied by farmers. Agronomic evaluation was conducted during the 2007 dry season at Makutupora Agricultural Research and Training Center (on station) and Veyula village (on farm) in Dodoma district, with irrigation according to need. Among the variables determined were fresh and dry matter leaf yields from up to five consecutive harvests, pod and seed yields with or without leaf harvesting, and phenology. All treatments (mixtures and their corresponding components) significantly differed in total fresh and DM leaf yields both on station and on farm, however, total pod and seed yields only differed on station. Using contrast analysis, mixtures showed no advantage over the mean of their components neither in leaf nor in seed yields. However, higher yield stability across different harvests was more observed for complex mixtures than in simple ones or mixture components. When interviewing farmers around villages in Dodoma district, they expressed their favouring variety mixtures because of their need for stability of both leaf and seed yields, also because they were familiar with different ways of mixtures for a better use of their scarce lands.

**Keywords:** African leafy vegetables, cowpea, indigenous african vegetables, Tanzania, under-utilised crops, *Vigna unguiculata*, vegetables

## **Germplasm Collection – Variety Tests – Seed Production – Marketing: Experiences with Local Vegetables in Lao PDR**

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Vegetables are rich sources of vitamins, micronutrients and fiber making them healthy food with high biological value. Many Lao farmers are using their own selections, adapted well to the specific environmental conditions in their local areas. Landraces are important resources for resistance to biotic and abiotic stresses. For this reason, local varieties are invaluable not only for the present but also for future generations. Between 2002 and 2006, the research team of the Haddokkeo Horticulture Research Center (HHRC), belonging to the National Agriculture and Forestry Research Institute (NAFRI), conducted nine collection trips in cooperation with the German Development Service (DED). The aim was to collect local vegetable varieties in 76 districts of all the 18 provinces of Lao PDR. As a result of these efforts, 2,100 accessions of vegetable were assembled and stored in the vegetable gene bank at HHRC.

A part of the gene bank material was subjected to screenings under natural field conditions in order to identify landraces possessing desirable characters. Activities were concentrated on locally important vegetables, such as chili, tomato, lettuce, yard long bean, and cucumber. After five years, new varieties were identified and released for seed multiplication for distribution to Lao farmers. First varieties were such of tomato and lettuce for rainy and dry seasons.

At present, the research is focused on detailed description of eggplant biodiversity. Indochina was considered as a secondary area of origin and the crop possesses a very rich diversity. More than 150 accessions from the whole country are characterised by morphological and agronomical traits to provide information for future breeding programs.

At the same time, a vegetable seed production network has been established that involves farmers around Vientiane. At present, 23 farmers' families in 11 villages are under contract system. In the season 2006/2007, they produced about 880 kg seeds of 18 open-pollinated vegetable species. Most of the seeds were sold to various projects throughout the country, to special shop owners in Vientiane or directly to the farmers. Every seed-producing family was able to earn an additional average income of 2 Million LAK (about 200 USD) through seed production.

**Keywords:** Agrobiodiversity, eggplant, genebank, plant genetic resources, vegetable seed production, under-utilised crops

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## New Varieties of Rice through Gamma Rays Application to Tackle Food Disaster in East Java Regions, Indonesia

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Paddy (*Oryza sativa* L.) is the staple food in several regions of Indonesia. Main problems in the rural areas there are that the surfaces for crop farming are delining and that the number of varieties that are adapted to the current agroecological conditions is decreasing. In 1993, Indonesia produced ca. 48.2 t ha<sup>-1</sup> of paddy. This production rose slightly to 52.2 t ha<sup>-1</sup> in 1998. However, the production increase could comply with the population development in Indonesia.

There are several ways for obtaining improved seed. For instance, through breeding new varieties with a high nutritional value or through selecting for varieties that particularly tolerate certain abiotic and biotic stresses. Breeding and mutation application are two techniques commonly used in Indonesia for enhancing plant variability. The mutation method uses gamma-rays to establish mutants that can be screened for the wanted characteristics. It is very important to identify seeds that can be used under extreme conditions as for example under very dry conditions, or on soils with high salinity.

The production of improved rice seed through gamma-rays application was enabled through collaboration with the Nuclear Centre Association. Consequently, several main characteristics such as dwarf growth, pest tolerance and natural protection against disease attacks, could be found in the produced rice seed mutants. The newly identified varieties Mira-I, Yuwono and Diah Suci are already widely spread at several locations of the East Java region. The first results showed that the mutation rice can produce about 9.8 t ha<sup>-1</sup> of rice and is absolutely tolerant to pests and diseases. This gamma-rays method is an alternative for acquiring both new phenotypes and increase genotype variability.

**Keywords:** Mutation, rice, *Oryza sativa*

## **Future of the Nigerian Under-Exploited Indigenous Fruits and Vegetables in the Era of Climate Change: The Need for Farmers Education**

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Indigenous fruits and vegetables are known to play major role in the nutritional livelihood of the Nigeria population especially in the rural areas where people cannot pay for meat, egg and milk. In the face of threats posed by climate change as exemplified by drastic changes in rainfall pattern, temperature, relative humidity, radiation, weeds-pests-diseases complex and general alterations in the trends of climatic elements, there is the need to discuss the future of the uncultivated but edible plant species which have served as basis of livelihood for the poor people over several years. Emerging evidence has shown that farmers in Nigeria are mostly illiterate and that they practise the cropping system inherited from their parents and are still caught up in the recent phenomenon of climate change. They are mostly not producing in large quantities and depend on rain for their crops. Most of the indigenous fruits and vegetables are still gathered from the wild and are not included in the research mandate of Nigerian agricultural research Institutes. In this era of climate change, it is important to discuss how these indigenous crops will not go into extinction since they are still good sources of food and possible sources of germplasm for crop improvement. The farmers therefore need to be educated on the importance of the crops and the danger of sending them into extinction in the wake of climatic change. This paper therefore discusses the diversity of indigenous fruits and vegetables in Southwest Nigeria by taking into account the available species, the density, the uses, the mode of exploitation and the role that extension education can play in bringing these crops into cultivation, especially in this era of climate change in order to prevent them from extinction.

**Keywords:** Climate change, extension education, indigenous fruits, vegetables, under-utilised crops

## Morphological Variation in Ethiopian Barley Germplasm (*Hordeum vulgare* L.)

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Ethiopia, with its diverse agro-ecological and climatic features, is well known for being one of the 12 Vavilovian Centers of Diversity. Barley (*Hordeum vulgare* L.) is one of the oldest cultivated crops and has been grown in Ethiopia for at least 5000 years. The altitudinal variation, which ranges from 110 m below sea level in areas of Kobar Sink, to 4,620 m a.s.l. at Ras Dashen, temperature and rainfall differences coupled with edaphic factors creates a wide range of ecological conditions in the country. Barley landraces, having evolved across thousands of years in a multitude of environments and local farming systems, have developed abundant patterns of variation and would represent a largely untapped reservoir of useful genes for adaptation to biotic and abiotic stresses. In Ethiopia Barley growing areas gradually diminish due to the expansion of wheat and rye cultivation in some regions. Currently the crop is pushed to marginal areas (to very high altitudes where frost prevails) and threatened by genetic erosion. Therefore, rare morphotypes are declining in frequency of occurrence through time.

The objectives of this study were to assess the extent of morphological variation in barley accessions in respect to regions and altitude of collection, to classify the accessions into relatively homogenous groups and to identify the major traits contributing to the overall genetic diversity of the germplasm. For this study a total of 199 barley landraces collected from 10 administrative regions of Ethiopia and four released cultivars were evaluated for 10 agronomic traits. The trial was conducted at Holeta and Bekoji Agricultural Research Centers, Ethiopia, in the main cropping season of 2006. In this contribution, results of this study will be presented and discussed.

**Keywords:** Ethiopia, genetic diversity, landraces, morphological variation

## **Interactive Effects of Host Genetic Background, Leaf Age and Isolate on the Inducibility of Tomato for Resistance to Late Blight, *Phytophthora infestans* by Baba (DL-3-Aminobutyric Acid)**

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Exploitation of induced resistance (IR) is a desirable strategy in plant protection since it involves enhancing natural defense mechanisms in plants. Despite the numerous instances in which induced plant responses have been demonstrated, only little use is made of these in crop protection so far. Before IR can be made use of in practice, it is important to understand as much as possible regarding the ecology and genetics of these inducing agents and their interactions with plants and pathogens. Effects of host genetic background were tested with thirteen tomato varieties. Leaf disks of plants that had been treated seven days before with BABA (DL-3-aminobutyric acid) or water were inoculated with two isolates of *P. infestans* (20  $\mu$ l sporangial solution at  $5 \times 10^4$  sporangia  $\text{ml}^{-1}$ ). Leaf age and isolate effects were tested using six isolates, six varieties and three leaf ages. There was a significant variety by treatment interaction with the degree of induction varying among varieties. Disease reductions through BABA were not the same on varieties of the same level of susceptibility. The tomato varieties, pathogen isolates, leaf ages and treatments significantly affected late blight disease development with significant interactions among tomato varieties, pathogen isolates, leaf age and treatments. These interactions indicate differing disease responses and resistance induction to tomato varieties by different isolates at different leaf ages. Level of induction was not related to the degree of susceptibility of a variety and the isolates used. The protection induced by BABA was significantly higher on the youngest leaf in all combinations of tomato varieties and pathogen isolates than on the other leaf ages.

**Keywords:** genetic variation, induced resistance, isolates effect, leaf age effect, *Phytophthora infestans*, tomato cultivars

## Natural and Anthropogenic Factors Affecting Gene Flow in Crop Sorghum and their Implications in Ensuring Varietal Integrity

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Ensuring varietal integrity is vital in achieving durable stability of introgressed traits and desirable agronomic qualities of improved crop varieties. The integrity of a variety depends on its purity and stability of heritable characteristics. Erosion of varietal integrity is mainly caused by gene flow through migration of individuals (*e.g.* seeds) or gametes (*e.g.* pollen). Presented here are results of a multi-approach based study to understand the effects of natural and human mediated factors affecting gene flow in sorghum [*Sorghum bicolor* (L.) Moench]. Outcrossing rates and pollen dispersal distances of landraces and modern varieties from Sudan and Kenya were analyzed. Further, simultaneous characterisation using molecular markers (microsatellite) of populations of several varieties from contrasting agro-eco-systems, Western Kenya and Eastern Sudan were done. On average, the Sudanese cultivars used in this study had higher outcrossing rates than those from Kenya (18.5 and 4.5 %, respectively). Pollen dispersal decreased drastically with increase in distance. Maximum dispersal distance was 200 m based on a mathematical modelling of the data. Microsatellite characterisation of *in situ* collected varieties revealed the impact of different seed systems and farming practices on their genetic structure. Differently named varieties from Western Kenya, particularly landraces were not resolved using the microsatellite data while those from Sudan were genetically well differentiated. Despite the high outcrossing rates of the samples from Sudan, the high genetic differentiation suggests that farmers' practices and seed systems play an important role. Indeed, it emerged from interviews with the farmers that varietal isolation is commonly practised in Sudan but rare in Kenya, due to small field sizes. Furthermore, the study shows that formal seed sector is more active in Sudan than in Kenya as far as sorghum is concerned. Finally, this study provides recommendations for maintenance of varietal integrity of improved varieties under diverse farming and seed management systems.

**Keywords:** Gene flow, microsatellites, outcrossing rates, pollen dispersal, seed systems, sorghum, varietal integrity

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## New Bananas for Poor Farmers in Tanzania – The Contribution of Agricultural Research to the Millennium Development Goals

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Bananas are a main staple food for rural households in East and Central Africa. Low productivity and susceptibility to diseases of traditional cultivars are major constraints for the production of food and income generation. In order to address these problems, banana cultivars with resistance to major diseases and higher yield potential have been disseminated in Kagera Region, Tanzania since 1997.

This study investigates to what extent the introduction of the new banana cultivars has contributed to the Millennium Development Goal on the reduction of poverty and hunger. Three questions were posed with particular reference to the poorest farm households in Kagera Region **(a)** to what extent have poor households adopted the new banana cultivars, **(b)** what factors drive or hinder the adoption of new banana cultivars among this group of farm households and **(c)** what has been the impact on food security and income generation. Panel data from household surveys in 2003 and 2008 were analysed to assess income growth and food security using a differences-in-differences approach. Rather than comparing absolute differences between adopters and non-adopters, in this approach growth rates over time are compared, controlling for fixed household effects e.g. differences in assets, education and/or infrastructure. The results show that the new cultivars demonstrate increased productivity thereby improving food availability in adopting households. The first adopters were households with higher education levels and larger farms. Households with more livestock assets were more likely to adopt the new cultivars, which is explained by the production of fodder as a by-product of the new bananas. However, over time, the differences in adoption rates of the new cultivars for poor and wealthier households diminished. The more marginal households were also able to use and benefit from the cultivars. Especially the lack of knowledge about processing and use of the new cultivars seemed to be a factor in delaying the adoption by poor households. These results show that in order to achieve faster impacts on poverty reduction and food security, the specific information needs of poor farmers should be addressed more explicitly in the dissemination of new technologies.

**Keywords:** Banana production, food security, impact assessment

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## Genetic Diversity and Greenhouse Modelling for More Successful Crop Production – A Case Study of *Solanum lycopersicum* grown in Greenhouses in the Tropics

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The tomato crop is an invaluable source for essential vitamins and minerals. Abiotic stresses restraint tomato greenhouse production in the tropics mainly due to high temperatures. The development of crop plants tolerant to high temperatures is essential to meet the growing food demand and sustainable agriculture.

In the tropics, where the crops are near their maximum temperature tolerance yields are likely to decrease. The objective of plant breeding for stress environments is to accumulate favourable alleles that contribute to stress tolerance in a plant genome. To enable improvements in thermotolerance, it is necessary to determine the genetic variation available for heat tolerance. Screening techniques are required to characterise this variation, to identify appropriate breeding materials and ultimately for selection for improved adaptation.

Earlier investigations revealed pollen as indirect selection criterion for heat tolerance since pollen viability and pollen amount are negatively influenced by high temperatures. Therefore, pollen viability and pollen amount which are essential for successful fruit fertilisation were investigated both under controlled conditions and in greenhouses with different set-ups in Thailand.

Experiments were undertaken to characterise the genetic variability of 16 tomato genotypes under greenhouse growth conditions in Thailand with regard to heat tolerance.

Generally, gene resources for tolerance to environmental stresses are not found within the cultivated species of tomato, in part due to the limited genetic variation, which resulted from the occurrence of several population bottlenecks during domestication and evolution. Nevertheless, our investigations under heat stress revealed remarkably variation between the pollen traits of the genotypes classified as heat tolerant by their suppliers.

The different greenhouse set-ups influenced the pollen characteristics in different ways depending on the season and other factors than ambient air temperatures were shown to influence pollen viability negatively.

We proved that genetic variation exists in the ability to reproduce under heat stress conditions even within *Solanum lycopersicum* and this needs to be combined with the increased ability of yield due to enhanced growing conditions obtaining an increased stability of yield.

**Keywords:** Genetic diversity, heat tolerance, *Solanum lycopersicum*, tomato

## Generation of Adaptable Diversified Modern Genetic Resources for On-Farm Selection and Participative Breeding of Wheat

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Plant breeding approaches favouring genetic uniformity for all traits has drastically reduced the diversity within varieties and species in agriculture over the past 100 years. Breeders and pathologists have all along pointed out that almost all co-evolutionary processes between hosts and their pests and pathogens have been eliminated. Also, dynamic adaptation of plant populations to changing environments e.g. climatic change is much hampered. While traditional landraces usually are genetically more plastic than modern varieties they often are inferior in performance. An alternative “evolutionary breeding” approach using composite crosses (CC) of up to 20 modern wheat varieties is currently pursued by a network of scientists within Europe. Three populations consisting of all 20 parents, 12 high quality or nine high yielding parents were created in 2001 and F4 seeds were distributed in 2005 to researchers within a European network. The aim is to produce modern landraces that combine the advantages of the breeding successes of the last 120 years, while reintroducing diversity into the system. In addition, within the populations new genotypes are expected to arise constantly. Currently, the CC populations that are being maintained at University of Kassel under organic and conventional conditions are in the F7 in replicated large plots and compared to modern wheat varieties grown under the same conditions. The morphological and resistance diversity in the populations is still extremely high, indicating ongoing outcrossing and segregation. The presentation will give a general introduction into the concept of modern landraces for diversified agricultural systems and the potential of this approach for use in participatory breeding. Field data up to the F7 will be presented.

**Keywords:** Co-evolution, evolutionary breeding, modern landrace, plant protection

## Cultivation of *Schoenocaulon officinale* for Improving the Procurement of Raw Material: An Ongoing Project

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*Schoenocaulon officinale* (Schltld. & Cham.) A. Gray ex Benth., known as Sabadilla, is used in folk medicine since ancient times. The agents, belonging to the alkaloids of the veratrum group, are reported to treat skin-infecting fleas, lice, and mites while in homeopathy medicine is used against flu and fever. It is also known as natural insecticide to treat ectoparasites in animals. At present, pharmaceutical enterprises strive for extending the use of *S. officinale* but face many problems regarding quantity and quality of seeds collected from the wild. Therefore, the objective of this project is to establish a seed production system under greenhouse conditions. Seeds of *S. officinale* were collected in January 2008. The tetrazolium test showed a viability of 97 %, the germination test at 20°C showed 97 % germination without any specific treatment for breaking dormancy. Seeds obviously show no dormancy. Further tetrazolium and germination test will be performed at regular intervals during storage to evaluate storability of the orthodox seeds. Cooking at different temperatures will be checked as mean for accelerating and uniforming germination. Seedlings will be grown in greenhouses under different temperatures and light regimes to evaluate optimum development conditions for flowering and seed set. Plant biomass will be weighted regularly to identify optimum growth conditions.

The comprehensive knowledge about the demands of the species during the early development stages will be the basis to initiate species cultivation. Since seed wild collection is currently increasing, future domestication of the species will help to reduce collection pressure on wild populations.

**Keywords:** Domestication, insecticide, Liliaceae, medicine, veratrum, wild collection



# Forage production and plant pollution

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## Modelling of Longterm Pasture Production and Estimation of Carrying Capacity of Ankole Pastoral Production Systems in Southwestern Uganda

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Ankole cattle pastoral production system in southwestern Uganda is based on pastoral grazing without supplementary feeding or regular water availability. In this area livestock production is highly dependent on the availability of natural grazing, the quantity and quality of which are primarily determined by the amount and distribution of rainfall. Recent development of opportunities in milk marketing such as establishment of a good road network in combination with the organisation of milk collection and processing centres, led to a market outlet for milk in urban areas. These prevailing market conditions have led to an increasing tendency by the farmers towards the keeping of separate herds of both Ankole and Ankole-Friesian crossbreeds for beef and milk production respectively. This emerging production system raises a number of questions concerning its sustainability in an area characterised with high disease incidence and long droughts. The success of any grazing management strategy depends on the ability to track availability of forage on the range and being able to relate it to the number of animals that can be grazed on the rangeland. The amount of available forage and the number of animals grazing on the area effect intake and therefore animal performance and productivity per unit area. A dynamic stochastic compartment model based on difference equations programmed in STELLA 9.0.2 (High Performance Systems, Inc., Hanover, New Hampshire) was developed to simulate the dynamics of standing crop forage using the concept of rain use efficiency (RUE, kg DM produced ha<sup>-1</sup> mm<sup>-1</sup> rainfall year<sup>-1</sup>). The model predicts the long term pasture production and carrying capacity of the production system. The study compares the carrying capacity with the current stocking rates in the area.

**Keywords:** Ankole cattle, modelling, pasture, production system, Uganda

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## Forage Nutrition of Range Grasses Growing in Northeastern Mexico

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The quality of range grasses is correlated with season and plant phenology. There are usually parts of each year when the nutritional value of vegetation is high and low. Typically, plants are of highest quality during their growing season. However, within the growing season there may be significant differences in nutritional quality. The objective of this study was to quantify the differences in nutritive value, over four seasons, of native grasses such as *Bouteloua curtipendula*, *Bouteloua trifida*, *Brachiaria fasciculata*, *Digitaria insularis*, *Chloris ciliata*, *Leptochloa filiformis*, *Panicum hallii*, *Panicum obtusum*, *Paspalum unispicatum*, *Setaria macrostachya*, *Setaria grisebachii*, *Tridens eragrostoides*, *TRIDENS MUTICUS* and naturalised *Cenchrus ciliaris* and *Rhynchelytrum repens* that are used as forages for range sheep. *Cenchrus ciliaris* was included as reference grass of good nutritional quality. Plants were collected in autumn of 2001 and winter, spring and summer of 2002. The nutritive value was assessed in terms of nutrient content, effective rumen degradable dry matter (EDDM) and crude protein (EDCP), metabolisable energy (ME) and metabolisable protein (MP). Most grasses had CP content comparable to the reference *C. ciliaris* grass (global annual mean = 12.0 %) and some of them were higher (14.0 %). Cell wall (NDF) and lignin content were lower in *C. ciliaris* (65.0 %, 3.0, respectively) than other grasses (mean = 70.0 %, 6.0, respectively). All grasses had less EDDM (mean = 42.0 %) than *C. ciliaris* (47.0 %). However, half of them were higher in EDCP. All grasses had ME content (mean = 1.33 Mcal kg<sup>-1</sup> DM) that was lower for maintenance requirements for growing grazing beef cattle. Conversely, mean MP values (6.8 g kg<sup>-1</sup> DM) were sufficient. All grasses, in all seasons, had sufficient CP and MP content to meet the maintenance requirements of growing beef cattle; higher levels were observed in summer and autumn. The same pattern occurred in EDDM and EDCP. Because of their higher nutritional quality, grasses such as *B. fasciculata*, *C. ciliata*, *P. hallii*, *P. obtusum*, *S. grisebachii*, *S. macrostachya* and *T. eragrostoides* can be considered good forages for grazing beef cattle.

**Keywords:** Chemical composition, range grasses, metabolizable energy, metabolizable protein, rumen degradability

## Constraints and Potentials for Environmental Protection in the Agro-Pastoral Land Use Systems of the Hawf Protected Area, Yemen

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Little is known about the agro-ecological conditions of the Hawf Protected Area in South-East Yemen, a unique *Anogeissus dhofarica* seasonal cloud forest on the Arabian Peninsula. To contribute to efforts geared towards conservation of this unique ecosystem, this study examines local agro-pastoral knowledge and crop cultivation with particular emphasis on resource users' willingness to abandon shifting cultivation practices. Semi-structured interviews were conducted to unravel what farmers perceived as the most pertinent problems in securing livelihoods in general as well as problems in livestock and crop husbandry. Farmers were further asked how these problems are related to environmental factors and how they might be addressed so as to meet the conservation goals of the protected area. Crop husbandry was characterised according to four parameters important for the farming system: (i) use intensity of single components; (ii) increase/decrease of productive elements; (iii) use of water and land; and (iv) variations in per hectare yields through use of inputs, which emerged as an often neglected aspect and was evidenced by the management measures taken on cultivated land holdings. Also investigated were the production and consumption patterns of farm households.

The results show that the major constraint to environmental protection in the Hawf area is not a lack of local knowledge manifesting itself in an adherence to detrimental traditional cultivation practices. Rather, changes in pastoral practices do not allow for the regeneration of the original forest cover in fallowed land. Wood extraction for construction purposes, requiring as many as 100–150 trees for a single house, is the main agent of deforestation. Moreover, the loss of traditional knowledge about crop husbandry and its increasing marginalisation reduces the dietary diversity of the local population with expected negative consequences for people's health.

**Keywords:** Agro-pastoral knowledge, conservation, crop production, Yemen

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## Fodder Balance and New Approach for Management of Pastoral Ecosystems in North-Benin

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The seasonal shortages and the poor quality of available fodder are the major problems faced by cattle breeders in Benin. These factors are sources of several conflicts between breeders and farmers in the north of the country. Getting data on the evolution of the natural grasslands is an urgent need today. It is within that framework that the present study on carrying capacity and the management of ecosystems in northern Benin was carried out. The aims of the study are: (i) to make the typology of the pastoral resources of the area, (ii) to determine the productivity and carrying capacity of the various types of Grasslands, (iii) to analyse the modes of exploitations of the fodder resources in the area (iv) to identify the impacts of these modes on the viability of the pastoral ecosystems and (v) to propose a strategic plan for sustainable management of those ecosystems.

Overall, 6 types of grasslands were identified on the basis of phytosociological field surveys. The average potential productivity of the herbaceous layer is about  $3.71 \text{ tDM ha}^{-1} \pm 2.07$ . That of the harvested residues is  $0.12 \text{ tDM ha}^{-1} \pm 0.07$ . This corresponds to a carrying capacity of  $0.32 \text{ UBT ha}^{-1} \text{ year}^{-1} \pm 0.31$  compared to a seasonal load rate of  $0.34 \text{ UBT ha}^{-1} \text{ year}^{-1} \pm 0.11$ . This results in a surplus load of  $0.02 \text{ UBT ha}^{-1}$ . This situation obliges breeders to prune woody fodder. The impacts of such practices are already perceptible on *Khaya senegalensis* and *Azelia africana* whose individuals present traces of multiple pruning. Strategic proposals for the control of the load rate (differential taxation) and the use bush fires,, with the aim of improving the quality and production of fodders, were formulated.

**Keywords:** Benin, carrying capacity, fodder resources, modes of exploitation, viability

## ***Canavalia brasiliensis* and *Vigna unguiculata* at Different Growth Stages**

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The cover crop legume *Canavalia brasiliensis* can be grown on a wide range of soils: soil pH 4.3–8.0, low fertile soils and up to a height of 1000 m .a.s.l. The annual *Vigna unguiculata* shows even a wider range of environmental adaptation.

The high level of crude protein of these legumes suggests a good suitability as feed supplement for ruminants and possibly even for swine.

*Canavalia brasiliensis* CIAT17009 and *Vigna unguiculata* CIAT9611 were established in September 2007 at Palmira station, Colombia, in quadruplicate. Each plot had a size of 5 m × 3 m. Row-spacing was 70 cm and within rows 30 cm or 20 cm respectively for *Vigna* at a sowing rate of 20 kg ha<sup>-1</sup>.

*Canavalia* was harvested at 8, 12, 16 and 20 weeks of growth, *Vigna* at 6, 8, 10 and 12 weeks. Yield, feed value and ensilability were determined.

The dry matter yield of *Canavalia* developed slowly from 1.1 t ha<sup>-1</sup> after 8 weeks of growth to 3.6 t ha<sup>-1</sup> after 12 weeks, then to 6.1 t ha<sup>-1</sup> at 16 weeks and 12.3 t ha DM after 20 weeks. The DM content rose from 21 to 24 % from 8 to 16 weeks, and to 39 % after 20 weeks. The fast growing *Vigna* started with a DM yield of 1.7 t ha<sup>-1</sup> (6 weeks), and increased to 3.5, 5.1 and 8.5 t ha<sup>-1</sup> with 8, 10 and 12 weeks, respectively. *Vigna* had a high water content in the stems, resulting in a total DM of 11–13 % until 10 weeks. Only in the final stage of pod ripening the DM content rose to 21 %.

Throughout the weeks 6 to 10 *Vigna* had a high *in vitro* DM digestibility (IVDMD) for ruminants of > 74 % and a CP content of 20–17 % in DM in comparison to 59–65 % IVDMD and around 16 % CP of *Canavalia* from 8–20 weeks. When *Canavalia* was used on-farm as a supplement in Nicaragua, it improved the performance of dairy cattle (van der Hoek, this volume).

**Keywords:** *Canavalia brasiliensis*, feed value, yield

## Short-Term Variation of Pesticide Loads in Mae Sa River, Northern Thailand

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Agriculture in the mountainous region of northern Thailand has been changed from traditional slash and burn to permanent cropping of cash crops. This land use change has been accompanied by an increased input of agrochemicals, which may be lost to streams and thus contaminate the surface waters in the lowlands. In previous phases, transport processes and flow mechanisms controlling the transport of pesticides from agricultural field into stream in field scale of the upland hill were studied. The investigations showed that pesticides are lost to the river predominantly by surface runoff and preferential interflow. There are several factors which affect loss of pesticides to surface waters; the time interval between the application and heavy rainfalls, the slope and the soil types in a catchment. The aim of this study is to determine the extent to which pesticide are lost to the Mae Sa stream and to explore the dynamics of losses after the first rain events in the rainy season. Pesticides monitored in this study include two organochlorines (Endosulfan, Chlorothalonil), four organophosphates (Dichlorvos, Chlorpyrifos, Dimethoate, Atrazine), one pyrethroid (Cypermethrin), and one benzenoid fungicide (Metalaxyl). Water samples were collected in the beginning of the rainy season 2008 in the Mae Sa watershed (77 km<sup>2</sup>), northern Thailand. We used automatic samplers (ISCO 6217) at two locations of the main river, upstream and at the outlet. Sampling was performed either at selected times or volume-proportional. Samples were taken before, during and after stormflows. Water samples were extracted by SPE (solid phase extraction) method. Finally, the samples were analysed by GC-ECD or GC-NPD. The method for analysing water samples for the seven selected pesticides has been established. Limits of detection (LOD) were in the range of 0.3–10 ng ml<sup>-1</sup> for GC- $\mu$ ECD and 5–30 ng ml<sup>-1</sup> for GC-NPD. In a pre-test, Cypermethrin and Atrazine could be detected in river water. Finally, the short-term dynamics of pesticide loads into Mae Sa River in the beginning of the rainy season 2008 will be shown.

**Keywords:** First rainfall, pesticides, short-term dynamics, watershed

## Short-Term Effects of Stocking Rate and Management System on Yield Performance and Forage Quality in the Inner Mongolia Grassland Ecosystem

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Overgrazing leads to degradation of the natural grassland in Inner Mongolia (China). Increasing stocking rates affect the long-term productivity of the *Leymus chinensis* and *Stipa grandis* dominated steppe. The aim of this study is to figure out the impact of grazing intensity and management system on yield performance and forage quality in a semi-arid environment. In this context short-term effects of grazing by sheep were determined experimentally in grasslands within the Xilin River Basin (116°42' E, 43°38' N).

Two grazing systems (mixed and traditional) and seven grazing intensities (0, 1.5, 3, 4.5, 6, 7.5, 9 sheep ha<sup>-1</sup>) were analysed in a split-block designed grazing experiment with two replications. Each system included areas for grazing and for haymaking. While in the Mixed System (MS) an annual shift between grazed and hay plots occurred, the Traditional System (TS) indicates a permanent separation of haymaking and grazing areas throughout the years. Due to the annual shift between haymaking and grazed sites we assume higher recovery and productivity potentials in the MS. Analysis of variance was performed for 2005 and 2006 separately using the Mixed Model of SAS 9.1.

Intensification of grazing showed negative effects on annual herbage mass production in the short-term. Forage quality parameters were also affected by stocking rate. Crude protein (CP) content decreased with increasing stocking rates in both experimental years. Other quality parameters, like in vitro digestibility (CDOM) and fibre concentration (NDF and ADF), showed inconsistent responses between the years. System related effects on yield parameter and forage quality were only marginal after two years. Concluding, herbage mass productivity and CP content were affected in the strongest form by altering stocking rates.

**Keywords:** Forage quality, stocking rate, management system, semi-arid grassland

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# Abiotic stresses: drought, salinity, nutrients and fertiliser

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## **Partitioning Pattern and Biomass Production of Yam (*Dioscorea rotundata*)**

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There has been a decline in yam production relative to cassava and rice in Africa but yam is such a preferred staple food that, bearing in mind population increases, demand will remain and there will not be an absolute decline. Tuber yield of yam (*Dioscorea rotundata*) is determined by the total production of dry matter (DM) and its distribution within the crop dry matter partitioning is of great importance in crop production. Improvement of crop yield by plant breeding has resulted from higher harvest indices rather than improved DM production. However, there are limits to the fraction of assimilates that can be diverted to the harvestable organs. In this present study the effect of fertiliser on biomass production and the distribution of dry matter increments to the plant parts of white yam was determined by analysing data from field experiments set up in the Upper Oueme Basin (Benin Republic) over two years (2005 and 2006) where yam was harvested periodically during the entire stages of its growth. It can be concluded that fertiliser application has highly positive significant effect on total biomass production of yam in both the years (an increase of 42 % and 84 % in total biomass production under fertilised condition was registered in year 2005 and 2006 respectively) and dry matter distribution tended to follow a regular pattern if expressed as a function of phenological growth phase of the crop in both fertilised and unfertilised management practice.

**Keywords:** Dry matter distribution, phenological growth phase, yam

## Water Use, Yield Formation and Gas Exchange of Cowpeas under Water Deficit at Flowering

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A greenhouse experiment with two irrigation treatments [control at 40 to 80 hPa and water deficit (wd) stress at 350 to 400 hPa] were conducted from September 2004 to February 2005 with nine non-nodulated cowpea [*Vigna unguiculata* (L.)] genotypes. At the onset of flowering wd stress was imposed to determine the effect on gas exchange, evapotranspiration efficiency (ETE) and productivity (biomass and yield), the relationship among these characteristics, and to identify possible surrogate traits for ETE and leaf-level transpiration efficiency ( $TE_i$ ) in relation to yield.

Gas exchange [net assimilation rate (A), transpiration rate (E) and stomatal conductance ( $g_s$ )] declined under water deficit (wd) stress. However,  $TE_i$  (that is A/E) was enhanced. Extended flowering relative to control ensued from wd. Under wd plants had shorter stems, reduced leaf area, increased specific leaf area (SLA), reduced shoot biomass, but the response of evapotranspiration efficiency (ETE) varied in genotypes. Relative to control wd reduced pod and seed mass in eight out of the nine genotypes. Pod and seed number displayed a corresponding reaction. Single grain mass, shelling out-turn and harvest index (HI) remained constant, declined or increased depending on genotype.

There were correlations among gas exchange parameters under both treatments. Among  $TE_i$ , ETE and HI no relationship was detected in both treatments, while there were correlations among  $g_s$ , ratio of stem length to stem mass (SMLR), ETE, SLA, biomass, pod and seed yield, and HI. Wd stress tended to reduce or remove those relationships. A wd susceptibility index calculated on the basis of seed yield indicated that UCR 328, Tu 12348 and IFH 27–8 were the least wd susceptible genotypes. Gas exchange had no direct bearing on productivity.

**Keywords:** Cowpea, evapotranspiration efficiency, harvest index, stem mass to stem length ratio, stomatal conductance, water deficit, water use



## Methods to Record Leaf Senescence for Assessing Drought Resistance of Sorghum

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Sorghum (*S. bicolor* L. Moench) is one of the most drought resistant crops. It is assumed that drought stress reduces yield via coordinated lowering of photosynthetic capacity and yield potential, and hence both effects were correlated with accelerated leaf senescence. Consequently we tested two non-destructive methods of leaf senescence assessment: measuring light reflection (digital imaging) and light transmission (SPAD-based Hydro-N-Tester).

For light reflection digital photographs of leaves or standardised segments of seven genotypes were taken during a greenhouse experiment and were analysed for the green and red light reflection per unit leaf area using Sigma Scan Pro 5.0 software. With respect to different irradiation in the greenhouse while taking the photographs, adjustment of the original values by simultaneous measurements of white or green standard plates was made. The regression of the original and the adjusted values with chlorophyll content of the segments was calculated. In a second experiment twelve genotypes were used for light transmission measurement with thirty measurement points per leaf. Also regression curves were calculated. Chlorophyll was generally determined by a colourimetric method.

For the light reflection method we found that average red values correlated better ( $r^2=0.723$ ) with the chlorophyll content than average green values ( $r^2=0.526$ ) and adjustment with the values of the white and green plates led to a marginal improvement of the correlation ( $r^2=0.736$ ) and lowering ( $r^2=0.327$ ), respectively. Genotypes exhibited differences in correlation coefficients ( $r^2=0.495$  to  $0.998$ ). The segments chosen for the photographs represented the leaf values very well ( $r^2=0.853$ ).

The correlation of the N-Tester values of leaf segments with corresponding chlorophyll contents differed considerable between genotypes ( $r^2=0.474$  to  $0.922$ ), while the correlation of the leaves' N-Tester values with the leaves' chlorophyll content was weaker ( $r^2=0.004$  to  $0.908$ ).

We conclude that light reflection measurement is more labour-intensive than light transmission measurement, but these values represent chlorophyll content of leaves better than N-Tester values of leaves. N-Tester values of segments were as highly correlated to chlorophyll content as average red values of segments. However, use of N-Tester obviously is restricted to leaves with chlorophyll contents not exceeding  $5 \text{ mg dm}^{-2}$  because of biases by high scattering within the leaf.

**Keywords:** Leaf senescence assessment, light reflection, light transmission, *Sorghum bicolor*

## Effects of NaCl-induced Salinity on Seedlings Growth of *Ziziphus spina-christi* Willd.: A Wild Fruit Tree Species

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*Ziziphus spina-christi* is a fruit tree that grows wild in arid and semi-arid areas of Pakistan and Sudan. The fruits, leaves, bark and the wood are intensively used by the rural population. Increasing soil salinity is one of the major abiotic factors threatening plant production in these regions. Planting of indigenous trees such as *Z. spina-christi* could therefore play an important role to productively use barren land.

A pot experiment under controlled environmental conditions was conducted to determine the response of *Z. spina-christi* to salt stress. Six weeks old seedlings were initially subjected to 0, 20, 40 and 80 mM NaCl (added to a Hoagland solution). After four weeks salt treatments were doubled (0, 40, 80 and 160 mM) to detect increase the level of stress.

Salinity levels of 80 and 160 mM resulted in a reduction of more than 50 % in plant height, leaf number, leaf chlorophyll content, total leaf area and dry matter as compared to the control. Leaf tissues accumulated 81- and 21-fold higher  $\text{Na}^+$  and  $\text{Cl}^-$  concentration as compared to the control at 160 mM, respectively. Excessive accumulation of salt ions in leaf tissues resulted in a remarkable foliar deterioration (chlorosis and necrosis) and 20 % seedlings mortality due to ion toxicity. Enhanced salinity increased leaf water contents by 14, 16 and 17 % at 40, 80 and 160 mM, respectively. At the same time, the  $\text{K}^+/\text{Na}^+$  ratio was barely affected by the different salt levels indicating an effective adaptation to tolerate low or moderate NaCl salinity.

Overall, our results allow to classify *Z. spina-christi* seedlings as moderat salt tolerant.

**Keywords:** Afforestation, NaCl salinity, neglected fruit species, seedling growth

## Drought Stress in Tropical Maize: The Genetic Dissection of Key Traits in Multiple Environments

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There is evidence that the global mean temperatures are increasing and the climate is becoming more erratic. Certain tropical and subtropical regions will particularly suffer from the drawbacks of higher temperature and reduced rainfall. Understanding the drought response of maize is a key to developing more drought tolerant cultivars that help ensuring food security.

To dissect the genetic basis of drought tolerance with a special emphasis on QTL-by-environment interactions (QEI), a recombinant inbred line population of sub-Saharan provenance was evaluated in nine field experiments representing four environments: water stress at flowering and well-watered conditions in Mexico and Zimbabwe. The non-linear, negative relationship between the anthesis to silking interval (ASI) and grain yield (GY) across water regimes and locations was observed, although the segregation of GY was larger in Zimbabwe compared to Mexico, whereas secondary traits were more important in Mexico. Besides calculating experiment-specific QTLs, joint QTL analyses were conducted per environment, per water regime across locations and across all experiments. The number of QTLs identified for male flowering time, ASI, GY, kernel number, 100-kernel fresh weight and plant height was low, despite high trait heritabilities, and pointed at high levels of epistasis. Relative chlorophyll contents (SPAD, only in Mexico) of the ear leaf and the second leaf from the tassel were controlled by a constitutive and a stress-adaptive QTL (chromosomes 2 and 10), the latter also affecting whole-plant senescence.

The results showed that drought tolerance mechanisms were largely masked by plant vigour, because of the distinct morphology and yield potential of the parental lines. The poor adaptation of the plants to the Mexican environments resulted in a larger number of QTLs than in Zimbabwe and in significant QEI when combining data across locations and water regimes, even though the QTLs were stable within each environment. Therefore, care must be taken when choosing plant material for genetic studies. QTLs involved in plant adaptation are very important in breeding for broad target environments, and methods to detect epistasis are needed to better understand drought tolerance mechanisms.

**Keywords:** Drought tolerance, epistasis, plant vigour, QTL-by-environment interactions, quantitative trait loci, *Zea mays*

## **Dynamics of Ear Grain Set in Maize under Drought Stress at Flowering**

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Drought stress is becoming a more severe problem than ever before for the stability of grain yield of maize (*Zea mays* L.) in tropical and subtropical dry land areas. Drought stress at flowering affects silk receptivity and kernel set and largely reduces grain yield. The ability of a plant to complete grain set within few days under drought stress is essential for a good residual yield. In this study, the dynamics of daily grain set are being tested on vigorous sweet corn hybrids, which have a high potential grain number and are comparable in flowering time to conventional maize. The silks of seven sweet corn mother plants were pollinated on seven consecutive days with pollen from two different sources (either sweet or normal maize). Pollen from normal maize (dominant allele) produces grains with hard texture, which serve as visual marker among the sweet grains (recessive allele) to visualise which grains have been pollinated on a specific day. The result of the field experiment conducted at the National Corn and Sorghum Research Institute in Thailand indicated that pollination proceeds from the lower middle part of the ear to the top and the bottom. More than 85 % of the ovaries were fecundated within the first four days after silk emergence. Drought stress did not affect pollen vitality, but slowed down the dynamics of silk emergence. As a result, kernel number decreased towards the tip of the ear under stress, compared to well-watered conditions, and the number of kernels per ear was significantly reduced.

**Keywords:** Drought, grain set, pollination, sweet corn, *Zea mays*

## Parameterisation and Calibration of the Tropical Soil Productivity Calculator (TSPC) for Cabbage, Sweet Pepper and Litchi in Mae Sa Watershed, Northern Thailand

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For the last 20 years, land use change in Mae Sa watershed has been influenced by governmental decisions and international donors' purposes. The conversion from opium and upland rice production over corn and coffee to its present land use system, consisting mainly of cash crops such as sweet pepper (*Capsicum annum*), cabbage (*Brassica oleracea*) and litchi (*Litchi chinensis*), in combination with an emergence of greenhouses in the last years are examples of this phenomena. In this context decisions taken by dwellers of marginal upland areas increasingly affect livelihoods of lowland people. This is especially true for water, which has become a limiting factor during the dry season and cannot be easily provided even under capital-intensive farming systems.

Under these circumstances, spatially explicit modelling of land use change can be a valuable tool for an ex-ante assessment of the impact of new land uses. Within the SFB Uplands Program such a Land-Use Change Impact Assessment (LUCIA) model is generated, which builds on the Tropical Soil Fertility Calculator (TSPC) as its crop module. TSPC is characterised by its low data requirements and based on empirical yield functions accounting for C, N, P, K and pH as yield determinants.

For the purpose of LUCIA, water supply will be taken up into the TSPC as an additional constraint to crop production. Water stress functions adapted from those of the CROPWAT model are being integrated to estimate site-specific crop water requirements. In a second step, this study will develop crop response functions for litchi, cabbage and sweet pepper as well as parametrise and calibrate their yield functions for local conditions of the Mae Sa watershed in Thailand. To this end data from field experiments in the area and literature values for each of the crops will be evaluated. The more process oriented crop model WaNuLCAS will provide further estimates of crop response to changing water and nutrient regimes to allow for a comparative validation. Finally, TSPC will be coupled to LUCIA using the PCRaster platform in order to evaluate feedback mechanisms between crop production and watershed functions in the future.

**Keywords:** *Brassica oleracea*, *Capsicum annum*, crop modelling, *Litchi chinensis*, northern Thailand, TSPC

## Nutrient Seed Priming Improves Germination Rate and Seedling growth under Submergence Stress at Low Temperature

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Seed quality plays an important role in crop production. Seed mineral nutrients are one of the key factors determining seed quality. Micronutrients take part in a number of biochemical and physiological processes during germination and early seedling establishment. Due to important functions in membrane stabilisation, free radical detoxification and secondary plant metabolism sufficient availability of micro-nutrients such as Zn, Mn or B in the seed is essential for seed germination and seedling growth, particularly when germinating seeds or seedlings are facing abiotic and biotic stress.

‘Nutrient seed priming’ is a technique in which seeds are soaked in a mineral nutrient solution with subsequent re-drying to the initial moisture content. The final goal is an improvement of germination rate, early seedling growth and stress resistance, acting via an improved micronutrient status and a pre-activation of metabolic pathways important for germination during the pre-imbibition treatment (priming effect).

In the present study, soybean (*Glycine max* L.) cv. ‘Conquista’ seeds were primed with nutrient solution of Mn, Zn and B (Mn and Zn at the rate 5 and 15 mM using  $\text{MnSO}_4$  and  $\text{ZnSO}_4$  solutions respectively, and B at 0.5 and 10 mM as Boric acid solution) for 12 hours at 20°C between 5 layers of moist filter paper. After seed nutrient priming seeds were dried to initial seed moisture content and stored at 4°C. After one week of storage, seeds were submerged into chilled water at 4°C for 24 hours as a stress treatment and subsequently tested for germination and early seedling development. Nutrient seed priming significantly increased content of micro-nutrients in the seeds up to 20 times for Mn, 5 times for Zn and 2 times for B. Boron seed priming increased germination rate significantly by 80 % compared to unprimed control, which was not able to produce any seedling under these stress conditions.

**Keywords:** Micronutrients, nutrient seed priming, seed germination, soybean, submergence stress

## **Biomass Production Potential on the Salt Affected Soils of India: a Database of the Requirements of Fast Growing Salt Tolerant Tree Species**

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Arid and semi-arid ecosystems belong to the ecosystems naturally vulnerable to salinisation. Due to increasing population and the economic development in the region of South-West Asia there is growing requirement of crop and wood production. Based on the intrusion of sea water, irrigation with poor quality water and climate change induced increase in evaporation, the extent of naturally salinized land is enlarged. The area affected by salinisation is rising in this region every year so that arable land used for agriculture is transformed to wasteland unsuitable for traditional agriculture.

The BIOSAFOR Project financed by the EU Commission is working on improvement of agroforestry cropping systems for producing biomass on salt affected soils and reclaiming strongly saline or sodic soils. These systems should avoid a competition with food production and should be economically and socially acceptable.

In the frame of BIOSAFOR, seven case study areas in India were chosen to characterise the typical conditions of salinisation having a potential for biomass production. The long term biomass data, growing parameters of salt tolerant trees and experience collected during the last 30 years at Central Soil Salinity Research Institute, Karnal and also literature data regarding the growth of salt tolerant tree species was used to build a database with the most important tree requirements. The tree requirement database developed for a BIOSAFOR project comprehends four groups of parameters impacting the tree growth: terrain parameters, soil fertility parameters, ground water parameters and climatic conditions. The tree requirements for most suitable salt tolerant trees e.g. *Acacia* spp., *Prosopis* spp., *Tamarix* spp. etc. comprised in these four categories have to be matched with the site characteristics of the potential area according the Land suitability Classification (LSC) of FAO to characterise the biomass production potential on saline soils for different tree species. Thus the database can improve the optimal choice of trees for biomass production and reclamation of salinized sites.

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**Keywords:** Biomass production, salt affected soils, salt tolerant trees, tree requirements database



## Resilience of Lowland Rice Production to ENSO (El Niño Southern Oscillation) Droughts in Central Sulawesi (Indonesia)

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A detailed rice farming survey was carried out at the villages of Maranatha and Rejeki (n=79 households) around Lore Lindu National Park for the growing season 2006/07 during which no water shortages occurred. Average rice yield was 4.8 t ha<sup>-1</sup> harvest<sup>-1</sup> at two harvests per year. A Cobb-Douglas production function for paddy rice was estimated (adj. R<sup>2</sup>: 61.9%;  $p < 0.001$ ). Rice field size (-0.370; standardised coefficient), labour for puddling (0.109), amount of seeds (0.231), and material input costs (fertilisers, pesticides, herbicides; 0.305) were used to predict rice yield. A dummy variable testing for differences between villages was not significant. A continuous area of 476 rice plots (~20 ha) in Rejeki mostly belonging to the surveyed farmers (91 %) was mapped, and the individual plots geo-referenced. Based on spatial design of the irrigation scheme and interview results on irrigation management, a water distribution algorithm was generated. In the 2002 ENSO drought, local water availability for paddy rice production was reduced from ~1260 mm to ~560 mm from July to November. Yield reactions due to water scarcity are modelled according to physiological rice demand. For the rice crop during the 2002 drought period, preliminary calculations estimate a yield reduction of 40%-49 %.

A yield reduction of 49 % in one harvest every three years instead of every four years (*i.e.*, at higher ENSO frequency) requires a productivity rise of 2.1 % to compensate yield losses. This could be achieved by a rather modest increase of material costs by 48,600 IDR (~3–4€; +7.7 %) per hectare and harvest. To completely offset drought effects during a three-year ENSO cycle demands an increase of 8.2 % in material inputs equivalent to 207,000 IDR (~15–17€; +35 %) per hectare and harvest. Valuated at local market prices, this represents 1 % of revenue from rice harvest per hectare. While these preliminary calculations do not make full use of the spatial and temporal resolution of the production data - and do not account for negative environmental long-term effects of intensification -, they still suggest that more intensified paddy rice production could play an important role for an increased socio-economic resilience of the local communities to ENSO droughts.

**Keywords:** Climate change, GIS-Model, Nopu, socio-economic adaption, STORMA, water resources

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## Nitrogen Transfer in Soybean/Chilli Pepper Intercropping Systems via Arbuscular Mycorrhiza Hyphae

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Soybean and chilli pepper are important food and cash crops in Indonesia. It was hypothesised that beneficial interactions in soy bean/chilli pepper intercropping systems are due to positive nutrient effects, such as increased biological nitrogen (N) fixation by symbiotic rhizobia, direct or indirect nutrient transfer between the two crops and increased nutrient utilisation efficiencies. Furthermore, the suppression of pathogens and pests could be a beneficial side effect. Arbuscular mycorrhiza (AM) might play a key role within these processes.

The objective of this experiment was to investigate the transfer of N from soybeans to chilli pepper via arbuscular mycorrhizal hyphae. Therefore, soybeans and chilli pepper were grown in separate compartments within pots containing 10 kg soil (collected at Banda Aceh, Indonesia) which had been inoculated with the AM-fungus (*Glomus intraradices* strain 510). For fertilization a low rate of N (20 mg kg<sup>-1</sup> soil) and phosphorus (30 mg kg<sup>-1</sup> soil) as well as sufficient amounts of potassium (K), magnesium (Mg) and micronutrients were supplied. The compartments were separated by use of different nylon nets which selectively allowed the penetration by mycorrhizal hyphae (pore size 40 µm) or not (pore size 1 µm). To study the effect of biological N<sub>2</sub>-fixation, soybeans were inoculated or not with rhizobia (Biomax, Grupo Bio Soja, Brasil).

The results showed that the chlorophyll concentration in leaves of soybean and chilli pepper measured by Chlorophyll Meter SPAD-502 as indicator for the nitrogen status of the plants were increased in pots inoculated with rhizobia and separated by nylon nets which allowed mycorrhizal hyphae to pass through. These findings suggest biologically fixed nitrogen had been transferred from soybean to chilli pepper via the network of arbuscular mycorrhizal hyphae.

**Keywords:** AMF, intercropping, nutrient transfer

## **Boron and Zinc Fertilisation to Compensate Negative Effects of Photooxidative Stress in Lychee (*Litchi chinensis* Sonn.)**

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Lychee is grown in mountainous regions in Southeast Asia. During the winter season with low temperature and high radiation, severe chlorosis are observed on south-southwest exposed branches, inhibiting flowering. This is probably due to a missing compensation of photooxidative stress caused by the widespread extremely low Boron (B) and/or Zinc (Zn) nutritional status of Lychee trees. The aim of this study was to identify the role of both nutrients in remediation of transient chlorosis.

In 2007 field experiments were conducted in Mae Sa Mai, Chiang Mai Province, northern Thailand. B and Zn were applied to field grown Lychee trees, by foliar, soil or combined foliar and soil fertilisation, a control group was not fertilised. Each group consisted of six trees. For foliar fertilisation branches were sprayed within one tree exposed to south-southwest direction. The treatments were: a) 0.5 % B b) 1.0 % Zn c) 0.5 % B and 1.0 % Zn in combination, for all formulations a surfactant was added. Soil treatments were always a combination of 13 g B and 142 g Zn per tree, dissolved in 10 l of water and applied in a ring 1.0 m around the tree trunk. Appearance and intensity of chlorosis were weekly observed and rated with respect to intensity. Green value (SPAD-meter, Minolta 502) and chlorophyll content (Opti-Science CCM200) were measured. To determine the stage of chlorosis a rating scale based on RGB green tones was developed and each stage was defined with SPAD-meter and chlorophyll values.

Foliar treatments showed a reduction of chlorosis. It made no difference whether the nutrients were applied single or in combination. Highest compensation of photooxidative stress was observed when combining foliar and soil fertilisation. Soil fertilisation alone could not increase B and Zn concentrations in the leaves to a sufficient level, resulting in chlorosis on all leaves exposed to South-Southwest direction.

In conclusion, nutrient deficiencies in Lychee trees have an impact on the appearance of photooxidative stress symptoms during winter in the uplands of northern Thailand and can be remedied by foliar application of B and Zn.

**Keywords:** Boron, lychee, photooxidative stress, zinc

## Efficiency of Boron Foliar Fertilisation in Soybean (*Glycine max* )

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Boron (B) is an essential micronutrient showing deficiency worldwide in crop production. B is particularly important for yield formation (pollination), fruit quality (storage capability) and stress tolerance. Soybean (*Glycine max* L.) is considered to be very tolerant to B deficiency in the soil, but recently effects on floral development and seed yield were reported for the Mideast of the United States and northern Thailand.

Soil applied Boron is easily bound (high soil pH) or leached after heavy rainfall (low soil pH). Since B is phloem immobile in most plant species, foliar B fertilisation is a widespread technique to cure B deficiencies. The performance of foliar sprays is still variable, depending on nutrient amount, weather conditions, timing and status quo of the plant. The aim of this work was to study the influence of plant nutritional status on foliar penetration and uptake, hypothesising an increased uptake in deficient plants.

Experiments were conducted under controlled conditions. Stable isotope enriched boric acid was applied to soybean leaves with low and adequate B nutritional status, achieved by a different preculture. At harvest, plants were separated in different segments to determine uptake, basipetal and acropetal translocation of foliar applied B in the plants. Plants with strong B deficiency showed a significant reduction in foliar uptake. This was against our hypothesis and common knowledge. B deficiency must have a direct or indirect effect on cuticula penetration and uptake mechanism.

To further investigate this effect we conducted a second experiment. We pre-cultured soybean plants with 4 different B concentrations in the nutrient solution, ranging from 0 to 15  $\mu\text{M}$ , to get good, sufficient, marginal and deficient level of B in the plants. To determine the deficiency status we made nutrient analyses and measured the membrane integrity, as K-efflux.

Results will be presented and discussed.

**Keywords:** Boron, boron deficiency, foliar fertilisation, micronutrient, soybean

## **The Effect of Drought on Secondary Dormancy Induction on Different Seed Canola Varieties (*Brassica napus* L.) under Absence of Light**

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Prolonged imbibition under conditions of water stress or light deficiency can lead to the induction of secondary dormancy in rape seeds. During imbibition in darkness, seeds develop light sensitivity. The percentage of seeds not germinating in the dark depends on various factors prevailing during and after the stress treatment, as well as on the intrinsic susceptibility of the seeds to these factors. In order to evaluate effects of drought and darkness on secondary seed dormancy of canola, an experiment was conducted with 3 replications in a completely randomised factorial design. Treatments were including 7 varieties of canola (Hyola60; Hyola308; Hyola330; Hyola401; Hyola420; Sarigol and AA1) and 3 drought levels (control, -1.5 MP and dry seed). In order to drought induction, samples were placed in 20°C two weeks, after treating by PEG6000 and then the samples were kept in soil (4 cm depth) for 4 months, to darkness induction. Results indicate significant differences between the 7 varieties at different level drought ( $p > 0.01$ ). The most and the least dormant seed percent were observed in Hyola60 (44 %) and Hyola420 (22 %) respectively. At different drought levels, germination percent of all varieties decreased significantly, except Hyola60. Otherwise, dormant seed percent in dry seed treatment were more than the seeds treated with -1.5 Mp droughts. In general, in addition to genotype, environmental conditions affect on secondary dormancy potential of seeds. As volunteer rape decreases crop yield, it is necessary widespread researches carried out on ecological and management aspects of this plant.

**Keywords:** Canola darkness effect, secondary dormancy, volunteer rape seed

## Adaptation Mechanisms in Rice Cultivars of Different Origin to Iron Toxic Conditions

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Iron toxicity is a complex nutritional disorder that differentially affects lowland rice cultivars. The occurrence of excessive amounts of reduced  $\text{Fe}^{2+}$  in the soil solution, its uptake by the rice roots, and its acropetal transport by xylem stream can lead to elevated  $\text{Fe}^{2+}$  concentrations in leaf cells that catalyse the formation of radical oxygen species, entailing structural damage, the visual symptom of leaf bronzing, and yield losses of up to 30 %. Diverse morphological and physiological adaptation mechanisms have been described, ranging from exclusion of toxic  $\text{Fe}^{2+}$  (e.g. oxidation power of roots), Fe partitioning (e.g. immobilisation in stem tissues or the apoplast) to tissue tolerance (e.g. scavenging of radicals by enzymes). The effectiveness of these adaptation mechanisms to cope with Fe stress differs between cultivars of different origin, and varies with plant age, environmental conditions (e.g. vapour pressure deficit - VPD), the nutritional status of the crop, the intensity and duration of the Fe stress, and the timing of its appearance. We hypothesise that an effective breeding or selection of cultivars for Fe toxicity tolerance requires the matching of the cultivar- and plant age-dependant coping-mechanisms with the prevailing environmental and Fe stress conditions.

Twenty rice genotypes (different species and cultivars of different origin) are being comparatively evaluated in hydroponic culture at the seedling, vegetative and early reproductive growth stages. Symptom occurrence, biomass accumulation, Fe translocation patterns, and the Fe content in various tissues are monitored. Cultivars are being classified based on their ability to cope with elevated  $\text{Fe}^{2+}$  (sensitive vs. tolerant) and their tolerance mechanisms (excluders vs. includers). Contrasting genotypes will be used to assess the effectiveness of various adaptation mechanisms to diverse stress situations (Fe intensities of 0, 1000, 2000 ppm  $\text{Fe}^{2+}$ , stress durations of 0 to 10 days, conditions of high and low VPD). First results of required cultivar characteristics for defined Fe stress conditions will be presented.

**Keywords:** Hydroponics, iron toxicity, *Oryza sativa*, oxidation power, tissue tolerance, rice

# Composts, organic substrates and (bio)fertilisers

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## Soil N Management Using Combined Application of Crop Residue and N Fertiliser: What is the Environmental Cost?

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Crop production in Africa is often limited by nitrogen availability. Crop residues could serve as alternative as they are readily available and easily accessible. However, certain limitations associated with crop residue use such as low-N use efficiency, high N losses via leaching and gaseous losses ( $\text{N}_2\text{O}$  emission) make the exclusive use of crop residue problematic.

Inorganic N ( $\text{NO}_3^-$  and  $\text{NH}_4^+$ ) release, and  $\text{N}_2\text{O}$  emission were measured in laboratory soil microcosm experiments following combined application of crop residues (clover and barley straw) and inorganic N fertiliser ( $\text{NH}_4\text{NO}_3$ ) in different proportional ratios: 100:0, 75:25, 50:50, 25:75 and 100:0; fertiliser-N: crop residue-N, respectively. Preliminary results indicated that inorganic N release and  $\text{N}_2\text{O}$  emissions were relatively higher in soils after incorporating crop residues with a lower C-to-N ratio. Moreover, results obtained showed that inorganic N availability increased significantly ( $p < 0.05$ ) with increasing proportion of inorganic N fertiliser applied. Whether this input stimulated N release from the residues, resulting in greater N availability for nitrification and subsequent denitrification, is verified using a  $^{15}\text{N}$ -enrichment approach to quantify  $^{15}\text{N}$ - $\text{N}_2\text{O}$  production following addition of  $^{15}\text{N}$ -labelled residues to soil.

Furthermore, labelled crop residue from tropical legumes cultivated under controlled environmental conditions are being applied either solely or in combination with N fertiliser to determine the contribution of crop residue to N release and  $\text{N}_2\text{O}$  emission. Furthermore the impact of recommended soil fertility management practices such as liming and soil water management on N availability and  $\text{N}_2\text{O}$  emission following combined application of crop residue and inorganic N are being investigated. It is expected that results obtained from the various experiments would amply demonstrate the optimum combination of crop residue and N fertiliser which, when applied to tropical soils would yield economically viable and environmentally sustainable yields.

**Keywords:** Crop residue, denitrification, nitrification, nitrous oxide



## Use of Plant Growth-Promoting Rhizobacteria to Improve Mycorrhisation, Nutrient Acquisition and Plant Health of Tomato Affected by Soilborne Pathogen

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Biological strategies to control plant diseases are regarded as environmental friendly alternatives to agrochemicals which may contribute to the development of sustainable cropping systems under humid tropical conditions. Only few studies have investigated the synergistic action of beneficial microorganisms such as *Pseudomonas spp.* and arbuscular mycorrhizal fungi (AMF) to improve the growth and resistance of plants against soilborne diseases. The objective of this study was to test the efficiency of *Pseudomonas proradix*® (Proradix®, Sourcon Padena, Tübingen, Germany) to improve mycorrhisation, nutrient acquisition and plant health of tomato, an important cash crop in Indonesia, affected by the aggressive root pathogen *Fusarium oxysporum* Schlecht f. sp. *radicis-lycopersici* Jarvis and Shomaker (FORL).

Tomato seeds (*Lycopersicon esculentum* Mill. var. Money Maker) were pre-cultivated in pots containing 50 g loamy clay soil/sand mixture (3:1) with and without Proradix® ( $1.5 \times 10^{10}$  cfu per pot), without and with AMF-inoculum (about 8000 propagules of *Glomus intraradices* strain 510; Mycotec Biotechnik Gbr, Hannover, Germany). Subsequently the three weeks old seedlings were transplanted to pots containing 2 kg soil/sand mixture, fertilised with 100 N, 50 P, 150 K, 50 Mg,  $0.06 \text{ Fe mg kg}^{-1}$  loamy clay soil. Top and bottom layer of the substrate contained soil/sand mixture only. The middle layer of the substrate was mixed with a spore suspension of FORL strain 11r (provided by Prof. J.C. Tello Marquina, Universidad De Almería, Spain) at a rate of  $4.5 \times 10^7$  spores in 10 ml water per 100 mg substrate. As a control, only sterile water was added.

Proradix® significantly improved the root colonisation by AMF and the biomass production of tomato, which was particularly pronounced in the soil with FORL-spores inoculation. Combined application of Proradix® and AMF lowered the disease severity of FORL and enhanced the concentrations of nutritional elements in the shoot tissue of tomato. To a smaller but still significant extent, disease severity was also decreased by single application of Proradix® and AMF. These results suggest that Proradix® functions not only as a mycorrhisation helper bacterium but also as a suitable biocontrol agents to restore plant growth and health when grown in severely FORL infested soils.

**Keywords:** AMF, biocontrol, FORL, *Pseudomonas*, soilborne pathogen, tomato

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## Regulation of *Medicago truncatula* N<sub>2</sub> Fixation under Phosphorus Deficiency

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Phosphorus is one of the most important elements that significantly affect plant growth and metabolism. The crop production on more than 30 % of the world's arable land is limited by P availability, with the acid, weathered soils of the tropics and subtropics particularly prone to P deficiency. For legume growth and symbiotic N<sub>2</sub> fixation, P is critically the major limiting factor. In extreme cases P deficiency prevents nodulation and symbiotic N<sub>2</sub> fixation. The legume *Medicago truncatula* and its microsymbiont *Sinorhizobium meliloti* serve as models to study the mechanisms of the regulation and inhibitory effect of low P supply on symbiosis. The aim of this study was to evaluate the hypothesis that control of nodulation and N<sub>2</sub> fixation under P deficiency involves sensing of change in tissue N composition and attempted to identify the potential biochemical signal(s) involved.

*Medicago truncatula* plants were grown in a growth chamber in a hydroponic system and inoculated with *Sinorhizobium meliloti*. Phosphorus was investigated in two different experiments: low (0.2 to 5.0  $\mu\text{M}$  P) and high (1.0 to 12.0  $\mu\text{M}$  P) P range levels. At day 52 phloem sap extracts were collected, plants were harvested and frozen in liquid N<sub>2</sub>. Free amino acids were analysed as well as sugars and organic acid concentrations in nodule tissues. P and N concentrations were analysed for various plant organs.

Low P concentrations strongly reduced the growth of *Medicago truncatula* plants. A very low P concentrations ( $< 1.0 \mu\text{M}$  P) totally prevented nodulation. Reducing P concentration impaired N assimilation and as a result the concentration of N and N/P ratios were much increased while C/N ratios were decreased. Free amino acid profile showed higher accumulation of free amino acids in the phloem and nodules and asparagine was the amino acid with the most dramatic increase in concentration under P deficiency. Accordingly, we propose that P shortage reduces the growth rate of the plants and protein synthesis. This will leads to higher N concentrations in the plants and gives rise to free amino acid accumulation. Therefore, we suggest a feedback mechanism for regulating nodulation and N<sub>2</sub> fixation under P deficiency.

**Keywords:** Asparagine, model legume, N<sub>2</sub> fixation, phosphorus, regulation

## Physiological Adjustment Mechanism of *Medicago truncatula* N<sub>2</sub> Fixation under Environmental Perturbations

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To regulate the uptake of nutrients that may be available in excess, plants may use feedback systems. These systems are envisaged to involve the cycling of nutrients within an organ or a plant and the regulation of further nutrient uptake by the products of assimilation. The concept of feedback regulation of N<sub>2</sub> fixation has been developed in the last decade of the previous century as a general mechanism governing regulation of N<sub>2</sub> fixation by environmental factors. Currently, we are testing the validity of such hypothesis on forage legumes under various environmental perturbations using the model plant *Medicago truncatula* as a test crop.

Two experiments were carried in a growth chamber in a nutrient solution and inoculated with *Sinorhizobium meliloti* 102F51. In the 1<sup>st</sup> experiment, 60 % of the leaves (lower part) were individually darkened (against control) while keeping the percentage of treated leaves constant by further darkening appropriate to new leaf expansion for 2 week. In the 2<sup>nd</sup> experiment, an open-flow gas measurement system was used to measure H<sub>2</sub> & CO<sub>2</sub> evolution and to calculate N<sub>2</sub> fixation and electron allocation from apparent nitrogenase activity (ANA) [80 % N<sub>2</sub>/20 % O<sub>2</sub>] and total nitrogenase activity (TNA) [80 % Ar/20 % O<sub>2</sub>] before and after high KNO<sub>3</sub> application.

Darkened leaves were senesced and %N in the whole plant was highly increased versus untreated controls thus leading towards the tendency of reduced C/N ratios. Surprisingly, the growth rate of treated plants exceeded untreated controls. The gas measurement trial revealed that H<sub>2</sub> evolution was decreased slightly while electron allocation coefficient (EAC = 1 – ANA/TNA) was increased (11 %) and the amount of N-fixed per day remained stable.

According to the N-feedback hypothesis, excess and high soluble N levels in the shoots reduce N<sub>2</sub> fixation rates after sensing and sending certain signal(s) and the repetition of this messenger(s) can induce nodule senescence. To avoid such detrimental effect the legumes must 'lock up' excess-N in proteins and retain it in this form. This could explain why N<sub>2</sub> fixing legumes are normally protein-rich plants. Additionally, perennial pasture legumes possess other physiological adaptation for such purpose (i.e. tannins and/or polyphenol oxidase).

**Keywords:** Combined-Nitrogen, leaf darkening, legume, N-feedback, N<sub>2</sub> fixation, regulation

## Bio-Fertilisers and Plant Strengtheners can Reduce the Susceptibility of Tomatoes to *Phytophthora infestans*

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Late blight, caused by *Phytophthora infestans* is one of the most destructive disease of tomatoes affecting organic and conventional tomato production worldwide. Exploitation of induced resistance is a desirable strategy in plant protection since it involves enhancing natural defense mechanisms in plants. Induction can be achieved via the leaves or via the roots. Induced resistance through plant strengtheners could be part of alternative strategies for the control of late blight of tomatoes. Organic fertilisers stimulate soil microbial activity and through this may also have positive effects on the host's metabolism ultimately limiting plant infestation.

The main aim of this research was to determine if soil fertility management and plant strengtheners interact in their effects on plant susceptibility. For this tomato plants (cultivar Philovita) were grown with three bio-fertilisers: horn meal, Bioilsa fertile and ILSA 12 with or without three plant strengtheners (Quality, Alfa-Alfa extract, Meat extract) in a commercial type of set up in a plastic tunnel. Detached leaves of adult plants were inoculated with 20  $\mu$ l sporangial solution at  $5 \times 10^4$  sporangia ml<sup>-1</sup> of one *P. infestans* isolate in the laboratory under controlled conditions two times during the season. In additional experiments the plant strengthener Quality was tested on young plants of various cultivars combined with various growth substrates. In comparison to horn meal, the bio-fertilisers Bioilsa fertile and ILSA 12 and the plant strengtheners significantly reduced late blight susceptibility. There were no interactions and the effects were additive. Bioilsa fertile, Quality and Alfa-Alfa extract were most effective in reducing late blight susceptibility. Quality reduced the susceptibility of tomatoes independent of plant age, growth substrate or fertiliser used. Combining plant strengtheners with organic soil fertilisers could become part of a strategy for disease management.

**Keywords:** Alfa-Alfa extract, Bio-fertilisers, Bioilsa fertile, ILSA 12, induced resistance, meat extract, *Phytophthora infestans*, plant strengtheners, quality, tomato

## Characterisation of Green- and Bio-Composts for Horticultural Growing Media

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There is an increasing demand for recycling of organic materials from domestic and industrial uses, as it reduces landfill volumes and disposal costs. Decomposed organic matter (OM) can then be used in agriculture (to enhance fertility), horticulture (as growing media), or local energy plants (for energy production). However, a wise and effective use of OM is determined mainly by the respective physical, chemical and microbiological properties. Organic matter for energy purpose, for instance, should contain high calorific value or carbon content, whereas OM for growing media should have stable carbon and nitrogen balances.

In this paper, we present a method that characterises six green- and bio-composts by fractionating their OM into four distinct components varying with particle size, density and stability to decomposition. These OM fractionates were: (i) dissolved (DOM;  $<0.45 \mu\text{m}$ ), (ii) light fraction (LFOM;  $<1 \text{ g cm}^{-3}$ ), (iii) medium fraction (MFOM; between 1 and  $1.37 \text{ g cm}^{-3}$ ), and (iv) heavy fraction (HFOM;  $>1.37 \text{ g cm}^{-3}$ ). The correlations between these fractionates and large arrays of physicochemical and microbiological properties (i.e., activity and biomass) were evaluated by a linear regression model to find out a simple parameter that predicts the stability of carbon and nitrogen balances of composts chosen for growing media.

Since microorganisms are only active at the solid-liquid interphase, DOM content was strongly correlated with microbial activity as measured by evolved  $\text{CO}_2$  ( $r^2 > 0.67$ ) and biomass as estimated by the fumigation extraction method ( $r^2 > 0.53$ ). Similarly, the correlation between C-to-N ratio of the DOM and microbial activity or other physicochemical properties (e.g., total carbon, nitrogen, bulk density) was relatively good ( $r^2 \geq 0.45$ ). Therefore, the higher carbon or lower nitrogen content in the DOM fraction may cause immobilisation unless compensated by fertilisation. LFOM also showed a similar trend although the computed r-values were small ( $r^2 \leq 0.36$ ). MFOM and HFOM, however, had no clear pattern. Since the separation of DOM is relatively simple (i.e., add water and remove the filtrate by applying suction), it can be used, but in a due connection with other physicochemical properties, as a quality criterion for selecting green- and bio-composts for horticultural purposes.

**Keywords:** Carbon, fumigation extraction, microbial activity, microbial biomass, nitrogen, organic matter fractions



# Organic farming: theory and practise

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## **Improved Legume-Cereals Based Cropping Systems for Improved Productivity and Natural Resource Management by Resource Poor Crop-Livestock Farmers in West Africa**

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Most farmers in West African savannahs grow local varieties of grain crops in various intercropping systems with little or no purchased inputs. In these systems, legumes yields are low due to shading by cereals and lack of plant protection measures while cereal yields are low due to lack of fertiliser. On-Station trials have shown that overall farm yield could be increased in a sustainable manner through adoption of improved varieties of crops, improved cropping systems, and crop-livestock integration. A large scale farmer participatory on-farm evaluation and dissemination of the system involving about 5000 farmers, covering different agro-ecological zones in the savannahs of West Africa was conducted from 2002 to 2007 to demonstrate the superiority of the improved systems on-farm and its importance in natural resource management. The system involved growing improved cowpea varieties with cereal in a 2 cereal: 4 cowpea row to row arrangements, with selective application of inorganic and organic fertilisers to the crops and 2 to 3 insecticide sprays to cowpea. Crop residues from the fields were taken to the homestead and fed to confined small ruminants during the dry season. The manure gathered from these animals was then taken to the field for soil fertility improvements. The result indicated that the improved cropping systems, using improved varieties of cowpeas, were superior to the traditional system with over 300 % increase in value of the crop produce depending on locations. Feeding the residues of cereals alone resulted in weight loss while feeding the residues of cowpea or groundnut alone resulted in the weight gain of about 13 % and 12 % respectively. Supplementing the cereals residues with about 300 g of cowpea or groundnut residues per ram per day resulted in slight gain in weight and thus the body weight was maintained. Farmers were able to generate an average of 550 kg manure (dry weight) in 60 days of confine feeding of average of 6 ruminants (sheep and goat).

**Keywords:** Cereals, cowpea, cropping systems, intercropping, strip-cropping



## Organic Tomato (*Lycopersicon esculentum*): Nutritional Quality and Late Blight Disease (*Phytophthora infestans*) Susceptibility

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The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. Tomato is one of the most popular and consumed vegetable worldwide. During growing, tomato is exposed to late blight disease that spreads very rapidly and kills plants once it is established in a cultivation area, caused by fungus *Phytophthora infestans*. The purpose of this study was to investigate the variation in some nutritional quality parameters and susceptibility to infection by late blight disease in six selected tomato cultivars from Germany: Resi, Rosa Roma, Ferline F1, SO<sub>3</sub>0a, Ostravske Rane and Harzfeuer F1, which differ in their size, colour and susceptibility to the late blight infection. These cultivars were organically grown in two different locations: Schönhagen (Thuringia) and Ellingerode (Hessen) in which organic manure was applied in October 2004 and January 2005, respectively. The organic tomato plants were planted on 25th Mai 2005 in both locations.

Results indicated variations among the cultivars within and between the locations regarding the nutritional quality and infection level by *Phytophthora infestans*. The fruit infection was higher in Ellingerode than in Schönhagen. The cvs. Ostravske Rane and Harzfeuer F1 expressed higher infection level but cvs. Resi and SO<sub>3</sub>0a showed lower infection level in both locations. Consequently, the yield was higher in tomatoes grown in Schönhagen (1094 g plant<sup>-1</sup>) compared to those from Ellingerode (932 g plant<sup>-1</sup>). Furthermore, the higher lycopene content was determined in tomatoes grown in Schönhagen (41.52 mg/100 g FW) than in Ellingerode (28.37 mg/100 g FW). Tomato fruits from Schönhagen were characterised by higher amounts of Ca and Fe (0.22 g/100 g DM, 6.5 mg/100 g DM), respectively. No differences were found between locations in the case of N, P and K contents in the fruits.

Generally, tomatoes grown in Schönhagen achieved higher yield with fruits characterised by higher contents of lycopene, Ca, Fe and lower *Phytophthora infestans* infection. Better quality of tomato was due to the better soil conditions of cultivation area in Schönhagen. The soil was of good structure, deep and of high water holding capacity.

**Keywords:** Cultivars, late blight disease, lycopene, nutritional quality, organic tomato

## Gaseous Carbon and Nitrogen Emissions in Organic Agriculture in Northern Oman

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Information about gaseous losses of carbon (C) and nitrogen (N) in irrigated organic agriculture in northern Oman is scarce. To fill this gap of knowledge a field experiment was carried out in an experimental farm near Sohar, during which applications of two bovine manure types (a C/N ratio of 39 at high fibre content and a C/N ratio of 31 with a low fibre content) and a control treatment (mineral fertilisers with equivalent levels of N and P and K) were factorially combined with two crop rotations comprising cauliflower (*Brassica oleracea*) and carrot (*Daucus carota* subsp. *sativus*) each preceded by a crop of radish (*Raphanus sativus*). Concentrations of soil-surface emitted NH<sub>3</sub>, N<sub>2</sub>O, CO<sub>2</sub> and CH<sub>4</sub> were determined using an INNOVA photo-acoustic infrared multi-gas monitor within a closed chamber system and accumulative leaching losses through cartridges filled with cation/anion-exchange resins.

Cumulative gas emissions during a 90 day cropping period attained a total of 14 kg N ha<sup>-1</sup> (68 % NH<sub>3</sub>, 32 % N<sub>2</sub>O) and 2,254 kg C ha<sup>-1</sup> (98 % CO<sub>2</sub>, 2 % CH<sub>4</sub>) for plots treated with organic manure of high C/N and high fibre as compared to equal 14 kg N ha<sup>-1</sup> and 1,889 kg C ha<sup>-1</sup> for plots treated with organic manure of low C/N and low fibre content.

Emission rates declined between irrigation events, most likely due to decreasing soil moisture. The significant effect of time on gaseous emissions determined for N<sub>2</sub>O ( $p = 0.0266$ ), CO<sub>2</sub> ( $p = 0.001$ ) and CH<sub>4</sub> ( $p = 0.001$ ) was likely due to changing soil moisture and relative humidity.

Cumulative N-leaching was with a total 13 kg ha<sup>-1</sup> higher on plots amended with organic manure of high C/N and high fibre in comparison to leaching losses of 6 kg N ha<sup>-1</sup> on plots with organic manure of low C/N and low fibre content. Cumulative N leaching losses were higher on plots planted with cauliflower than on carrot plots. This may be due to differences in the rooting system and uptake dynamics of both crops.

**Keywords:** Oman, organic agriculture, vertical nutrient fluxes

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## Soil Cover Plants and Physical-Hydrical Attributes of a Rhodic Haplustox in Organic Production System

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This work had the objective to evaluate the effect of different soil cover plants on the physical and hydrical attributes of a Rhodic Haplustox in an organic production system, under two tillage systems, no-tillage (SPD) and conventional tillage (SPC). In each soil tillage system the following cover plants were evaluated: velvet bean (*Mucuna aterrima*), sunn hemp (*Crotalaria juncea*), pigeon pea (*Cajanus cajan*), sorghum (*Sorghum technicum*), and fallow. Soil physical and hydrical attributes and aggregation status was analysed in the soil layers of 0–10, 10–20, and 20–30 cm depth. The experiments were carried out at the experimental area of Embrapa Rice and Beans, in Santo Antônio de Goiás, Goiás State, Brazil. The experimental design was a randomised block, in  $2 \times 5 \times 3$  factorial scheme, with four replications. The soil cover plant management was done at flowering. The cover plant straw stayed on the soil in SPD and it was incorporated at soil profile in SPC. The soil water retention, evaluated by retention curves, was affected by soil tillage systems and cover plants. In the superficial layer, 0–10 cm deep, there was higher soil water retention in no-tillage system. In this system, at 0–30 cm deep, the soil cultivated with legumes showed higher soil water retention than that cultivated with sorghum or in fallow. The soil aggregation status was influenced by soil tillage system. The percentage of aggregates with diameter higher than 2 mm and the mean weight diameter of aggregates was higher in SPD than in SPC, at 0–10 cm and 10–20 cm soil layers. A positive correlation between these variables and soil organic matter was observed in SPD. In both tillage systems, soil organic matter content decreased with soil depth.

**Keywords:** Leguminous, no-tillage system, soil aggregation, soil water retention

## Feasibility Study for Domestication of *Teucrium polium* L. Based on Ecological Agriculture

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*Teucrium polium* is a species of the Labiatae family. It grows in sandy and poor regions. This species is treated by human irregular exploitation, excessive domesticated animals grazing, drought, salinity, global warming, climate change, and also rangeland conversion to agricultural fields. In order to evaluate agroecological criteria for possible domestication of *Teucrium polium* under cropping conditions based on ecological agriculture, a primary survey was made in natural habitat of Tandureh national park in North Khorasan. In this case, biological criteria of plants including plant density, height, biomass and crown diameter was measured. Also in 2 separate field trials, agronomic criteria of this species were studied for two years (2006 and 2007) in experimental field of Institute of Plant Sciences of Ferdowsi University of Mashhad. In the first experiment, direct seeding (16 Oct, 22 Dec, 15 Mar and 13 Apr) and densities (25, 17 and 13 plants per m<sup>2</sup>) and in the second experiment, date of transplanting (17 October and 5 May) and density was evaluated. In the natural habitat, this plant grows in altitude of 1000–1100 m, on poor loamy soil. Field experiment indicated that direct seeding is not successful and autumn transplanting was superior to spring transplanting. Plants performed much better in the second year compared to the first year. In natural habitat in the first year, plant essential oil percent was more than in the field. Essential oil yield was higher in the field plants compared of natural habitat. However, it is necessary that more research should be conducted on other agronomic aspects of this problem.

**Keywords:** Biomass density, domestication, natural habitat, Tandureh national park, *Teucrium polium* L., transplanting

## Problems and Potentials of Organic Agriculture Development in Nepal

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Current research focuses on the problems and potentials of organic agriculture in Nepal basing on the study of stakeholders of organic agriculture. It has been found out that about 2.5 % of households of urban areas are consuming organic products and almost 30 % are found to have desire. Most of the organic production and marketing system in Nepal is on the basis of community trust. Market for organic products is quite rudimentary and legal certification hasn't started. There has been lacuna in research on the technologies to support organic agriculture. Most of the farmers are well aware about the negative repercussion of the indiscriminate use of the agro-chemicals in their farm and opined that they would like to shift from inorganic towards organic agriculture; however, marketing for such products is the greatest bottleneck.

All domestic organics reach to consumers without labeling. Consumers have a belief that organic food is healthier, less polluted and more natural, than conventionally produced foods. Many of the consumers are of the view that quality of the organic products is good and that's why these products are expensive. Most of them are willing to pay 10–15 % of more price to the organic products over inorganic while they are willing to pay 20–30 % more price to the organic products if they are labeled. Organic products are usually sold directly from farmers or through specialised shops and restaurants. Organic industry is too small and a long way to go in Nepal. Due to the lack of financial support for conversion, organic farmers rely only on consumers' willingness to pay higher prices to obtain compensation for lower yields or higher costs that may arise due to the organic practice. Till date there is a vacuum of government policy to support organic opportunities in the country. Managing own Internal Control Systems better prepares farmers to manage plethora of other standards that are increasingly mandated for the trade. Political commitments such as avoiding conflicting drive to maximise production, hammering proactive policy, providing market incentives and institutionalisation of Nepalese organic movement are imperative to further enhance organic sector in Nepal.

**Keywords:** Consumers, households, labeling, marketing, organic agriculture



# Biocontrol and natural enemies

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## Sequential Application of Antagonists for the Biological Control of the Burrowing Nematode *Radopholus similis* in Banana

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Recent work suggests that the combination of different biocontrol agents with different modes of action could be more effective for the control of nematodes than individual application. The aim of this work was to determine the biocontrol effects of single or sequential applications of the mutualistic endophyte *Fusarium oxysporum* strain 162 ( $5 \times 10^6$  and  $1 \times 10^7$  spores per plant), the eggs pathogen *Paecilomyces lilacinus* strain 251 ( $1.8 \times 10^7$  conidia  $\text{g}^{-1}$  soil) and the antagonistic bacteria *Bacillus firmus* (2 g of product/plant) toward *Radopholus similis* in banana in pot trials under greenhouse conditions. The single or combined application of fungus-fungus or fungus-bacteria was shown to reduce *R. similis* penetration and reproduction. The combination of *F. oxysporum* and *P. lilacinus* caused a 68.5 % reduction in nematode density in the root system, whereas the individual applications reduced the density by 27.8 % and 54.8 % over the control, respectively. Satisfactory results were also obtained with sequential application of *F. oxysporum* and *B. firmus*. The combined treatments reduced the density of *R. similis* up to 86.2 %, followed by 63.7 % and 32.7 %, with a single application of *B. firmus* or *P. lilacinus*, respectively. The combination of *P. lilacinus* and *B. firmus* increased significantly the biocontrol of *R. similis*, compared with the single applications of the agents and the absolute control. The density of nematode in the root system was reduced to 91 % with mixed inoculations of both biocontrol agents. Meanwhile, the single applications of *P. lilacinus* or *B. firmus* reduced *R. similis* population up to 58 % and 67 %, respectively. The compatibility of the biocontrol agents, as well the capacity of *F. oxysporum* to colonize banana roots in absence and presence of *P. lilacinus* or *B. firmus* was also investigated. *P. lilacinus* or *B. firmus* did not adversely affect endophytic colonisation by *F. oxysporum*. It can be concluded that biological control of *R. similis* in banana can be enhanced via sequential application of antagonist with different modes of action that target different stages in the infection process.

**Keywords:** *Bacillus firmus*, bacteria, combined applications, endophytic, fungi, *Fusarium oxysporum*, *Musa*, *Paecilomyces lilacinus*

## Effect of Natural Plant Enhancers on Soil Bacteria and Control of Plant-Parasitic Nematodes in Lettuce

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The root-knot nematode *Meloidogyne incognita* has a world-wide distribution and is a major limiting factor in vegetable cultivation. Today there is an increasing demand for environmental friendly products to substitute or alternate with pesticides in IPM management programs for plant parasitic nematodes control. The impact of plant growth enhancers on the microorganisms that make up the soil antagonistic potential has not been studied in detail. The aim of this study was to investigate the effect of natural plant growth enhancers on soil bacteria population densities and on control of the economically important root-knot nematode, *M. incognita*, in lettuce. The plant enhancers evaluated were Azet®, Oscorna®, MagicWet®, TerraPy®, chicken manure and green compost. All treatments were compared to a biological and a chemical nematicide, DiTera® and NemaCur®, respectively. Oscorna® (450 kg ha<sup>-1</sup>), Azet® (300 kg ha<sup>-1</sup>) and DiTera® (112 kg ha<sup>-1</sup>) significantly increased bacterial population densities over the other treatments 1 and 3 weeks after application. Azet® (300 kg ha<sup>-1</sup>) reduced *M. incognita* penetration to lettuce roots 50 % from day 0 to 30 days after soil treatment. MagicWet® (200 kg ha<sup>-1</sup>) reduced *M. incognita* 50 % 7 days after treatment but its efficacy was lost 2 weeks later. DiTera® controlled *M. incognita* similarly to NemaCur® the week after application but its nematicidal activity slightly decreased 4 weeks later. Chicken manure (5,000 kg ha<sup>-1</sup>) was phytotoxic inhibiting lettuce germination even 30 days after application. The study revealed that Azet® greatly stimulates soil bacteria biomass which seems to be related to a reduction in the root-knot nematode. The results suggest that specific antagonistic bacteria increase when this compound is applied to the soil thereby stimulation the suppressiveness of the soil to nematode damage.

**Keywords:** Biocontrol, compost, fatty acid derivatives, fenamiphos, *Lactuca sativa*, *Myrothecium verrucaria*, plant lipids, root-knot nematodes, soil amendments, sugar based surfactants, vegetables

## **The Role of Natural Enemies in *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) Population Suppression in Cereal Culture in Ethiopia**

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*Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) is an exotic stemborer introduced to Africa from Asia some eighty years ago which results in 30–50 % grain losses by attacking all stages (seedling, vegetative, flowering and maturity) of the crop in the field. As the case in all exotic pest, the control of *C. partellus* was attempted through classical biological control by introducing an endo-larval parasitoid, *Cotesia flavipes* (Cameron) (Hymenoptera: Braconidae) from India and Pakistan. The field release of *C. flavipes* was done in most of the eastern and southern African countries where *C. partellus* is a very important pest. However, in Ethiopia the parasitoid established with out release. The population established in Ethiopia might be from the Somalia release of 1997 along the Shebele river. *Cotesia flavipes* was for the first time recorded in Ethiopia and the 2007 survey showed that the average parasitism rate was 72.5 %. The rate growth in parasitism since its establishment is tremendous indicating the success of biological control in suppressing the density of *C. partellus*. More over, there are a number of pupal and egg parasitoids of *C. partellus* recorded in Ethiopia. A number of entomopathogens belonging to fungi and nematodes were also isolated from *C. partellus* in Ethiopia. In summery natural enemies can give sufficient control of *C. partellus*. However, the naturally occurring bio-agents should be complemented with other control options such us habitat management (push-pull) and Varietal resistance among others. Augmentative release of *C. flavipes* and application of conservation mechanisms should also be done.

**Keywords:** Ethiopia, stemborer, natural control, integrated pest management

## Can *Fusarium*-Wilt-Resistant Tomato Varieties Suppress the Biological Control of Root-Knot Nematode Induced by Mutualistic Non-Pathogenic *Fusarium oxysporum* Antagonists?

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Mutualistic endophytes are well known for their antagonistic activity against a wide range of plant pathogenic fungi and nematodes. One of the most important these endophytes is non pathogenic *Fusarium*. Many studies have been conducted using different isolates of the mutualistic endophytic *Fusarium oxysporum* as antagonists against different genera of plant parasitic nematodes on different hosts and varieties. Obtained results of these studies revealed that, there are many mechanisms involved in the interaction between these endophytes and the target pest or disease. Induced systemic changes in host attractiveness and or production of repellents is considered one of the most unique of these mechanisms. The Induction of host systemic resistance by the mutualistic endophytic *oxysporum* against *Meloidogyne incognita* was detected on susceptible tomato varieties to *Fusarium* wilt pathogen. In this study the endophytic fungus, *oxysporum* strain 162, was used in a split-root system to determine if *Fusarium*-wilt resistant tomato varieties adversely affect the induction of systemic activity to the root-knot nematode, *M. incognita* or not. Obtained results of presented study showed that the mutualistic endophytic *oxysporum* isolate (162) maintains effectiveness and significantly reduces infection on both inducer and responder root sections. The reduction in gall number was similar, 36 % and 34 %, on the inducer and responder sides respectively. The results therefore demonstrated that the induced systemic resistance activity of this antagonist was present even on tomato plants having resistance to the wilt fungus *F. oxysporum*. This is of practical importance in that many commercial varieties are resistant to the wilt fungus.

**Keywords:** Biological control, *Fusarium* wilt resistance tomato, induced resistance, *Meloidogyne incognita*, *Fusarium oxysporum*, root-knot nematode

## A New Version of the Prototype for Mechanical Distribution of Beneficials

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A new version of the device patented by University of Catania and already used in natural enemy distribution trials on greenhouse vegetable crops has been designed and constructed in order both to increase the work capacity and to promote a low impact pest control, which respects the environment and consumers' and farmers' health.

This version has the same working principle of the former prototype, but materials and dimension of the hopper, the distributor and the rotating disc have been changed. Currently, it is made up of a conical aluminium hopper to hold and to measure out the product. The top is fitted with an electric motor which governs the rotation of a distributor, fixed along the vertical axis of the hopper. Product falls onto an aluminium distributor disc which rotates around its vertical axis by means of a second direct-drive electric motor attached below the prototype.

With this model, set on a handle directly carried by the operator, the device performance will be improved both in distribution uniformity in time and in manoeuvrability within a greenhouse. Consequently, greater work capacity and higher work quality will be achieved.

Several laboratory trials, preliminary to field tests, have been carried out to evaluate some machine parameters: the throw direction, the spatial distribution, the quantity distributed, the uniformity of throw in time, the vertical distribution of product at different distributor heights as well as at different distances from the test bench. The tests were run with inert material commonly used for marketing bottles of beneficials: humid vermiculite and buckwheat husks mixed with humid vermiculite.

Moreover, experienced entomologists have evaluated throw effects on natural enemies vitality, with samples both from the hopper and from the rotating disc throw. Negligible or absent impact on natural enemies proves prototype efficacy and enables its usage both with technical and economic advantages on manual distribution, which is actually practised in Italy.

The preliminary tests are really encouraging and let us think about a possible wide diffusion of this device for beneficial distribution in biological crops.

**Keywords:** Greenhouse, natural enemies, plant protection machines, sustainable pest management

## Isolation and Screening of *Pseudomonas fluorescens* Isolates from Indonesian Soils against *Fusarium oxysporum* Schlecht f. sp. *radicis-lycopersici* Jarvis and Shomaker

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The application of antagonistic microorganisms for biological control of root diseases in agriculture is an increasingly important alternative or supplement to chemical pesticides. Fluorescent pseudomonads have several advantages compared to other biocontrol agents and attracted particular attention among scientists. Strains of *Pseudomonas* spp. isolated from the rhizosphere are promising as seed inoculants in innovative agriculture to promote plant growth and crop yield and reduce various plant diseases. In the present study, *Pseudomonas* isolated from Indonesian soils have been investigated with respect to their biochemical and physiological characteristics and their effectiveness against *Fusarium oxysporum* Schlecht f. sp. *radicis-lycopersici* Jarvis and Shomaker (FORL 11r).

From four soil samples, collected from the rooting zone of tomato, maize, peanut and cacao at farmer's field in Banda Aceh, Aceh and in Palu, Central Sulawesi, Indonesia, altogether 28 pseudomonads strains were isolated and selected for biochemical and physiological characterisation. Therefore the soil samples were serially diluted up to 10<sup>-9</sup>, plated on King's B (KB) agar medium and incubated at room temperature (27±2°C) for 48 h. Distinct colonies showing fluorescence under UV light at 360 nm were picked and streaked on KB agar medium to check the purity. The isolates exhibited a wide variation in production of several considered substances as biocontrol factors such as: siderophores, cyanide, chitinase, protease, proteinase and arginine dihydrolase. Antagonistic growth inhibition of FORL by the pseudomonads strains was tested by coinoculation on KB medium. All isolates inhibited the mycelium growth of FORL but five isolates showed superior antagonistic efficacy over the other isolates. These five isolates were selected for further studies on their effect in improving mycorrhisation and suppressing soil-borne pathogen under greenhouse conditions.

**Keywords:** Biocontrol, FORL, isolate, *Pseudomonas fluorescens*, Soilborne pathogens, *Fusarium oxysporum*, Indonesia

## Effects of Different Entomopathogenic Fungi on Western Flower Thrips and Selected Thrips Predators

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Western Flower Thrips, *Frankliniella occidentalis* (Pergande) (WFT) has become a very important pest in Europe that causes significant losses of high value crops in greenhouse and open field production. To overcome increasing selection of pesticide resistant biotypes Integrated Pest Management (IPM) with combinations of safe control alternatives should be the method of choice for thrips management. Besides thrips predators, application of insect pathogenic microorganisms such as Entomopathogenic Fungi (EPF) is highly promising and recommended. EPF are naturally occurring pathogens that attack a wide range of insects and arthropods. However, combination of both strategies may arise some possible antagonistic effects against each other. The main objective of the present study was to investigate under laboratory conditions, the efficacy of nine EPF strains against WFT, and particularly the susceptibility of common predators of thrips such as *Amblyseius cucumeris* (AC), *Orius laevigatus* (OL) and *Hypoaspis aculeifer* (HA). Test organisms were short time immersed in EPF spore solutions and mortality rate was evaluated on daily basis for seven days as main parameter for the susceptibility of each organism. The EPF screened with WFT adults included strains from the following species: *Beauveria bassiana* (Bals.) Vuill., *Paecilomyces fumosoroseus* (Wize) Brown and Smith, *Verticillium lecanii* (Zimm.) Viégas and *Metarhizium anisoplae* (Metsch.). After a series of screening experiments, including optimisation of test arena layout and assessment of convenient humidity regimes, the strains *B. bassiana* (Naturalis), *P. fumosoroseus* (Fwa3) and *M. anisoplae* (2936) were selected for further testing against predators. By using the Kaplan-Meier estimator the survival function for each predator was estimated from life-time data. The obtained data suggest statistically significant differences on cumulative survival (for seven days) by Naturalis treatment (AC:  $0.386 \pm 0.103$ , HA:  $0.438 \pm 0.105$ , OL:  $0.190 \pm 0.086$ ) compared with the control (AC:  $0.656 \pm 0.099$ , HA:  $0.917 \pm 0.056$ , OL:  $0.864 \pm 0.073$ ), for the three predators evaluated. Further experiments will distinguish possible formulation effects before finally rating the impact of the evaluated EPF on non-target organisms.

**Keywords:** Entomopathogenic fungi, non-target effects, predators, western flower thrips

## Differential Immuno-Suppressive Ability of Different Morphotypes of the Invasive Fruit Fly *Bactrocera invadens* towards Eggs of the Parasitoid *Diachasmimorpha longicaudata*

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In 2003, the Asian fruit fly *Bactrocera invadens* Drew, Tsuruta & White (Diptera: Tephritidae) was first reported in Africa. This insect is an invasive species that is to date considered to be among the major pests of mango in Sub Saharan Africa. Being an alien pest and lacking indigenous parasitoid species, the use of introduced parasitoids against *B. invadens* may be a promising pest management strategy. One key factor for the success of such classical biological control programs is the physiological compatibility between the parasitoid and the target pest. Preliminary work indicated that *B. invadens* exhibits a differential ability of immuno-suppression against the introduced endoparasitoid *Diachasmimorpha longicaudata* (Ashmead) (Hymenoptera: Braconidae). Within the population of *B. invadens* there are eight distinct morphotypes based on the pattern of the scutum. We hypothesised that the intraspecific variability in encapsulation ability is related to these different morphotypes. Four major morphotypes have been evaluated for the ability to encapsulate *D. longicaudata* eggs. The total and differential haemocyte counts and number of encapsulated and non-encapsulated parasitoid eggs for the parasitized fly larvae were recorded at different time intervals after parasitisation, for each morphotype. The haemocyte counts were compared with that of unparasitized larvae of the same age as that of the parasitized ones. Additionally, the impact of parasitoid adaptation to the host has been investigated by recording the number of encapsulated and non-encapsulated eggs of consecutive generations of *D. longicaudata* reared on *B. invadens*. The potential use of this parasitoid species in classical biological control of *B. invadens* will be discussed.

**Keywords:** *Bactrocera invadens*, *Diachasmimorpha longicaudata*, immuno-suppression



## Selection of Entomopathogenic Fungi for *Spodoptera litura* Control

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Biological control with pathogenic fungi is a promising alternative to chemical control against the insect pest of vegetable. Ten isolates of green muscardine fungus, *Metarhizium anisopliae* as entomopathogenic fungus were used to test for pathogenicity on second instar of common cutworm, *Spodoptera litura* under the laboratory conditions. The tested larvae were placed in Petri dishes containing green muscardine fungus and they were allowed to make a direct contact with the particular entomogenous fungus. It was revealed that 3 isolates of green muscardine fungus, BCC1858, BCC4849 and Khon Kaen were effectively killed 100 % of the cutworm larvae within 2 days. Subsequently, *M. anisopliae* isolates were brought to examine with 8 different media for physiological properties. The result showed that mungbean agar (MU) was the best for mycelial growth and sporulation. Moreover, the optimum temperature for growth was ranged around 30–35 °C. When the isolates were kept in the room with 12 hours light alternated with 12 hours dark, they were produced more green spores than the other. [The best conditions for sporulation were observed when the isolates were kept at 30–35°C with 12 hours light alternated with 12 hours dark.] When the 3 most effective isolates were tested with the 1<sup>st</sup>, 2nd and 3rd instars of cutworm at 4 concentration levels included of 107, 108, 109 and 1010 spores ml<sup>-1</sup>. The result indicated that the isolate 4849 with the concentration of  $6 \times 10^8$  spores ml<sup>-1</sup> was the most effective one. It was observed to cease the 3rd instar of cutworm by 79.49 % within 7 days.

**Keywords:** *Spodoptera litura*, Biological control, Entomopathogenic fungus, *Metarhizium anisopliae*

## Susceptibility of Different Stages of the Mediterranean Fruit Fly *Ceratitis capitata*, to Entomopathogenic Fungus *Lecanicillium muscarium*

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This study determined the pathogenicity of *L. muscarium* to eggs, larvae and adults of *C. capitata* under laboratory conditions.

Four ml of suspension of *L. muscarium* ( $4 \times 10^7$  conidia  $\text{ml}^{-1}$ ) was applied on sterile filter paper in Petri dishes and water for the control respectively. Eggs were placed on the infected filter paper and incubated at 20°C. After 24 h 10 contaminated eggs were transferred on artificial diet and incubated at 25°C and 70 % R.H (5 replicates).

The entomopathogenic fungus was low pathogenic to the eggs, although the differences in the mortality between the fungus (24 %) and the control (8 %) was significantly.

To evaluate the susceptibility of the old larvae, plastic container (3,8 cm diam.  $\times$  2,8 cm high) were filled with 10 g dry soil and sprayed with 1 ml suspension ( $4.3 \times 10^6$  spores  $\text{cm}^{-2}$ ) on the soil surface using a small dash bottle. On each container 10 old larvae were transferred on the treated soil in the container. Container were incubated at 25°C and 70 % R.H (5 replicates).

*L. muscarium* reduced emergence of adult at 46 % in comparison to the control with 74 %. In the treatment 54 % were dead but 40 % of those were infected probable with *L. muscarium*.

To evaluate the susceptibility of adults in plastic container (5 cm diam.  $\times$  3,5 cm high) were filled a small layer of soil and 15 ripe pupae spread uniformly on the surface. Above it 2 to 3 cm layer of soil were filled again. Three ml suspension ( $3 \times 10^7$  conidia  $\text{ml}^{-1}$ ) was sprayed on the soil surface. Incubation took place (5 replicates) at 25°C, and 70 % RH. All emerged adults were transferred daily to cages with water and dry yeast extract-sucrose. All dead flies were disinfected, placed on water agar in Petri dishes and incubated at 20°C.

The fungus was pathogen to the flies. In course of experiment 65,6 % of flies were dead in comparison to the control with 13,2 %. 40,6 % of emerged flies was moulded. These results indicate, that *L. muscarium* is pathogenic against *C. capitata*. From all developmental stages the adults are mostly susceptible against this entomopathogenic fungus.

**Keywords:** *Ceratitis capitata*, developmental stages, *Lecanicillium muscarium*, mortality

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## Combinations of Fungal and Bacterial Antagonists for Biological Control of the Rice Root-Knot Nematode *Meloidogyne graminicola*

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The rice root-knot nematode *Meloidogyne graminicola* is a serious pest across rice-wheat rotation areas of South Asia's IndoGangetic Plain and in rice producing areas of Southeast Asia. This nematode can cause yield losses of between 20 and 80 %. Two of the most effective control measures, soil flooding and nematicide application, are of increasingly limited utility due to water shortage and high cost of nematicides. Given the limited scope of management options, the development of an integrated strategy that combines resistance breeding with biological and cultural control is needed. Biological control using endophytic microorganisms has been demonstrated to be highly effective against sedentary and migratory endoparasites including plant parasitic nematodes. Therefore, a biological control system, as an alternative control measure for management of the rice root-knot nematode, is being developed. Three different antagonists; a pathogenic fungus (*Trichoderma* sp.), mutualistic endophyte (*Fusarium verticillioides*) and an endophytic bacterium (*Bacillus megaterium*) isolated from soils of different rice growing regions in Vietnam and Taiwan, were used in different combinations to enhance biological control of the root-knot nematode. The effect of single or multiple applications of these biocontrol agents against *M. graminicola* infestation was investigated under greenhouse conditions. The biocontrol agents were applied to the rice seedlings at different growth stages either individually, simultaneously or sequentially. Root galling severity was then compared between different treatments. Compatibility of these microorganisms in vitro was also studied. This paper discusses methods of fungal and bacterial application, compatibility of biological control agents in vitro and the possibilities of combining different antagonists to enhance biocontrol efficacy.

**Keywords:** *Bacillus megaterium*, biological control, endophytic bacteria, endophytic fungi, *Fusarium verticillioides*, *Trichoderma*

## Effect of Non-Pathogenic *Fusarium oxysporum* Strain 162 in *Solanaceae* and *Cucurbitaceae* Crops Towards *Trialeurodes vaporariorum*

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The greenhouse whitefly *Trialeurodes vaporariorum* (GHWF) is one of the most widely distributed insect pests in tropical and subtropical agricultural regions, affecting over 600 different plant species. *T. vaporariorum* (GHWF) has been a problem in greenhouses for many years, because it has the capability to reduce plant productivity and longevity. Besides whiteflies are very important vectors of viruses and are able to cause significant crop damages and yield losses. Induction of systemic resistance by non-pathogenic micro-organisms is a well known option in plant protection. For example non-pathogenic strains of fungi of the genus *Fusarium* used to induce systemic resistance are able to control the incidence of *Fusarium* wilt and *Meloidogyne incognita* in tomato. Accordingly the objective of this study was to evaluate the effect of *F. oxysporum* strain 162 (Fo 162) in two different vegetables towards *T. vaporariorum*. Fo 162 was applied at  $1 \times 10^6$  cfu g<sup>-1</sup> of soil twice to the respective treatments. The first fungal inoculation took place during germination time and the second when the seedlings were transplanted. About 1000 GHWF adults were released in each trial. Ten days after the second Fo162 inoculation, the number of GHWF adults on the leaves was counted for the next 12 and 9 consecutive days on tomato (*Lycopersicon esculentum*) cv. Hellfruecht and on squash (*Cucurbita pepo*) cv. Eight Ball, respectively. The study revealed that 38 % (mean number of all consecutive samplings) of the released GHWF adults could be found on the tomato plants treated with Fo162 in comparison to 62 % of all counted GHWF adults detected on the leaves of the non-treated control plants. In squash the percentages were 20 % (plants treated with Fo162) and 80 % (control plants), respectively. This investigation demonstrates an impact of the endophytic fungus Fo162 in tomato and squash on *T. varporariorum* because it reduces the population density of this pest on the leaves of the tested crops. This might be used as a further option in an integrated pest management system to control this serious greenhouse pest. The possible fungal mode of action and its effect on insects regarding resistance mechanisms are discussed.

**Keywords:** Cucurbitaceae, endophytic fungi, insects, pests management, resistance mechanisms, *Solanaceae*, vegetables, whiteflies

## Developing New Techniques for Managing *Phyllotreta striolata*: Analysis of Host Plant Preference and Impact of Glucosinolates

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*Phyllotreta striolata*, the striped flea beetle, has a narrow host plant range restricted to the *Brassicaceae*, *Capparaceae*, and *Tropaeolaceae*. This beetle feeds on stems and leaves of many economically important crops, especially *Brassica* vegetables such as cabbage, cauliflower, radish and pak-choi. The coincidence that the preferred plant families are known to contain glucosinolates (gs) suggests these compounds may act as chemical cues for host plant acceptance in *P. striolata*. Evidence for this hypothesis comes from field studies demonstrating the striped flea beetle is attracted to allyl isothiocyanate (AITC) and other glucosinolate breakdown products. In field experiments, we have shown that AITC at a dose of 0.8 ml per trap could significantly increase trapping of flea beetles. To investigate the relationship between this pest and host plant volatiles, we examined nine different commercial *Brassica* crops (cabbage, cauliflower, broccoli, Chinese kale, Chinese cabbage, pak-choi, winter rape, Indian mustard, and radish) under free choice conditions. The *P. striolata* infestation of crops inside a net house in the field was observed for four to five weeks. In all experiments we found *Brassica oleraceae* sub-species (cabbage, cauliflower, broccoli, and kale) were significantly less preferred than the other crops. The preference for some crops, e.g. pak-choi and Chinese cabbage, changed during the growing period. We subsequently analysed the total gs content and profile of crop plants using HPLC. Chinese cabbage and pak-choi had the lowest amount of gs (< 10 mol per g dry weight) while Indian mustard and radish leaves had the highest gs content, up to 100 mol per g dry weight. Because crops with the highest as well as the lowest total gs content are preferred by *P. striolata*, we assume the total gs content is not critical for this interaction. Interestingly, sinigrin (allyl gs), the precursor of the volatile AITC, was found in both preferred and non-preferred plants. However, sinigrin was not detected in Chinese cabbage and pak-choi. The analysis to identify the bioactive compounds in *Brassica* for *P. striolata* is in progress.

**Keywords:** Glucosinolates, *Brassica*, *Phyllotreta striolata*, host plant preference



# Biopesticides, mycorrhiza and others

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## **Molecular Dissection of the Systemic Defense Response in Banana against *Radopholus similis* Infection Induced by Beneficial *Fusarium oxysporum* Strains**

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The burrowing nematode *Radopholus similis* causes the so-called toppling disease to banana plants and is a major problem in banana producing areas worldwide. It was recently shown that systemic resistance against *R. similis* can be induced, when the root system of banana plants is colonized with specific stains of non-pathogenic, endophytic *Fusarium oxysporum*. This offers a biological pest management alternative to the use of highly toxic nematicides commonly used for nematode control. However, not all non-pathogenic *oxysporum* strains show the ability to elicit this type of systemic resistance in banana. One objective of our research is the early identification of promising *F. oxysporum* strains by means of phylogenetic analysis, which can accelerate the screening process for beneficial isolates, by eliminating time consuming screenhouse bioassay. Although *F. oxysporum* has been identified as elicitors of the systemic induced resistance, the exact mechanism responsible for the induction is not yet known. Therefore another research goal is to elucidate the exact mode of action responsible for the induction of the systemic resistance in the banana plant on the molecular level. Analysis of the in planta-accumulation of salicylic acid, jasmonic acid, NPR1 and PR protein coding transcripts will serve as markers to determine whether Induced Systemic Resistance (ISR) or Systemic Acquired Resistance (SAR) are playing a role in the induced plant defense response and whether they are similar to that found on model plant species. The output of this research must lead to improving the biological pest management of nematodes in banana cropping systems.

**Keywords:** Banana, biological pest management, endophyte, *Fusarium oxysporum*, induced resistance, *Radopholus similis*

## Induction of Resistance to the Whitefly *Trialeurodes vaporariorum* in Tomato by External Application of JA and BTH

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Induction of resistance in plants to herbivorous insects may supplement biological control strategies relying on combinations of control measures. It is well known that herbivore feeding and pathogen attack induce defense mechanisms in plants and that the jasmonic acid (JA) and salicylic acid (SA) pathways are centrally involved in the signaling cascade leading finally to temporary accumulation or activation of defense compounds. Besides pest or pathogen attack, defense reactions can be enhanced by the external application of JA and SA. Plant responses are species specific in terms of plants and pests; hence plant responses vary with plant- pests systems. Former studies using application of JA and/or SA were mainly directed towards chewing insects. We intend to study the effects of resistance induction in tomato towards *Trialeurodes vaporariorum* (Westwood) using preference, development, and fecundity as main resistance/suitability parameters. Treatments included different concentrations of JA, Benzothiadiazole (BTH; an analogue to SA) and water as control. Plant reaction to inducers was confirmed by measuring the activity of proteinase inhibitors and peroxidase, well characterised enzymes responding to JA and SA pathway activation respectively. In choice experiments, we found avoidance reaction of whitefly adults for inductor treated leaves of tomato plants when insects were released one or two days after spraying. In order to study the development of whiteflies on treated plants in comparison to control plants, we investigated oviposition intensity and development of subsequent larval, late larval (pupal), to adult stages. When plants were treated with JA and BTH before egg deposition, 75–80 % of eggs developed to adults' stage in all cases. On the other hand, when plants were treated one week after egg deposition and treatments were repeated after two weeks at larval stage, we found a significant reduction in relative amount of eggs (compared to untreated control) that reached the adult stage on both BTH and JA treated plants. Newly emerged females from different treatments showed distinct differences in fecundity. Females from BTH treated plants had significantly lower fecundity (5.25 eggs female<sup>-1</sup> day<sup>-1</sup>) compared to JA treated (8.04) and control (8.22) plants. Yet the feeding intensity of early as well as late instars larvae was not different among any treatments.

**Keywords:** Induced resistance, jasmonate, tomato, whitefly

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## Combination of Antifungal Genes (chitinase and glucanase) to Increase the Resistance Level of Transgenic Pea against Fungal Diseases

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Pea (*Pisum sativum*) is an important grain legume worldwide, used both as a source of dietary protein for human and animal nutrition. The protein concentration of peas ranges from 15.5 to 39.7 %. Its production, however, is affected by different pests and diseases among which fungal diseases are the most important ones. A major objective in breeding therefore is to improve the resistance of pea to fungal diseases which can cause considerable loss of more than 30 %. In addition, most phytopathogenic fungi leave mycotoxin residues in the crop. In order to control fungal infections, pea transgenic lines with enhanced resistance to fungal diseases through heterologous expression of chitinase and glucanase genes have been established.

One way of enhancing or broadening resistance is to combine these transgenes expressing several resistance genes into a single line via conventional crossing. The aim of this study was to enhance the resistance level of transgenic pea plants (expressing chitinase and glucanase individually) against fungal diseases. The transgenic lines expressing both chitinase and glucanase were characterised at the molecular level, segregation and stability expression were analysed. Finally, the transgenic hybrids will further be tested for their resistance against different phytopathogenic fungi following resistance assay procedures leading to the establishment of resistance assays.

To achieve the above objective, 24 out of 29 hybrid plants were grown in the F1 generation. Transgene detection was made by PCR using different primer combinations (Chit 555 and Gluc 823). The results clearly showed the integration of chitinase and glucanase genes in the crossed plants. Stability expression was confirmed in the F2 where 182 F1 seeds were grown. Ninety-three plants were homozygous for our genes. Mendelian segregation pattern (9:3:3:1) was observed. Activity assays were performed and some of the crossed transgenic plants are showing an increased effect in activity.

**Keywords:** Combined transgenes, expression stability, fungal resistance, pea

## Molecular Characterisation of Silicon-Induced Resistance in Potato against Bacterial Wilt

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Bacterial wilt caused by *Ralstonia solanacearum* attacks more than 200 crop species, among them important *Solanaceae*. The soilborne pathogen is widespread in tropical and subtropical areas and causes devastating losses. Host plant resistance as a control strategy has not been successful so far, either because germplasm resistance is not stable or/and because of high genetic diversity within the *R. solanacearum* species complex. Alternatively, integrated disease management is considered as a promising strategy to be exploited. We are studying the role of silicon (monosilicic acid) amendment in the potato (*Solanum tuberosum* L.) × *R. solanacearum* interaction as a potential element of such a strategy. We have previously shown by gene expression profiling that silicon was able to induce defense-related genes and to subsequently reduce disease incidence in tomato (*Lycopersicon esculentum* Mill).

Silicon application led to reduced disease incidence in two moderately resistant potato genotypes, but not in a susceptible one. Our main focus is now referred to the kinetic of the phenylpropanoid metabolism in both roots and stems in a time frame of 24–120 hours post inoculation. Phenylalanine ammonialyase (PAL) activity and total soluble phenols are being measured in both plant organs. Recently, in collaboration with Max-Planck Institute for Molecular Plant Physiology (Golm, Potsdam, Germany) we initiated a metabolomic approach by using gas chromatography coupled to mass spectrometry (GC-MS) in an attempt to correlate the profile of secondary metabolites (phenylpropanoid metabolism) as well as other defense-related metabolites to the resistance reaction of our pathosystem after induction through silicon application. Preliminary results showed no role of silicon in PAL activity in inoculated plants of a moderately resistant potato genotype. Additionally, we used three monoclonal antibodies against pectic polysaccharides of the cell walls (JIM7 and JIM5, recognising high and low esterification levels of homogalacturonan, respectively) and arabinogalactan proteins to study the involvement of the cell wall in the resistance reaction. Preliminary results from these antibodies showed a relation between high esterification level and arabinogalactan proteins with the level of resistance.

**Keywords:** Bacterial wilt, induced resistance, potato, *Ralstonia solanacearum*

## Action of the Mycoherbicide *Fusarium oxysporum* F. sp. *Strigae* ‘foxy 2’ on *Striga hermonthica*: An Anatomical Study

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Proper delivery and timely establishment of the potential biocontrol agent *Fusarium oxysporum* f. sp. *strigae* “Foxy 2” in the appropriate infection zone of the root parasite *Striga hermonthica* is necessary for ensuring a high biocontrol efficacy and facilitating field application and integration. In this study, anatomical investigations using light microscopy were performed to assess the pattern and extent of infection and colonisation of *Striga* by Foxy 2. When applied as seed coat, Foxy 2 was able to proliferate on coated seeds and the fungal mycelia started slowly colonizing the roots of sorghum, the potential infection zone of *Striga* without damaging sorghum plants. Observations of the sorghum roots-*Striga* seedlings interface showed that *Striga* was able to penetrate and start to invade the central cylinder of its host sorghum to obtain access to water and nutrients, but further development was stopped by Foxy 2. Hyphae of Foxy 2 invaded all tissues of the young *Striga* seedling (including the endophyte, the entire hyaline tissue and xylem elements), 21 days after sowing the Foxy 2 coated sorghum seeds. Hyphae were able to completely destroy *Striga* seedlings 26 days after sowing. This proved the ability and aggressiveness of Foxy 2 against *Striga* and additionally prevented some *Striga* emergence. For emerged *Striga* plants (above ground), both longitudinal and cross sections showed a lot of hyphae masses in the xylem. Hyphae had penetrated, proliferated and colonised vessels forming masses over long distances and were identified even to the top of the shoots. Some vessels were blocked such that no space larger than 1 µm could be seen between the hyphae in cross sections. This caused clogging of shoots by hyphae and contributed to wilting and subsequent death of *Striga*. The prevention of *Striga* emergence reduces its further seed production and seed bank build up that may lead to improvements in crop yield in subsequent years. These findings support the suitability and appropriateness of seed treatment for the delivery and field application of the mycoherbicide.

**Keywords:** Anatomical studies, biocontrol, delivery system, *Fusarium oxysporum*, light microscopy, seed treatment, sorghum root colonisation, *Striga hermonthica*

## Ozone Application for Controlling Seed-Borne Pathogen and Insect in Rice cv. Khao Dawk Mali 105

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The purpose of ozone application was to determine and evaluate the efficiency of ozone to control seed-borne fungi and insect in rice seed cv. Khao Dawk Mali 105. The percentage of seed-borne invasion was 87.50, mainly 69.63 percent was *Alternaria padwickii* and 3.63 percent was *Fusarium moniliforme*. The moisture conditioned rice seeds 11 and 18 percent were treated with 1.25 mg g<sup>-1</sup> rice seed h<sup>-1</sup> ozone for 2, 4, 6 and 8 hrs. The result showed that the ozonation on wet seed (18 % moisture content; MC) had more effective than on dry seed (11 % MC) in control seed-borne fungi. The results in this experiment indicated that 1.25 mg g<sup>-1</sup> rice seed/ hr ozonation for 6 hr on the wet seed was the best condition for controlling seed-borne fungi in rice seed. The percentage of infected seed was decreased to 26.39, the infection from *A. padwickii* was decreased to 21.57 percent and from *F. moniliforme* was decreased to 1.01 percent. The 8 hr of application time resulted the most efficacy to control fungi such as, the percentage of infected seed decreased to 17.88 and 26.25 in the wet and dry seeds, respectively. The percentages of *A. padwickii* infection were decreased to 14.38 and 20.38 in the wet and dry seed, respectively. The *F. moniliforme* were decreased to 1 and 0.63 percent in the wet and dry seed, respectively. Anyhow, the ozonation time for 8 h significantly reduced seed qualities. Furthermore, the efficacy of ozone in controlling insect estimated by the percentage of *Sitophilus oryzae* mortality at adult stage after ozone treatment with 1.25 mg g<sup>-1</sup> rice seed h<sup>-1</sup> for 1, 2, 3 and 4 h showed that the increasing of ozonation time significantly increased their mortality. The duration of ozonation at the dose of 1.25 mg g<sup>-1</sup> rice seed h<sup>-1</sup> for 3 h could eradicate *S. oryzae* to 100 percent at adult stage.

**Keywords:** Insect damage, ozone, rice, seed-borne fungi

## Control of Seedborne Pathogen in Rice Seed by Coating with Organic Substances

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Types and quantities of seed-borne fungi on rice seed cv. Khao Dawk Mali 105 were assessed by using blotter method. *Fusarium* sp. and *Curvularia* sp. were found as the main fungi 20.67 % and 2.25 %, respectively. Various concentrations and volumes of non-ionic polyacrylamide (PAM) were applied to control seed-borne fungi on rice seed. It was found that the speed of germination was increased to 15.10 seedling day<sup>-1</sup> after treated with PAM at 1 % w/v and with the volume of 2 ml/25 g seed. The increasing of PAM concentration reduced the speed of germination of coating rice seed. However, coating seed with all PAM concentrations showed no significantly effect on the germination percentage.

Combination of PAM (1 % w/v, 2 ml/ 25 g seed) and clove and star anise essential oils at different concentrations: 0.01, 0.03 and 0.05 % were applied to rice seed. Coating seeds then subjected to their quality testing and their seed health evaluating. Treated seed with PAM and various essential oils showed the promising results in inhibiting seed borne fungi. The higher concentration of the coating substances, the better the efficacy *Aspergillus* sp. and *Nigrospora* sp. were completely 100 % under control. Nevertheless, compare to chemical treatment under captan application; captan showed the best in controlling, followed by clove essential oil 0.05 % and star anise essential oil 0.05 %. Seed qualities; speed of germination, germination percentages were not affected by all treatments.

Clove and star anise crude extracts were investigated then, it showed their positive tendency in seed borne fungi inhibition. Coating seed with all concentration of clove and star anise crude extracts inhibited growth of *Nigrospora* sp. equal to 100 % inhibition. All concentration of star anise crude extract completely inhibited *Aspergillus* sp. and *Bipolaris* sp. For seed qualities, the germination percentage of seed coated with star anise crude extract at 0.05 % w/v showed a high germeability, evenso for captan. Seed coated with the crude extract of clove at 0.01 % w/v showed the highest value of seedling growth rate with 6.2 mg seedling<sup>-1</sup> for 7 days; but, the germination speed was slightly decreased.

**Keywords:** Coating, organic substances, PAM, rice, seed borne fungi

## Biochemical Characterisation and Resistance Induction by Bacterial Antagonists against Bacterial Wilt Caused by *Ralstonia solanacearum*

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A total of 150 rhizosphere bacterial strains were isolated from tomato and potato rhizosphere soil and roots from Ethiopia. The strains were screened *in vitro* for their antagonistic effect against the pathogen *R. solanacearum* on NGA agar medium using the dual assay test. Of all the tested isolates fifteen were found to inhibit the pathogen; among these four were selected for an ad planta experiment with two tomato varieties: King Kong–2 and L390, moderately resistant and susceptible, respectively. The antagonistic strains were characterised phenotypically and physiologically using the standard microbiological methods such as colony morphology, oxidase test, catalase test, gram-reaction, gelatine liquidification, growth at different salt concentrations. Further characterisation of isolates, metabolic fingerprinting by C-source utilisation using the Biolog microplates and fatty acid profiling was done. Thus selected, promising strains suppressed wilt severity and incidence both in split root and pot experiments and improved growth of the plant under glass house conditions, indicating the potential for resistance induction and for growth promotion, respectively. Bacterial numbers of *R. solanacearum* in midstems of genotype King Kong–2 were found to be lower than in the susceptible tomato genotype L390 in antagonist treated plant. The strains were further characterised for plant growth promoting activity such as siderophore, indole acetic acid and hydrogen cyanide production and phosphate solubilisation capacity. The alteration of the cell wall structure after infection and inoculation of the plant with antagonistic bacteria was investigated by immuno-fluorescent microscopy. To confirm the rhizobacteria-induced systemic resistance, enzymatic assays and quantitative real time PCR are being performed to quantify the level of expression of target enzymes involved in resistance signaling pathways in the plant.

**Keywords:** Indole acetic acid, induced resistance, *Ralstonia solanacearum*, rhizosphere bacteria, siderophore, split-root test



## Evaluation of Allelopathic Effects of Fenugreek Extract on Germination and Growth of Some Crop and Weed Species

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Allelopathy refers to the beneficial or harmful effects of one plant on another plant through the release of chemicals from plant parts by leaching, root exudation, volatilisation, residue decomposition and other processes in both natural and agricultural systems. Allelochemical concentrations in the producer plant may also vary over time and is produced in the plant tissue.

In order to study the effects of different organ extracts of fenugreek (*Trigonella gracum*) on germination of some crops and weeds an experiment was conducted as a completely randomised design with 3 replications at the Ferdowsi University of Mashhad, Iran. Factors included 4 crops: soybean (*Glycine max*), sesame (*Sesamum indicum*), pigweed (*Amaranthus retroflexus*) and velvetleaf (*Abutilon theophrasti*) and the extract of different Fenugreek organs (leaf, stem, seed, pod and total organs) were applied at 4 levels: check, 4, 8, 32 and 64 g powder l<sup>-1</sup> distilled water.

The results showed that the reactions of the crops and the weeds depended on the concentrations of the different organ extracts. Fenugreek extract not only reduced seedling growth of different species, but also inhibited seed germination. Negative and significant correlation was observed between the germination percentage and different concentrations of Fenugreek organs. A minimum regression slope could be obtained for the stem extract. Root and shoot length showed also a negative and significant correlation with the Fenugreek extract concentrations for all crops except for soybean. In general, velvetleaf was the most sensitive for fenugreek allelochemical. Alternatively, application of allelopathic compounds before, together, or after the application of synthetic herbicides could increase the overall effect of both materials. In this way, application rates of synthetic herbicides could be reduced.

**Keywords:** Allelopathy, fenugreek, *Trigonella gracum*, soybean, *Glycine max*, pigweed, *Amaranthus retroflexus*, sesame, *Sesamum indicum*, velvetleaf, *Abutilon theophrasti*



# Weeds and invasive plants

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## **The Impact of Common Dry Bean (*Phaseolus vulgaris*) Planting Dates and Densities on Weed Growth Characteristics**

ZEINAB AVARSEJI, MOHAMMAD HASAN RASHED MOHASSEL, AHMAD NEZAMI

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Common bean (*Phaseolus vulgaris*) is one of the most susceptible plants to herbicides. Environmental concern increased the necessity of using non chemical weed control strategies against weeds in common bean. Planting dates and crop densities are two important cultural practices in growing beans. Appropriate planting date and crop density could reduce weed dry matter and increases crop competition abilities. A field experiment was conducted in Ferdowsi University of Mashhad, College of Agriculture Experimental Station at 2006 in order to study the effectiveness of different planting dates and crop densities on weed growth characteristics. Experiment was arranged as an split plot based on a completely randomised blocks design , with 3 replications in which the main plots were planting dates (April 25<sup>th</sup> - May 10<sup>th</sup> - May 24<sup>th</sup>) and the sub plots were different plant densities (10–20–30 plant m<sup>2</sup>). The results indicated that different planting dates and crop densities had significant reduction in weed biomass and decreasing weed growth rate. The minimum weed dry matter and growth rate was observed in planting date of April, 25<sup>th</sup> compare to other planting dates. However in this treatment the crop biomass and the crop growth rate were high. The maximum yield, dry matter and crop growth rate of common bean were obtained in crop density of 30 plants m<sup>2</sup>. Whereas, the least amount of weed growth rate and weed dry matter obtained in 30 plants m<sup>2</sup>. The minimum weed dry matter and weed growth rate and maximum crop growth rate, yield and biomass was obtained in treatment of 30 plants m<sup>2</sup> and planting dates of April 25<sup>th</sup>.

**Keywords:** Agronomic practices, common bean, *Phaseolus vulgaris*, weeds

## ***Parthenium* Phyllody in Ethiopia: Epidemiology and Host Range of Phytoplasmas within Important Crops Cultivated in Ethiopia**

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*Parthenium hysterophorus* is an annual weed originating from Central America. It was introduced to Ethiopia in the 1980ies and became the major invasive weed in both arable and grazing lands, due to its competitiveness and adaptability to different climates and soils. In Ethiopia a disease caused by phytoplasmas was commonly observed in *Parthenium* (up to 75 % field incidence). Diseased plants are characterised by excessive branching (witches' broom), reduced plant height and leaf size, and modification of floral structures into leaf-like structures that lead to sterility (phyllody). More than 700 plant diseases are associated with phytoplasmas. In order to test whether *Parthenium* plants harbor phytoplasmas, which may also infect important agricultural crops in Ethiopia, weeds and cultivated plants showing phyllody symptoms were collected. Furthermore, planthoppers that are supposed to serve as potential vector insects were captured from phyllody diseased *Parthenium* plants and transmission studies were carried out by use of leafhoppers. Phytoplasma infection was assessed by polymerase chain reaction (PCR) and the PCR products were further characterised by sequencing allowing species identification of the pathogens. DNA fragments specific for phytoplasmas could be detected in *P. hysterophorus* as well as in important crops in Ethiopia, e.g. groundnut, sesame, and grass pea. The phytoplasmas belong to the Peanut witches' broom (16 SrII) group and can be transmitted by the leafhoppers *Orosius cellulosus* native to Ethiopia. Moreover, it could be shown that nymphs as well as adult planthoppers of the genus *Hilda* (family Tetrigometridae) collected from phyllody diseased *Parthenium* can acquire these phytoplasmas. This suggests that *Parthenium* represents a pathogen reservoir for the phytoplasmas affecting agricultural crops in the country. Since phytoplasma infections can lead to sterility of the inflorescences, severe losses in yield of agricultural crops could be expected. Thus, control of *Parthenium* and putative vectors transmitting phyllody disease is important.

**Keywords:** Ethiopia, invasive weeds, *Parthenium hysterophorus*, phyllody, phytoplasma

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## Effect of Plant Diversity and Nutrient Resource on Weed Composition and Density in Different Cropping Systems

GOLSOOMEH AZIZI, ALIREZA KOOCHKEI, MEHDI NASSIRI MAHALLATI

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In order to investigate the effects of plant diversity and nutrient resource on weed composition, density and dry matter in different cropping systems, an experiment was conducted as split plot based on complete randomised block design with 3 replications at the agricultural research station, Ferdowsi University of Mashhad, Iran, during 2006 and 2007. Treatments included manure and chemical fertilisers in main plots and intercropping of 3 soybean varieties (Williams, Sahar and Gorgan3), intercropping of 3 millet species (common millet, foxtail millet and pearl millet), intercropping of millet, soybean, sesame (*Sesamum indicum*) and intercropping of millet, sesame, fenugreek (*Trigonella foenum-graecum*), ajowan (*Trachyspermum ammi*) in sub plots. Result indicated that nutrient resource affected weed dry matter and density. Weed dry matter and density was respectively, 1.3 and 1.8 folds higher in chemical fertiliser compared to manure in first year. In the second year, weed dry matter in manure and chemical fertilisers was 173.2 and 300.2 g m<sup>-2</sup> and weed density was 98.6 and 84.9 plants per m<sup>-2</sup>. With increasing crop diversity, weed dry matter and density decreased and intercropping systems had the lowest weed dry matter. Crop species affected weed dry matter in monocultures. There was a negative correlation between diversity and weed dry matter. In the first year Shannon diversity index was highest in sesame and ajowan monocultures (0.75 and 0.72, respectively). Different intercropping systems had the lowest Shannon index. In the second year, Shannon index was highest in soybean (Sahar variety) monoculture (0.72) and 3 Millet species intercropping (0.71). more researches on the effects of crop diversity on weed population is needed in mixtures.

**Keywords:** Intercropping, shannon index, species diversity, weeds

## Optimal Herbicide Application Rate for *Pueraria* Fallow Recalculation: Effects on Vine Growth, Soil Cover and Weed Suppression

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Demographic growth in combination with increased prices of food imports demand an increased output of local agricultural systems in the humid forest zone of Cameroon. Leguminous fallow systems based on *Pueraria phaseoloides* (tropical kudzu) are a promising technology to intensify land use in the traditional slash and burn fallow systems by speeding up fertility restoration in the fallow period. Reclaiming the fallowed land by direct planting into an undisturbed mulch layer is labour efficient and has other advantages, including prolonged arable weed suppression and soil erosion protection. Herbicide treatment could be an appropriate technology to control *P. phaseoloides* in commercial food crop fields where labour is scarce. However, the dosage of herbicide needs to be balanced between effectively delaying recovery of *P. phaseoloides* without killing the cover crop. Objective of this study was to find the optimal pre-planting herbicide application rate reducing early competition for resources and crop damage caused by climbing vines, but avoiding the loss of benefits of in-situ mulch production. An experiment was set up in a 3-year-old *P. phaseoloides* dominated fallow where soil cover and vine growth were monitored after Glyphosate was applied at a rate of 0, 360, 720, 1440 and 2880 g ha<sup>-1</sup>. None of the treatments was lethal. *P. phaseoloides* climbing activities were effectively delayed for 29 days by the 720 and 1440 g ha<sup>-1</sup> treatments followed by a 81 days delay by the 2880 g ha<sup>-1</sup> treatment. The 360 g ha<sup>-1</sup> treatment did not postpone *P. phaseoloides* regrowth compared to the control although it reduced the initial growth rate considerably. Weed cover was low in all treatments resulting in no significant difference over all treatments in weed biomass at 123 days after treatment. Interestingly, also the dry weight of litter layer did not show differences over the treatments, suggesting that *in-situ* litter production in the control treatment may have been compensated by a higher decomposition rate under the standing crop. Overall, these results show the potential of a single herbicide application of 720 g ha<sup>-1</sup> to create a closed semi-live mulch layer suitable for direct planting of maize crops with zero pre-planting labour requirements.

**Keywords:** Glyphosate, improved fallow, kudzu, pueraria



## Hydrogen Cyanide Production Ability by *Pseudomonas fluorescence* Bacteria and their Inhibition Potential on Weed Germination

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This research was undertaken to isolate and purificate indigenous *Pseudomonas* spp., to evaluate its ability in hydrogen cyanide synthesis and also to evaluate the potential of super-strains on seedling growth inhibition of weeds. The research was carried out in laboratory tests. 136 strains (obtained from rhizosphere soil of 62 weed species) and 27 strains of *Pseudomonas fluorescence* were sub-cultured, purified and refreshed. Then these strains were evaluated for the capability in cyanide synthesis and at last 4 super-strains of cyanogenic *Pseudomonas* were selected and used in further experiments. The effects of these strains on stem length, root length and stem length/root length rate in rye, wild barley, and wheat were evaluated in three different *in vitro* tests examining the effects of gas and liquid metabolites produced by the bacteria.

The results showed that the abundance and probability of the bacteria isolation was low (about 3.6 %). About 37 % of *Pseudomonas* were capable of HCN production and this capacity was different among the strains. Gas metabolites reduced more than 90 % of root and shoot growth in weeds. These gas metabolites had larger inhibitory effects than other metabolites on plants. However, these influences were different in every bacteria treatment. Also wheat had less growth reduction if compared to weeds, indicating that the bacteria are probably plant specific.

In conclusion, the results proved that cyanogenic *P. fluorescence* had the potential of biological weed control. However, further studies on its application under natural conditions like greenhouse and field conditions, seem to be necessary.

**Keywords:** Biological weed control, growth inhibition, hydrogen cyanide, *Pseudomonas* spp., weeds

## **Evaluation of the Effects of the Fallow / Forage-Barley and Sugarbeet / Forage-Barley Rotations on Density and Distribution of Weeds**

ASIEH SIAH-MARGUEE, MOHAMMAD HASAN RASHED MOHASSEL,  
MOHAMMAD BANNAYAN, MEHDI NASSIRI MAHALLATI, LEILA ALIMORADI,  
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In order to evaluate the effects of the pre-culture fallow or sugarbeet on density and distribution of different species of weeds in a forage-barley field, a study was executed at the Mashhad Experimental Station of the Ferdowsi University in 2003. Rotations of fallow / forage-barley and sugarbeet / forage-barley are conventional management systems. Samples were taken from the corners of the 7m\*7 m grids using 0.5m\*0.5 m size quadrates at three development stages (pre-application of herbicide, post-application of herbicide and pre-harvesting).

The results indicated that the density of annual weeds in the sugarbeet / barley rotation was higher than in the fallow / barley rotation. However, the density of perennial weeds was higher in the fallow / barley rotation than in the sugarbeet / barley rotation. Mapping of the species distribution and their density confirmed the patchiness of the weed distribution. The shape and size of the patches differed between field and weed species, but spatial distribution did not change considerably before and after application of herbicide. Percentage of free weed areas was 11.5 % and 1.5 % in fallow / barley rotation and 0.6 % and 0 % in sugarbeet / barley rotation in first and second sampling stage respectively. These results indicate the inefficacy of sugarbeet as pre-culture as compared to fallow with regard to weed density in a forage-barley field.

The evaluation of crop rotation management practices with special attention to weed dispersal within the field, is able to identify appropriate management strategies of high efficacy and profit for the farmer as well as to reduce crop damage.

**Keywords:** Forage barley, patchiness distribution, site specific management, weed management, crop rotation

## Allelopathy as an Alternative Method for Weed Control in Saffron Fields: A Suitable Approach to Sustainable Agriculture

LEILA ALIMORADI<sup>1</sup>, GOLSOOMEH AZIZI<sup>1</sup>, MARYAM JAHANI<sup>1</sup>, ASIEH SIAH-MARGUEE<sup>1</sup>, ATEFEH KESHAVARZI<sup>2</sup>

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Allelopathy, the chemical mechanism of plant interference, can affect many aspects of plant ecology including plant occurrence, growth, succession, structure plant community, dominance, diversity, and plant productivity. An allelopathic plant can potentially be used to control weeds. In a rotational sequence, when an allelopathic plant is left as a residue or mulch, especially in low-till systems, could control subsequent weed growth. Allelopathy is characterised by a reduction in plant emergence or growth, reducing their performance in the association. To study the effect of saffron (*Crocus sativus* L.) extract on germination of *Rapistrum rogosum* and *Gypsophilla pillosa*, an experiment was conducted in a completely randomised design with 3 replications at Ferdowsi University of Mashhad, Iran. Treatments included the extract of saffron seeds and leaves at 5 levels (check, 0.5, 1, 1.5, and 2 %). Results indicated that seed extract did not affect germination percentage significantly, but seed germination was affected by different concentrations of leaf extract. With increasing concentration of leaf and seed extract decreased the rate of germination, shoot length, root length and seedling dry weight of *Rapistrum rogosum* and *Gypsophilla pillosa*. On the whole, *Rapistrum rogosum* was more tolerance than *Gypsophilla pillosa* and root length was more sensitive then shoots length to saffron extract. From a holistic poit of view, research potential and use of allelopathy in an agroecosystem is very wide. The richness of agricultural techniques, crop rotation, cover cropping, and related practices allow researchers to evaluate and make use of allelopathic chemicals for weed management in agricultural systems.

**Keywords:** Allelopathy, biological control, saffron, weeds

## Effect of Plant Diversity and Nutrient Resource on Weed Composition and Density in Different Cropping Systems

GOLSOOMEH AZIZI, ALIREZA KOOCHKEI, PARVIZ REZVANI-MOGHADAM,  
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In order to investigate the effects of plant diversity and nutrient resource on weed composition, density and dry matter in different cropping systems, an experiment was conducted as split plot based on complete randomised block design with 3 replications at the agricultural research station, Ferdowsi University of Mashhad, Iran, during 2006 and 2007. Treatments included manure and chemical fertilisers in main plots and intercropping of 3 soybean varieties (Williams, Sahar and Gorgan3), intercropping of 3 millet species (common millet, foxtail millet and pearl millet), intercropping of millet, soybean, sesame (*Sesamum indicum*) and intercropping of millet, sesame, fenugreek (*Trigonella foenumgraecum*), and ajowan (*Trachyspermum ammi*) in sub plots.

Results indicated that nutrient resource affected weed dry matter and weed density. In the first year of the experiment, chemical fertilisers resulted in a 1.3 and 1.8 folds higher weed dry matter and the weed density, respectively if compared to manure application. In the second year, weed dry matter on manure fields and with chemical fertilisers was 173.2 and 300.2 g m<sup>-2</sup> and weed density was 98.6 and 84.9 plants per m<sup>-2</sup>, respectively.

With increasing crop diversity, weed dry matter and density decreased and intercropping systems had the lowest weed dry matter. Crop species affected weed dry matter in monocultures. There was a negative correlation between diversity and weed dry matter. In the first year Shannon diversity index was highest in sesame and Ajowan monocultures (0.75 and 0.72, respectively). Different intercropping systems had the lowest Shannon index. In the second year, Shannon index was highest in soybean (Sahar variety) monoculture (0.72) and 3 Millet species intercropping (0.71). more researches on the effects of crop diversity on weed population is needed in mixtures.

**Keywords:** Intercropping, Shannon index, species diversity, weeds

# Cropping systems: resource use and technologies

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## System of Rice Intensification (SRI) in Southeastern Lowlands of Amazonia – A Viable Alternative for Smallholder Irrigated Rice Production?

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The System of Rice Intensification (SRI) has been enthusiastically proposed as an alternative for irrigated rice production by development projects in Asia. Compared to conventional management, SRI supposedly attains higher yields combined with lower input demands, making it both accessible and attractive for smallholder agriculture. SRI is based on the following presumptions:

(i) though wetland rice is well adapted to anaerobic conditions (flooding), it prefers a moist but aerobic environment, and

(ii) high plant densities unduly increase competition and thus reduce plant vigour and overall yield, and increase susceptibility against pests and diseases.

Consequently, SRI differs markedly from conventional management:

(i) careful transplanting of seedlings from a nursery (rather than direct seeding)

(ii) maintenance of moist but non-inundated conditions, and

(iii) plant densities of 25 seedlings m<sup>2</sup> (rather than 500 seeds m<sup>2</sup>).

SRI could revolutionize smallholder rice production, but sound scientific data are scarce. We evaluated SRI on an alluvial soil of the Mearim river, southeastern periphery of Amazonia. Experimental layout was a completely randomised block design with 4 treatments involving SRI vs conventional management at 2 levels of N-fertilisation (200 kg N ha<sup>-1</sup> as cow manure, and cow manure + 100 kg N ha<sup>-1</sup> as urea) and 4 replications, plot size was 52 m<sup>2</sup>.

Rice production was slightly but significantly higher in conventional than in SRI treatments (4.4 vs 3.2 t ha<sup>-1</sup> grains with manure and 6.2 vs 5.7 t ha<sup>-1</sup> grains with manure + urea application). Plant biomass and 100 grain weight were likewise higher and root:shoot ratios lower in conventional than in SRI treatments. Plant tissue analyses indicate that SRI may have suffered P-deficiency induced by the prevailing oxic conditions. Weed pressure was a further problem associated with the lack of flooding in SRI. Nevertheless, the merely slightly lower productivity of SRI confirms its potential as management alternative. Future R&D is needed and under way to investigate (i) SRI-induced P-deficiency, (ii) the potential of SRI in other soils, (iii) the danger of greenhouse gas emissions associated with SRI, and (iv) better adapt SRI management to the local context.

**Keywords:** Irrigation, lowland rice, Maranhão state, P-deficiency, plant density, water regime

## Technical Efficiency of Farming Systems and its Determinants in East Gojjam, Ethiopia

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Following the seminal work of Farrell (1957) and the influential Shultz's (1964) "poor but-efficient" hypothesis, several studies have been conducted in different countries to examine technical efficiency of smallholder farmers. In Ethiopia, however, the literature is scanty. More importantly, little has been done on the investigation of efficiency variations across agro-ecologies. It is to be noted that studies considering agro-ecological zones will have important policy implications to identify appropriate development strategies thereby enhancing the current performance of the agricultural sector. The present study is, therefore, an attempt to fill an existing gap by examining the level of technical efficiency and its determinants across agro-ecological zones in eastern Gojjam, Ethiopia. From our sample, it can be observed that there exists a 64 % of variation in the total output due to technical inefficiency. Therefore, maximum likelihood estimates were preferred to OLS to avoid biased results. From the stochastic frontier analysis, the mean technical efficiency (ranging from 36.15 % to 92.66 %) was found to be 75.08 %. The results of the F-test in ANOVA show that there exists a statistically significant difference in technical efficiency between agro-ecologies with dega areas scoring the highest. Maximum likelihood estimates also indicate that the coefficients for land, draft power, labour, and fertilisers are positive and highly significant. Since education, proximity to markets, and access to credit were found to reduce inefficiency levels significantly, future endeavours may need to look into mechanisms by which farmers can get access to better ways of farming through trainings, onsite visits by extension agents, improved market outlets and reduced liquidity constraints.

**Keywords:** Agroecology, cereal production, Ethiopia, technical efficiency, stochastic



## **Studying the Expansion of Olive Plantations into Syrian Dry Areas to Assist in Preparing a Suitable Agriculture Extension Program for the Olive Farmers in these Areas**

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Since the last decade of last century, developments have taken place in Syrian dry areas by expanding the olive agriculture. As result of that, the number of olive trees has increased rapidly by 50 % across Syria. This study carried out in the Salamieh area in the middle of Syria, which includes 165 villages approximately. The agriculture and livestock breeding are considered to be as main economic activities in this area. Due to the lack of water in Salamieh area the production of irrigated crops like wheat and cotton were restricted to specific areas, while the number of olive trees recently increased dramatically with a growth rate of 18 % in 2007. Accordingly, the main objectives of this paper is to study the status of olive farming in the agro-climatic zones in Salamieh area, and to suggest policy recommendations, which are necessary for preparing an integrated extension programme for the olive farmers. The study based on primary data, which was collected from 114 farmers in 25 villages randomly by means of questionnaire during season 2006–2007. Results showed that the local olive's varieties (Surani, Kaisi), supplemental irrigation, fertilisation and the alternate bearing, affected the average of olive production. Moreover, there was a lack of sufficient experience in the field of olive by some farmers, 40 % from the age composition of the olive trees was 5–10 years old, and there was an adoption of modern irrigation techniques. Considering the fact that 50 % of farms size is 0.5–1 ha together with high costs of production; this shows the urgent need of preparing an agriculture extension programme for the olive's farmers. It will be in cooperation with the government and the other non-government organisations to help farmers in the all stages of the olive production, in addition to milling and marketing of the production, which would increase the farm income in the study area.

**Keywords:** Dry zones, extension programme, olive trees, Syria

## **Spatial Variability of Maize-Cassava Productivity in Uplands of Northwest Viet Nam**

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With rising population and high world market prices for crops such as maize, the pressure on upland fields for agricultural production has reached a new all time high. Therefore, deep slopes, decreasing soil productivity and high erosion rates do not hinder farmers of using such fields in mountainous regions. The overall goal of this study is to better understand the impact of land-use intensification on maize-cassava productivity and related nutrient flows at landscape level. Five fields were selected in the Chieng Khoi watershed, Son La province, Northwest Viet Nam to study the impact of field accessibility, based on distance from village, crop performance and soil fertility. At each of the five fields three plots were marked in the upper, middle and lower slope position and will be monitored during the 2008 cropping season to assess crop performance, based on plant density, ground cover, leaf area index and greenness of leaves. In addition, yield parameters will be collected. For linkage towards soil quality, soil samples will be collected from each plot till a 40 cm depth before planting and after harvest to assess changes in soil fertility. Soil texture, particle size distribution, pH, organic matter, water retention and bulk density are of interest as well as nutrients. Amount and quality of runoff as well as total eroded soil within the cropping season will be monitored by Gerlach troughs established on upper, middle and lower slope positions and erosion pins. The focal point will be on soil degradation, crop performance and their spatial distribution within and across selected fields as affected by distance to village or homestead, slope gradient and field cropping history. The expected results will allow predicting the long term soil loss of the current production practice (maize-cassava). Thus, this study will contribute to recommendations on an improved management for increased productivity in this ecologically fragile and economically disadvantaged mountainous region of Southeast Asia.

**Keywords:** Crop performance, erosion, field accessibility, intensification, land use, soil degradation

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## **Integrating Resource Conservation Technology for Sustainable Agro-Ecosystems in Hill Farming System of Nepal**

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Sustainable resource management is widely acknowledged as important strategy to combat poverty and environmental degradation in all the developing countries. Particularly, in mid hill regions of Nepal, its relevance becomes more prominent where agriculture is practised in sloppy and fragile land, aggravating the problem of soil erosion and loss of organic matter.

Management of soil organic matter in a way that it supports current as well as future long term food production is the key principle for sustainable agricultural practices. Resource conservation technologies for example, zero tillage; mulch tillage and minimum tillage are in line with this principle and shown better performance in most part of the world. Several researches in Nepal have proved that excessive tillage of the sloppy land for summer crop production during the pre-monsoon period which leaves soil loose and prone to high impact of rainfall, is the main casual factor of soil and nutrient loss in the hill agricultural system. It leaves soil loose and prone to erosion. Therefore, the present study attempts to perform economic analysis of minimum tillage as a feasible resource conservation technology in a typical mid hill farming system of Nepal.

The results of the cost benefit analysis for next 25 years of time horizon show that minimum tillage could be a financially attractive technology for maize cultivation in rainfed lands of the mid hill region. Since, minimum tillage is able to conserve a substantial amount of soil and nutrients, it has a long-term positive impact on the crop yield in comparison to the conventional tillage system. Short-term yield loss due to sudden reduction in number of tillage is compensated by the remarkable reduction in soil and nutrient losses coupled with lower labour cost for land preparation. The study has high policy implication for sustainable and resource-efficient agricultural production system in hill farming systems where marginality of resources has threatened the livelihood of the people.

**Keywords:** Cost benefit analysis, hill farming system, minimum tillage, sustainable agricultural practices

## **No-Till and Direct Seeding into the Mulch of Legume Prunings as a Sustainable Land-Use Alternative for the Humid Tropics**

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In northern Brazil, the grand challenge to develop sustainable land-use systems has yet to be resolved. Rural population still depends on fire for land preparation, thereby causing negative impacts both on local and global environment and lacking any type of social benefits. This situation creates a vicious feedback cycle in which rural poverty increases the pressure on natural resources and in which the degradation of these resources in turn increases rural poverty. The main challenge for research in this region is in the development of alternative technologies which unite the enormous potential for biomass production with the poor capacity of soils to provide adequate conditions for crop roots. Research conducted by the MSc course of Agroecology of Maranhão State University points to no-till with permanent soil cover and soil acidity correction as the most important management measures for sustainable agriculture in the region. Alley cropping with no-till combined with direct seeding into the mulch of legume prunings takes advantage of rapid tree growth and has been found to be capable of meeting such requirements, offering the following advantages: **(i)** unification of grain production and fertility restoration processes in the same time and in the same field; **(ii)** maintenance of continuous soil cover and efficient nutrient cycling by the combination of tree legumes with high and low residue quality; **(iii)** two harvests per year consisting of annual rotations of medium-cycle crops such as maize and upland rice followed by short-cycle crops such as beans or sorghum; **(iv)** maintenance or even increase of soil organic matter, essential for the sustainability of humid tropical agroecosystems, and **(v)** accumulation of mineral nutrient reserves accessible by microbially mediated processes providing an economically promising alternative to the soil saturation of soluble nutrients for sustainable land use.

**Keywords:** Alley cropping, organic matter, soil fertility

## **Regional Assessment of Agricultural Cropping Systems in the North China Plain: A Modelling Approach Towards Sustainable Resource Use**

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The North China Plain (NCP) covers an area of around 328,000 km<sup>2</sup> and is one of the most important regions of cereal crop production in China. Wheat and maize rotations and one season cotton are the most common planting systems. The region contributes at an amount of about 50 % to the countries wheat production and about one third of maize yields. Crop production in the NCP was focused in the last decades on increasing yields to meet the growing food demand accompanied by the limitation of arable land as a result of urbanisation rate i.e. of the Beijing District. Food production needs can nowadays only be achieved by the optimisation of agricultural management, i.e. fertiliser input, irrigation, improved crop rotations. The focus on increasing yields raised serious environmental problems, like water shortage and pollution, air pollution and soil contamination. Hence the development of future land use system approaches improving these conditions is essentially. This may provide both a high production level as well as a protection of resources. The multidisciplinary collaborative International Research Training Group project (IRTG) “Modelling Material Flows and Production Systems for Sustainable Resource Use in Intensified Crop Production in the North China Plain”, funded by the Deutsche Forschungsgemeinschaft (DFG) and the Chinese Ministry of Education, was launched to detect the potential of adjustments in cropping systems and develop management practices for sustainable resource use and protection of environmental conditions while assuring a high yield level. Our work concentrates on the simulation of different spatial-temporal scales in order to detect the effects of changing land use patterns within scenarios. To fulfil this task we locally adapted the concept of cellular automata (CA). Simulations i.e. of fertiliser input levels are obtained by transition rules for different cell stages. The possibility to create cells in hierarchical order, so called hierarchical automatic cellular automata (HACA) proposes the opportunity for regionalisation. Secondly we use the crop model DSSAT (Decision Support System for Agricultural Transfer) to predict and regionalise water use efficiency, fertiliser efficiency and yield under iterative management scenarios.

**Keywords:** Agriculture, cellular automata, China, crop modelling, China, regionalisation

## Developing Decision Support System for Agricultural Land Use Planning and Management at the District Level in Viet Nam

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After agricultural renovation policies launched in 1988, farm household was recognised as a self-control economic unit, so Viet Nam agriculture has obtained profuse achievements such as self-sufficiency in rice, surplus rice for export and poverty alleviation, etc.

However, most of farm households have been making production decision by itself. Therefore, production decisions have not been made based on the long-term predictions of market demand and comparative advantages under the assistance of scientists as well as administrators. It may caused unsustainable environment.

This caused both shortage and surplus agricultural product in the market. Farmers' income was low and instable. Upgrading capability in making decision of farm households and administrators at commune and district levels is topicality and necessity. Nevertheless, this is very complex responsibility in real life.

It is necessary to have a tool to support policy makers and planners in developing, appraising, and selecting planning scenarios which collaborate different social, economic, and environmental development dimensions in order to gain sustainable development goals.

This problem can be solved by implementing interdisciplinary research methods, which relate to Scientists in the fields of geography, land use planing, agronomy, agricultural economics and informatics technology.

Information that will be collected including land use planning and management by applying Geographical Information System (GIS) technique and Remote Sensing (RS); current crop patterns and local knowledge of farmers; household economy in relationship with land use planning, environment, market prediction and risk

Informatics and mathematical modelling techniques will be of use in data processing, optimal solution determining and information providing for making decision support. The decision support system will provide tools for planners, policy makers and others to improve policies on land use planning and implementation of other rural development and land resource management programs.

**Keywords:** Decision support system, land use planning, Viet Nam

## **Improving Smallholder Cassava Production using New Varieties and Best Agronomic Practices on Ultisols in Southern Cameroon**

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Cassava is the main subsistence staple for farmers and a preferred food item for both rural and urban consumers in southern Cameroon. Urbanisation and increased world market prices of alternative starchy staples have resulted in an increased demand for both fresh and processed cassava. At present, the high demand is not met by increased supply, resulting in higher prices which undermine food security for a growing segment of urban poor. Cassava is currently produced by fragmented smallholder producers in mixed food crop fields with groundnut as the major cropping partner. The main objective of these fields is subsistence food production and not cash generation. Cassava root yields in subsistence fields are considered low caused by a combination of low plant density and high pest and disease pressure. Better market prices and improved cassava performance may provide an incentive to farmers to shift to more commercially oriented cassava fields to complement their income. The objective of this study was to develop a set of best practices to be recommended to farmers to lift productivity to commercially attractive levels for local markets. In a multi-locational participatory field trial in three villages in the Yaoundé area, performance of IITA improved cassava germplasm was compared with the best local variety. The experiment compared a combination of cultural practices including planting pattern (square vs rectangular), soil management (level till vs ridged vs no-till) and groundnut intercropping in a factorial design. Harvest data is currently evaluated with the collaborating farmers and is soon to be analysed.

**Keywords:** Agronomy, Cameroon, cassava, improved germplasm

## Impact of *Canavalia brasiliensis* on Nitrogen Budgets in Smallholder Crop-Livestock Farms of the Nicaraguan Hillsides

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In smallholders farming systems of the Nicaraguan hillsides, intensification of land use resulted in soil nutrient depletion and a decrease in agricultural productivity. Nitrogen (N) is considered as most limiting nutrient in the traditional maize-bean-livestock system. Furthermore, farmers lack forage for their livestock. We are testing the hypothesis that an underutilised and drought tolerant cover legume, *Canavalia* (*Canavalia brasiliensis*), can be introduced into the traditional system to overcome soil fertility decline. On farm trials were conducted between June 2007 and January 2008 at four locations in the Nicaraguan hillsides. We set up the soil surface N budget of traditional maize-bean (M/B) rotation and compared it with the budget of maize-*Canavalia* (M/C) rotation, with different cutting intensities of *Canavalia* above ground biomass to simulate grazing. Nitrogen input variables were mineral fertiliser N, N input with seeds and symbiotic N<sub>2</sub>-fixation, estimated using the natural abundance method. The estimation of N output was based on N removed with harvested parts of maize, bean and *Canavalia*. *Canavalia* fixed between 15 to 38 kg N ha<sup>-1</sup> while bean fixed 10 kg N ha<sup>-1</sup> on average. Fixation by bean was lower due to its low biomass production. Farmers applied between 38 and 60 kg N ha<sup>-1</sup> in form of mineral fertilisers, while N contained in seed represented only between 1 and 4 kg N ha<sup>-1</sup>. Highest N outflow occurred with harvest of maize, with an average of 43 kg N ha<sup>-1</sup>. Nitrogen output by bean remained under 10 kg ha<sup>-1</sup> due to small yields. The different *canavalia* removal proportion had an important impact on the N balance: on average, when 0% of *Canavalia* was removed from the field, N surplus was 31 kg N ha<sup>-1</sup>. In contrast, complete removal of *Canavalia* biomass led to a N deficit of 10 kg ha<sup>-1</sup>. Under M/B rotation, the N balance remained more or less equilibrated with on average a N surplus of 10 kg N ha<sup>-1</sup>. *Canavalia* shows potential to fix a significant N amount. However, when completely removed as forage, it bears risk of soil N depletion unless N would be recycled to the plot by animal manure.

**Keywords:** <sup>15</sup>N natural abundance method, *Canavalia brasiliensis*, N budget, Nicaraguan hillsides, on-farm trial

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## Parameterisation and Modelling of Growth and Yield Development of Mango (*Mangifera indica* L.) in North Thailand with Application of the WaNuLCAS Model

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In mountainous areas of North Thailand soil erosion is a severe problem, resulting from population growth and expansion of agricultural land into fragile uplands. Mango, one of the major fruit crops in Thailand, can be an alternative to annual crops and is, thus, an option to prevent soil degradation. To test mango growth under different environmental conditions and in diverse agricultural systems modelling can be a useful tool. The aim of this study was to parameterise mango growth of the Thai varieties “Chok Anan” and “Nam Dok Mai” for two sites in North Thailand for the calibration of WaNuLCAS 3.2 (Water, Nutrient, and Light Capture in Agroforestry Systems). Data collection for the parameterisation took place at Mae Jo mango orchard, north of Chiang Mai, which is managed with four irrigation treatments and at the Multiple Cropping Centre of Chiang Mai University, North Thailand. To access mango parameters ten farmers were surveyed, three expert interviews were conducted and the leaf area index (LAI), leaf weight ratio (LWR), specific leaf area (SLA), a functional branch analysis (FBA) and root length density (RLD) were measured. The parameters were statistically evaluated and used to create a mango tree data set for the model and calibrated thereafter. Results showed that the LAI of Chok Anan mango differed with measuring time and with respect to pruning but not between irrigation treatments. In contrast irrigation increased the SLA. RLD was not different between the mango varieties Chok Anan and Nam Dok Mai. Furthermore scenarios with irrigation, off-season production and intercropping were run to characterise tree growth changes in response to crop management options. The WaNuLCAS model simulated mango LAI and fruit biomass well, whereas tree biomass, height and diameter as well as irrigation and especially off-season production showed somewhat poorer results. In conclusion mango growth was satisfactorily modelled by WaNuLCAS under the given conditions. The model may, thus, contribute to identify and evaluate options for alternative cropping systems, but the mango tree data sets still have to be validated for future general use.

**Keywords:** mango modelling, model performance, parameterisation, simulation scenarios

## **Sustainability of Maize Based Cropping Pattern in the Mid-Hills of Nepal**

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Maize based cropping pattern is the most important pattern for food security in the mid hills of Nepal where agriculture is the mainstay for livelihood. Maize is the second most important staple food in Nepal. This cropping pattern finds its position in excessively drained, slopy land, shallow soil depth prone to moisture deficit and low soil fertility. Because of lack of irrigation, most of the slopy lands in mid hills are unsuitable for rice production. The study has been carried out to monitor sustainability of this system and finding causes of productivity declination of the system. Organic matter content has been higher in slopy land than flat land owing to the application of farm yard manure in the former while flat land receives more urea. Integration of livestock and forestry with that of agriculture is the common rule in mid hills of Nepal. The traditional system of livestock rearing and access to the forest resources couldn't be further sustainable as pressure on the limited arable lands had increased due to the continuous growth rate of human population and the related consequences. Traditional grazing practice contributes to the land degradation. Slopy lands are not poor in terms of phosphorus and potash contents; however, it is severely poor in nitrogen content. Soil conservation measures have not been initiated in such slopy lands leading to severe erosion each year. This cropping pattern not sustainable anymore. There is the urgent need to initiate practices like erosion control, conservation of nutrients in the soil, using land scientifically and making provision of irrigation to make mid hill slopy lands more productive and sustainable. Planting plants with good anchorage root system, for example grass species, in the eroded slopes could help recover eroded land. Soil erosion control measures should be taken in the danger zones to control further damages. Legume species fodder trees on the terrace risers should be planted to control soil erosion and as source of protein fodder with subsidiary effect on soil fertility improvement.

**Keywords:** Cropping pattern, slope, sustainability, *Zea mays*

## The Structure and Function of Urban and Peri-Urban Gardens in Khartoum, The Republic of the Sudan

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Little is known of its agricultural potential and level of ecological sustainability of urban and peri-urban agriculture (UPA) along the River Nile at Khartoum, the capital city of the Republic of the Sudan. This land use system leads to intensive vegetation in an otherwise arid city landscape and contributes to urban food security. Understanding the role of UPA has increasing importance in Sub-Saharan Africa where it is predicted that more than 50 % of the population will live in urban areas by 2020, with urban population growing from 294 million in 2000 to 724 million in 2030.

The study comprised 120 gardens, covering 160 ha at 3 locations. Tuti Island, where production of lime (*Citrus aurantiifolia* (L.) Swingle) was widespread, had the lowest crop species diversity with a mean species richness of 1.7 and a Shannon index of 0.4. Shambat, where leafy vegetables were common, had higher crop diversity levels with a mean species richness of 4.4 and Shannon index of 1.2. Peri-urban El Hal-faya, which was the only location where spices and condiments were produced, had a species richness of 3.7 and a Shannon index of 1.0. The survey identified 84 species from 35 plant families, of which 47 were utilised as crops predominantly for commercial production of fruits, vegetables, spices and condiments, grains, and fodder crops. Hierarchical cluster analysis revealed 4 garden groups that were differentiated according to the cropping focus: field crops, orchards, micro-orchards, and diverse gardens.

Despite the fact that 46 % of garden households rely on off-farm income, that gardens provide only 12 % of household food, and that low market prices and high costs were cited as major problems by respondents in the study, the sustainable development of the gardening system has the potential to promote the future viability for UPA in Khartoum in the face of ever increasing pressure on land for multiple purposes other than agriculture.

**Keywords:** Agroforestry, biodiversity, food security, homegardens, Sudan, sustainable agriculture, UPA, urban agriculture, peri-urban agriculture

## Status and Potential of Fences in the Urban and Peri-Urban Agriculture Gardens of Khartoum, the Republic of the Sudan

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Greater Khartoum, capital of the Republic of the Sudan, provides an example of a rapidly expanding Sub-Saharan Africa city where urban and peri-urban agriculture (UPA) plays an important role in the livelihoods of farm households and urban consumers. Greater Khartoum has a reported population of 6.2 million inhabitants, a current annual population growth rate of 4.2 % and accounts for 16.7 % of the national population. This study was conducted in 120 gardens, covering 160 ha at one peri-urban and two urban locations to determine the previously undocumented extent and composition of fences and to identify the role of living fences in the structure and function of the prevailing agricultural ecosystems.

Fences were recorded in 51 % of the gardens, as external boundaries and internal subdivisions, with non-living fences and living fences of various types accounting for 66 % and 34 %, respectively, of the 14,279 m of fences recorded. The survey identified 22 plant species used in living fences, of which some species, such as Christ's thorn (*Ziziphus spina-christi* (L.) Willd.), were used to construct dead branch barrier fences that comprised 45 % of all fences in the study areas. Fences played important roles in the protection of orchards, enclosure of livestock and residential compounds, and as barriers to sand encroachment along local roads. It was apparent that living fences were under-utilised as sources of food or non-food products, as windbreaks, or for the improvement of soil and garden environments.

**Keywords:** Agroforestry, hedges, homegardens, land demarcation, living fences, Sudan, sustainable cities, UPA, urban agriculture, peri-urban agriculture

# Animal sciences

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# Animal nutrition

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## How Do Increasing Feed Costs Affect Livestock Production in Tropical Countries?

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Especially during the past 8–12 months, the strong rise in prices for meat and milk has made consumers aware of the increased demand for livestock products that had already been predicted under the “livestock revolution” concept in the late 1990s. At the same time, the globally increased demand for energy, high oil prices, regional harvest failures and market speculation lead to a sudden increase in prices of major cereals used for food and feed.

Against this background, the paper tries to identify to what extent different types of livestock producers might be affected by feed price increases. The large-scale market-oriented livestock farmers should be able to pass down increased feed costs to the buyers of their products, and small-scale farmers as well as pastoralists who predominantly raise their animals on internal or communally available feed resources might, to some extent, benefit from improved product prices but suffer little or not from increased feed prices. The group for which the question cannot be answered unambiguously consists of those smallholders who rely, at least seasonally, on the supplementation of their animals with purchased feeds. For them the (un)certainly of marketing the livestock product at a profitable price will determine their willingness to invest in feeds. Smallholders with a weak link to markets may need to reduce herd sizes, abandon animal husbandry altogether or at least change their feeding practices. Since crop residues are least affected by increasing prices, these might regain importance for the latter group of farmers. To make up for reduced concentrate feeding, qualitative upgrading of crop residues through physical, chemical or biological measures, or through crop breeding strategies contributing to improved residue quality might be (re)considered. While such measures have largely been investigated with respect to ruminants, studies targeting pigs and poultry are less numerous. However, the majority of these studies focussed on the feeding value of (treated) crop residues and their utilisation by the animal, while questions such as smallholders’ access to these techniques, ease of their applicability on farm, maintenance of feed quality during storage, and economic considerations including questions of scale tended to be ignored.

Another option is the increased use of (monogastric) livestock breeds with a higher capacity of using poorer quality and high fibre feeds. The “reduced productivity” of such breeds might need re-evaluation if production costs for modern breeds with a probably higher demand for high quality feeds continue to rise.

**Keywords:** Crop residues, feed conversion, feed costs, livestock revolution, meat demand

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## Feeding Value of Under-Utilised Food Byproducts and Forages as Alternatives to Conventional Feeds for Syrian Awassi Sheep

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The search for alternative feed resources for livestock not competing with human nutrition is getting increasingly important during the current food crisis. In semi-urban areas of dry regions of the Middle-East, there are quite a number of under-utilised feeds which include both agro-industrial by-products and forages. However, these alternatives probably differ largely in nutritional value. So far only few studies investigated and compared such under-utilised feeds. Two comparative experiments using  $2 \times 5$  diets, characterised by one feed each, were conducted in the present study. Per diet, six castrated male Awassi (fat-tailed) sheep weighing on average  $41.5 \pm 4.3$  and  $39.7 \pm 4.7$  kg (means  $\pm$  SD; Expt. 1 and 2, respectively) were employed. Diets in Expt. 1 had a barley straw:concentrate ratio of 0.5:0.5 with 2/3 of the concentrates being either barley/wheat bran (control), tomato pulp, olive cake, sugar beet pulp or broken lentils. In Expt. 2, diets with a forage:concentrate ratio of 0.73:0.27 contained either barley straw (control), olive leaves, lentil straw, Atriplex halimus (saltbush) foliage or vetch hay as the only forages. Diets were isonitrogenous and supplemented with a vitaminized mineral-salt mixture. Animals were offered 1.1 kg dry matter/d and had unrestricted access to water. In Expt. 1, palatability of olive cake was low, and comparative calculations from dietary organic matter (OM) digestibility (0.48 of intake) suggest that metabolisable energy is only 1.9 MJ/kg dry matter. Diets based on sugar beet pulp (0.68) and broken lentil (0.69) were similar to control (0.66), while the tomato pulp diet ranged slightly lower in digestibility (0.59). The Atriplex-based diet had a relatively high digestibility of fiber (NDF, 0.58) and OM (0.71), but supply with digestible OM was limited by its high salt content. Additionally, Atriplex leaves at that level were either not completely consumed or caused diarrhea and 2.5-fold water intakes. The other forages were quite similar in digestibility, except the well-digestible vetch hay, and no significant effects on body N-balance were noted. The study showed some promising alternatives to traditional feeds, while others (e.g. olive cake) might be used at low levels only. Atriplex is a special case, where also the extra water expenditure might restrict its use.

**Keywords:** Atriplex, digestibility, lentil, olive leaves, sheep, sugar beet pulp, tomato pulp, vetch hay

## Potential of *Canavalia brasiliensis* as a Dry Season Supplement in Central American Mixed Crop-Livestock Systems

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In Nicaraguan hillsides livestock suffer forage shortage during the dry season of five months with subsequent production decline. Because of its drought tolerance, introduction of *Canavalia brasiliensis* into the traditional maize-bean-livestock system is thought to be a good option and its potential was assessed on-farm. Experiments at three smallholder farms with two treatments each were performed. At each farm two plots of 0.35 ha were planted with maize during the first rainy season and either beans (treatment 1, control) or *Canavalia* (treatment 2) during the second rainy season. After removing maize cob and beans at harvest, three groups of 3–5 lactating cows entered the maize stover fields and grazed first the plots with the maize stover (and weeds/legumes) followed by the maize plots with *Canavalia*. Each treatment had duration of eight days, of which were four days of adaptation and four days of data collection. Biomass production was estimated, and milk production and quality were determined.

As a mixed crop with maize, an average *Canavalia* yield of 1.6 t ha<sup>-1</sup> dry matter (DM) was achieved after 16 to 20 weeks of growth which was lower than in pure stands (Martens et al., this volume). However, total biomass of the mixed *Canavalia*-maize plots was significantly higher than the control maize plots: 4 versus 3 t ha<sup>-1</sup> DM, providing a higher feed availability and also better quality of feed.

The high *in vitro* DM digestibility of *Canavalia* of 65 % versus 41 % of maize stover, the lower lignin and cellulose content (ADF 39 % vs. 50 % of DM) and the additional protein supply of *Canavalia* contributed to a significant increase in milk production by 0.5 kg d<sup>-1</sup>\*cow (15–20 %) on average. No effect was found in milk quality.

The farmers recognise the positive effect on milk production and they show a clear interest in continuing integrating *Canavalia* in their farming system.

**Keywords:** *Canavalia brasiliensis*, Central-America, maize stover, milk production, mixed crop-livestock systems

## Performance of Sheep Grazing *Brachiaria decumbens*, *Panicum maximum* and *Pennisetum purpureum* in *Leucaena leucocephala* Alley Plots

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A major problem facing livestock farmers worldwide is how to economically maximise animal production with limited land availability. The situation is even worsened by desertification, leaching and population explosion in the humid tropics. The potential to increase ruminant production on these land areas can be realised if innovations in managing rangeland are adopted. Tropical pastures have long been recognised as capable of producing large quantities of forage dry matter; however, individual animal performance is normally less per animal than for similar animals grazing temperate zone forages. It was against this background that an experiment was designed to study performance of sheep grazing *Brachiaria decumbens*, *Panicum maximum* and *Pennisetum purpureum* in *Leucaena leucocephala* alley plots. Twelve paddocks of approximately 0.03 ha containing *leucocephala* alley planted in rows 4 m apart and interplanted with 4 rows of either *B. decumbens*, *P. maximum* or *P. purpureum* were each grazed by 3 sheep. The three grass combinations within the alley plots were replicated four times. The animals were grazed continuously for 28 days in the sub plots. Sheep grazing the *Leucaena* / *Panicum* plot had a higher ( $p < 0.01$ ) growth rate ( $35.3 \text{ g d}^{-1}$ ) than those animals grazing both the *Leucaena* / *Bracharia* ( $20.6 \text{ g d}^{-1}$ ) and *Leucaena* / *Pennisetum* ( $15.5 \text{ g d}^{-1}$ ) plots respectively. There was no difference between sheep grazing the *Leucaena* / *Bracharia* and *Leucaena* / *Pennisetum* plots. The total dry matter intake of sheep on the *Leucaena* / *Panicum* plot was higher ( $p < 0.05$ ) ( $1.48 \text{ kg DM d}^{-1}$ ) than that of sheep on *Leucaena* / *Pennisetum* ( $0.69 \text{ kg DM d}^{-1}$ ) but not different from the *Leucaena* / *Bracharia* ( $1.08 \text{ kg DM d}^{-1}$ ) plots. The total biomass from the *Leucaena* / *Panicum* ( $12.8 \text{ t ha}^{-1}$ ), *Leucaena* / *Pennisetum* ( $12.3 \text{ t ha}^{-1}$ ) and *Leucaena* / *Bracharia* ( $11 \text{ t ha}^{-1}$ ) plots were not significantly different ( $p < 0.05$ ). These results demonstrate that grazing West African dwarf sheep in a *Leucaena leucocephala* / *Panicum maximum* plot improved their growth rate during dry periods when feed supplies are limited. It also underscores the poor performance of animals grazing *Pennisetum purpureum* in *Leucaena leucocephala* alley plot.

**Keywords:** *Brachiaria*, grazing, *Leucaena*, *Panicum*, *Pennisetum*, sheep

## Removal of Inorganic Nitrogen by Integrating Seaweed (*Sargassum* sp.) into Western King Prawn (*Penaeus latisulcatus*, Kishinouye 1896) Culture

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Effluent water from intensive prawn ponds typically has high concentrations of dissolved nutrients such as nitrogen. An experiment was conducted for 28 days to investigate the nitrogen flow in a treatment where seaweed (*Sargassum* sp.) was integrated into western king prawn (*Penaeus latisulcatus*) culture. Three treatments were used, each consisting of four, 0.1 m<sup>3</sup> plastic tanks. Treatments 1 and 2 were the monocultures of western king prawns ( $5.48 \pm 0.29$  g) and seaweed (young seaweed), respectively. Treatment 3 was an integrated culture of prawns and seaweed. Five prawns were stocked in each tank of treatment 1 and 3. About  $137 \pm 0.36$  g of biomass seaweed was stocked in the treatments 2 and 3. Prawns in treatments 1 and 3 were fed twice a day at a rate of 2.5 % of total body weight.

The concentration of dissolved inorganic nitrogen (DIN) discharged from the prawn only treatment increased from 0.126 to 10.98 mg l<sup>-1</sup> during the experiment. The concentration of total ammonium nitrogen (TAN), nitrite-nitrogen (NO<sub>2</sub><sup>-</sup>) and nitrate-nitrogen (NO<sub>3</sub><sup>-</sup>) in the integrated culture treatment was significantly lower at the termination of the trial than the prawn monoculture treatment ( $p < 0.05$ ). The concentration of TAN, NO<sub>2</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup> and DIN in the integrated culture treatment remained within non-toxic limits for the duration of the experiment. Integrating *Sargassum* sp. with prawns did not alter the specific growth rate (SGR) and survival rate of the prawns ( $p < 0.05$ ). The mean biomass of seaweed in the integrated culture treatment increased at the rate of  $3.16 \pm 0.74$  % g per day in the first week, which was significantly higher than the growth rate of the seaweed in the monoculture treatment ( $5.70 \pm 0.82$  % g per day) ( $p < 0.05$ ). The results suggest that integrating seaweed into prawn culture can benefit prawn farming by assisting in the maintenance of optimum water quality and thereby, also reduce environmental impacts on surrounding areas.

**Keywords:** Aquatic nitrogen flow, *Sargassum* sp., seaweed, western king prawn

# Livestock production systems

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## Comparing Resource Use Efficiency in Typical Dairy Production Systems in South Africa, Morocco, Uganda and Cameroon

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Population growth, urbanisation and increased per capita milk consumption are main reasons for increasing milk demand in Africa during the recent years. As opposed to the past when dairying in Africa was mainly for subsistence, market-oriented dairy production units are now evolving. Due to globalisation, it is important to increase the efficiency of resource use in dairy farms order to be competitive and/or promote the local industry. This study aims at analysing input levels and efficiency of farm resource utilisation as well as their impacts on farm returns. Data was collected from typical dairy farms in South Africa, Morocco, Uganda and Cameroon using the panel approach and farm visits. The TIPI-CAL (Technology Impact, Policy Impact Calculations model) was used to analyse and compare data entries from selected dairy farms.

Generally, as farms grew larger in size, family resources (especially land and labour) became insufficient and there was a greater need for their acquisition from external sources. Land efficiency was extremely high in intensive systems as compared to extensive ones. There was a higher return to labour in larger farms than in smaller farms of the same production systems in all the countries except South Africa, showing a positive effect of scale economies on labour efficiency. The capital costs in Moroccan farms were extremely high due to relatively higher input costs, leading to very low capital productivity in Morocco. Meanwhile, South African farms, which were the largest farms in the sample, had the highest capital productivity.

Though extensive dairy farming systems in Uganda and Cameroon had the lowest costs of milk production ( $>20$  US-\$ per 100 kg milk), their input productivities as well as milk yields were lower, leading to very low net cash returns from the dairy enterprise. Large intensive farms in South Africa had relatively low costs ( $<30$  US-\$ per 100 kg milk) and a high Return on Investment (ROI) due to a higher efficiency of input utilisation. It was concluded that, intensification of dairy farming and simultaneously increasing the scale of production will greatly increase productivity of farm inputs, thus recommended for dairy development in African countries.

**Keywords:** Dairy production systems, resource efficiency

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## **Institutional Framework and Farm Types Characterising the Kenya Boran Cattle Breeding Programme**

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Structured breeding programmes have three core platforms: performance recording, planned mating and genetic evaluation, performed either by government or non-governmental organisations. The organisational structure supporting the breeding of Kenya Boran cattle is presented here. The organisational players range from government institutions, national agricultural research systems to cattle keepers. The structure is not exclusive to Boran cattle (other cattle breeds also benefit from these institutions), nonetheless, the Boran breeders are considered one of the most active breeders' associations. The roles of the stakeholder institutions are described. These institutions include: The National Beef Research Centre, the Central Artificial Insemination Station, the Livestock Recording Centre and the National Agricultural Research Systems. The organisational structure also depicts the informal interactions between interest groups such as Animal production Society of Kenya and also between the different farm types keeping Boran cattle. Since 1951, Kenya Boran cattle has undergone some level of organised management and strategic breeding under the Boran Cattle Breeders' Society. Today, there are five main categories of commercial beef ranches in Kenya (approximately 454 ranches in number) sub-divided on the basis of ownership as: group ranches (321), private company ranches (84), co-operative ranches (17), public company ranches (2) and government ranches (30), a majority of which are group ranches and private ranches. The institutional framework presents possibilities for the establishment of sustainable long term breeding programmes for the Kenya Boran cattle. As the breeding organisation changes from government driven to farmer driven, the role of the Boran Cattle Breeders Society will change from just information users to decision makers matching animal mating decisions with information from genetic evaluation.

**Keywords:** Breeding organisation, Boran cattle, breeding programme, Kenya

## **“Chicken and Egg” Problem in the Meat Sector of Buryatia**

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During centuries animal husbandry was the most traditional agricultural activity of Buryats. Under the command economy the region was specialised in the meat sector, with the largest meat processing factory in Russia. Due to imports from Mongolia the factory benefited from economies of scale.

During the transition period Mongolia found new markets for its products. Also in Buryatia the transition period hardships caused a substantial decrease in meat production. The decrease in meat production caused an immediate decrease in livestock production.

The main problem in development of regional agriculture in Russia is to reveal the regional comparative advantages taking into consideration local agro-climatic conditions and resource endowments.

Buryatia has a risky agriculture, with grain yields of 1.1 t per ha, the yield of milk of 2400 kg per year, and daily average weight growth of cattle by 300 grams. Nevertheless compared with other regions, where the sector of agriculture experiences steady negative growth, the last years witnessed a growth of cattle (4%-8 %) in Buryatia.

Also the large share (43 % compared with 27 % in Russia) of rural population; 35 % unused agricultural land; foreign investments (in 2007, 140 % that of 2005).

The above mentioned arguments encourage the hypothesis, that Buryatia has a comparative advantage for animal husbandry.

The methodology of spatial equilibrium analysis using the GAMS programming techniques was applied to test the hypothesis. The results of the empirical model and the sensitivity analysis prove that among all the analysed meat products the development of sheep breeding industry has the highest comparative advantage in Buryatia. The model provides the optimal production and consumption quantities and prices, as well as recommends the optimal trade flows of the three selected products to other regions presented in the model.

The favourable position of mutton production can be explained with the keeping of native breeds of sheep and with the availability of pastures. Yet the chicken and egg problem remains: should the development of meat processing enterprises in Buryatia stimulate the development of animal husbandry or vice versa? Here is an adequate state intervention necessary.

**Keywords:** meat production, spatial equilibrium



## **Production Objectives, Breeding Practises and Management Strategies of Dairy Goat Farmers in Kenya: Implications for a Breeding Programme**

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Production objectives, breeding practises and management strategies of smallholder households participating in dairy goat breeding projects were analysed in relation to their ability to bring about sustainable genetic improvement in the dairy goat flocks in Kenya. A stratified survey involving 311 goat keepers in 4 project sites was used. Milk production and sales of breeding stock were high priority functions for the objective to create a financial buffer. The breeding objective traits that farmers perceived as being of primary importance were milk yield, growth rate, body size, fertility and disease tolerance. There were logical trade-offs in the choice of these traits by farmers. Female dairy goats were mainly culled due to old age, poor fertility, small body size and poor health. Farmers did not place a large significance on unsatisfactory milk performance when culling female goats, mainly due to the very small production size and the high demand existing for breeding animals. Factors affecting milk yield and flock size presented satisfied a  $p < 0.1$  significance level. Positive and significant relations were found for administrative province of residence, supplementation feeding and type of births while gender of the farmer and kid rearing system were negative and significantly related to milk yield. Strong positive relations were found for administrative province of residence, education level, land ownership and grazing/ fodder land size, while age of the farmer was negative and significantly related to flock size. Multiple birth affected flock size positively while mortality and age at first mating of females showed a negative effect. The performance levels of dairy goats were mainly influenced by breeding and management strategies and the resource availability at the farm level. The optimisation of genotype  $\times$  environment interactions remains the biggest challenge given the objectives set by.

**Keywords:** Breeding practises, dairy goats, management strategies, production objectives, smallholder farmers

## Supporting Farm Decision Making by Modelling the Impacts of Policies and Farm Strategies on Sustainability of Dairy Farms in Uganda

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Studies on the priorities for agricultural research in Eastern and Central Africa concluded that milk was the most important commodity for research and development in the region, based on its potential contribution to the agricultural GDP (gross domestic product). According to ILRI (International Livestock Research Institute), the right policies, marketing systems and technical support must be sought for dairy development in Africa. In order to determine the right development pattern, appropriate analytical tools must be applied.

The TIPI-CAL (Technology Impact Policy Impact Calculations model) was used to analyse and rank the impact of various policies and farm strategies on the most typical dairy farming system in Uganda. Policy scenarios were identified and described by panels consisting of farmers, government officials, veterinarians, extension workers, NGO officials, milk processors, researchers and others. Seven influential policy areas were identified: provision of veterinary services, consumption promotion, marketing promotion, input provision, credit access improvement, milk quality improvement and genetic improvement.

In general, the policy impacts were very little on smallholder extensive dairy farms, having less than 10 local cows, which were the most typical farms in the region. These results could however be magnified up to threefold, if the farms had graded cows. Policies which improve farmers' accessibility to markets had the greatest impacts on the livelihoods of farmers, through improved income generation from dairying. Genetic improvement of cattle breeds was recommended as an initial strategy, which could improve the impact of other farm policies.

The adoption of graded breeds and appropriate technology could be facilitated by farm credits. However, at current interest rates of 4 % per month, obtaining credits for genetic improvement will double the cash costs of the farm, hence discouraging farmers from this investment. It was concluded that, a set-up with a more incentive-based environment is required to support such private initiatives and the adoption of intensive farm technologies. This study further illustrates the role of various stakeholders such as the government, national and international organisations as well as farmers in the allocation of land, labour, capital and expertise to promote sustainable dairy development.

**Keywords:** Dairy farms, decision making, sustainability, TIPI-CAL model, Uganda

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# Aquaculture, fisheries and basic research in animal science

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## **Impact of the Artificial Rearing System on Awassi Lambs' Behaviour and Growth Performance – A New Approach of Sheep Husbandry in Subtropical Countries**

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Mutton and sheep milk have traditionally a very important role in the food supply of the Mediterranean and Middle-East countries. Awassi is a widespread fat-tailed sheep breed of these regions. A relatively new technology – intensive milk producing with artificial lamb rearing – has been introduced in Israel and imported to Hungary to increase the milk production of this breed. Twenty-one artificially housed Awassi lambs were selected for this trial. Growth rates (body weights, average daily gain – ADG) and behaviour of lambs were investigated. Animals were divided into three groups of 7 each. IW lambs (immediately weaned) were separated from dams immediately after lambing; 6H and 12H lambs were removed from dams 6 and 12 hours after parturition. Proportion of active (moving, playing, feeding) and inactive (lying, resting, standing) behavioural elements were compared in the first week after grouping. It was found that the duration and number of inactive elements at IW lambs showed a significantly higher increasing than the other two groups. IW lambs accepted earlier the stockperson and his/her assistance during feedings. Lambs in the IW group also accepted earlier the artificial teat of the feeding equipment and learned to use it for the 2nd day. The other two groups needed strong assistance until the 4<sup>th</sup> life day, and 2 lambs from 12H group did not accept the artificial feeding and passed away at the 5<sup>th</sup> life day. Regarding to the growth rates, IW lambs showed the highest ADG during the experiment and the differences were significant compared to group 12H ( $p < 0.01$ ). The 6H lambs had higher body weights than 12H lamb from the 2nd week ( $p < 0.01$ ) and it was the same with ADGs ( $p < 0.01$ ). IW lambs showed significantly ( $p < 0.05$ ) the highest average ADG (app. 230 g/4wk) and body weight ( $9.98 \pm 2.57$  kg) at the end of the experiment. Artificially reared lambs showed very good growth rates in this trial. This new technology should give an opportunity to develop the mutton and milk production level of the sheep husbandry in subtropical countries. This project was supported by the “Deák Ferenc Scholarship” of Hungarian Ministry of Education.

**Keywords:** Artificial rearing, awassi sheep, behaviour, growth performance

## **Avian Influenza Control in Indonesia: A Situation Overview, Poor Orientated Research Approaches of ILRI Targeting Backyard Poultry – Preliminary Results**

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HPAI has become endemic in most parts of Indonesia despite the interventions that have been implemented by the government and international organisations. The current situation and applied control measures will be shortly presented and discussed. The main programme increasingly implemented in Indonesia is the Participatory Disease Surveillance and Response (PDSR), an active search for AI like cases on village level followed by adapted control measures in case of an outbreak. Although the PDSR programme was able to sensitize farmers on the clinical manifestation of the disease as well as simple measures that can be applied in the villages to prevent exposure and limit spread, there is a growing fear that the persistence of the disease in the country is causing apathy amongst the farmers and PDSR officers. The International Livestock Research Institute (ILRI) has profound experience on participatory approaches and expanded its activities recently also to SE Asia, Indonesia. One of the ILRI research activities in Indonesia is the Operational Research Project (ORI). The overall objective is to determine and evaluate different control strategies (treatment sets) that would work under the local circumstances. The study targets backyard chickens and the treatment sets to be evaluated include: preventive mass vaccination against AI, preventive mass vaccination against AI and Newcastle disease, and culling with compensation fully provided. The baseline treatment level would be the control measures being implemented by the PDSR program, which include disinfection, community education and focal (voluntary) culling as compensation funds are often not available. The main research will be supported by limited targeted research activities like specific vaccination trials and sensitivity/ specificity studies on the currently applied PDSR programme. In addition base line data will be collected for each District (e.g. on household level, poultry movement and population). Selected preliminary results of the on-going project will be presented.

**Keywords:** Avian Influenza, backyard poultry, poultry control, Indonesia

## **Fattening and Carcass Traits of Broiler Genotypes with and without Feathers under Hot Conditions**

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Heat stress due to high ambient temperature hampers broiler production in the tropics and subtropics leading to depression in feed consumption and growth rates of birds and high mortality while at the same time reducing breast meat yield and quality. Adapting the environment to the demands of fast-growing broilers by means of high-cost cooling and ventilation system is feasible, but in many cases is neither economical nor affordable by farmers in developing countries where electric power and water are not in constant supply. The problem of heat stress on broilers and the non-sustainable management practices used in combating it could be alleviated by introducing the scaleless (sc) gene. This major gene improves the adaptation to hot climates by eliminating feathers. Previous studies on the sc gene indicated that the relative weight of the breast was increased in featherless birds. An experiment was set up involving 200 featherless chicks and 200 feathered sibs who were reared under hot conditions in two rooms (average temperature 29 to 33°C) divided into pens by genotype. Fattening and carcass traits considered were live and slaughter weights, and mortality. The studied breast meat quality traits post mortem (PM) were: colour (Lightness (L\*) and redness (a\*)), drip loss, thaw loss and drip-thaw loss. The quality traits were studied on 56 individuals from each genotype. Results confirmed statistically significant improvements in breast meat quantity and quality of featherless birds under hot conditions: breast meat yield was around 50 % higher, mortality due to a heat wave of 38°C on day 45 was lower (2 % vs 42 %), breast colour at 24h and 72h PM was better with lower L\* values (52.8 vs 54.4, 53.2 vs 55.6, respectively) and higher a\* values (3.2 vs 2.5, 4.2 vs 3.2), lower drip loss on day 4 PM (1.9 % vs 2.6 %), lower thaw losses (2.3 % vs 3.4 %) and drip-thaw losses (4.1 vs 5.9) on day 7 PM.

**Keywords:** Featherless broiler, heat stress, hot tropics, meat quality, meat yield

## **Fighting Poverty and Unemployment with Efficient Fish Farming in Nigeria**

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Most past agricultural policies to fight poverty and unemployment failed due to drudgery, large capital outlay, and low return to resources. Fish farming, which requires small capital outlay; has high returns to resources, is less tedious and alleviates nutritional deficiency coupled with Nigeria's high potentials in aquaculture production (about 1 million km<sup>2</sup> for subsistence and commercial aquaculture), will be the panacea for solving poverty and unemployment problems if efficiently managed.

This paper examined how efficient fish farming can solve the hydra-headed poverty, unemployment and nutritional deficiency problems in Nigeria especially among the educated youths. For the study, 100 fish farmers were selected using multistage sampling technique. Data were analysed using budgetary and stochastic frontier (production and cost functions) analyses to examine the profitability, productivity and efficiencies (technical (TE), allocative (AE) and economic (EE)) of fish farming enterprise in Nigeria. Results revealed that young, educated, well-trained people were involved in fish farming and private hatcheries, surface concrete tanks with spring water were the important technical factors in the enterprise. Average fish output of 12 800 kg with net-profit of N128.63 kg<sup>-1</sup> showed fish farming as profitable. Productive resources were efficiently utilised while overall production was in the economic efficient stage as shown by the return to scale (RTS) value of 0.381. The efficiency analyses showed significant levels of inefficiencies with cooperative membership positively affecting TE while AE were positively influenced by education, experience and cooperative membership. Though average TE, AE and EE were 0.866, 0.894 and 0.773 respectively, there was room for improvement in the fish farming efficiencies by paying attention to those variables in the inefficiency models that negatively influenced efficiencies while fish farming output would increase if attention is equally paid to those variables with negative elasticities of production.

The policy implication of the study is that efforts should be made by governments to mobilise and empower young school leavers to go into fish farming for income and employment generation and alleviation of nutritional deficiency.

**Keywords:** Fish farming, Nigeria, poverty, unemployment

## Northern Delta Lakes, Egypt: Constraints and Challenges

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Egypt drives its fish yield from three main fishery resources; marine (Red and Mediterranean seas), inland (Delta and coastal lakes and River Nile with its tributaries) and aquaculture. These fisheries are one of our chief sources of wealth, if we give them due care, we can increase our national income and solve many of our problems. The lakes' fisheries play an important role in Egyptian economy, where they provide about 39 % of harvested fish in Egypt (1980–2006). The Egyptian Mediterranean coast exhibits six lakes or lagoons which are situated along the Nile delta coast (Northern delta lakes: Manzala, Borollus, Edku and Mariut) and to the east of the Suez Canal (Port-Fouad and Bardawil). All of them, with the exception of Lake Mariut, are directly connected to the sea. The northern Delta lakes are the most productive Egyptian lakes, where more than 75 % of Egyptian lakes fish production was harvested from them. The current status of northern Delta lakes' fisheries were evaluated and an assessment of the different fishing gears operated inside them was done. Fishery statistics of the different fishing gears over the last 20 years (1987–2006) were collected and analyzed. The biomass – based model of Schaefer was applied to the catch per unit of fishing effort (CPUE) indices. The maximum sustainable yield (MSY) and the relevant level of fishing effort ( $f_{MSY}$ ) for the northern Delta lakes were estimated. Also,  $2/3 f_{MSY}$ , as a target reference point was calculated. All challenges facing the sustainable development of these lakes were identified and some of practical solutions were advised.

**Keywords:** Biomass-based models, Egypt, reference points



## Environmental Impacts and their Socioeconomic Consequences of Shrimp Farming in Bangladesh

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Commercial shrimp culture in Bangladesh has expanded dramatically over the last two decades for its high demand in the international market and its potential for making quick profit. Large farm size, very low input, low stocking density, diseases infestation and low production are the characteristics of most shrimp farms. While other Asian countries like Taiwan, Malaysia, Thailand, India and Sri Lanka have been successful in increased production through better management and eco-friendly cultural technologies, Bangladesh is still struggling with lower production and high production costs. Traditional or improved traditional or extensive cultural system is providing her 70–250 kg ha<sup>-1</sup> of production. To survive in competitive international market, Bangladesh is trying to increase production through horizontal expansion in terms of area rather than attaining efficiency in production system. The shrimp farming has also expanded from 20,000 ha in 1980 to 150,000 ha in 2001. This study was carried out to investigate the environmental impacts and to identify their socio-economic consequences for horizontal or area expansion of shrimp farming in southwest coastal belt of Bangladesh. From this study, it is found that this development has caused serious environmental impacts *e.g.*: deforestation, cutting of mangrove forests, intrusion of saline water, decreased crop diversity and fisheries, water pollution and changing hydrological characteristics. These ecological imbalances again create negative impact on socioeconomic environment at surrounding areas like as lower production from crops and vegetables, loss of valuable fruit trees, fresh water crisis for drinking and related diseases like diarrhoea and dysentery, loss of grazing lands as well as livestock and poultry resources, lack of fuel wood, decline in household incomes from both on-farm and off-farm sources, extra burden on women and children for collecting drinking water and fuel wood from far places. Shrimp cultivation is no doubt economically beneficial for a selected group of people as well as for Bangladesh, but it has negatively affected the livelihoods of landless and marginal farmers, making difficulties for them to survive in the area.

**Keywords:** Environmental impact, socioeconomic impact, horizontal expansion

## **Economic Valuation of Indirect Benefits of Ashtamudi Estuary in South India**

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Ecosystems, especially the wetland ecosystems, are boon to humanity given the manifold services provided by them. The direct use benefits refer to the tangible benefits accruing to the local community. In case of wetland ecosystems like estuaries, the direct benefits comprise of fishery, tourism, inland navigation etc. In addition to such direct use benefits, these wetland ecosystems provide quiet a number of indirect benefits in the form of various ecological services which may not be tangible as in case of direct benefits. People seldom understand such kind of benefits due to lack of knowledge and inadequate awareness about it.

The Ashtamudi estuary located in Kollam district of Kerala state in South India is a RAMSAR site. It provides many indirect use benefits to the local community in terms of flood protection, protection of the marine shrimp larvae during the juvenile stage, carbon sequestration, etc. However, the role of Ashtamudi estuary as a nursery for the marine shrimp larvae is of utmost economic value because of its effect on marine shrimp catch and the livelihood of fishermen associated with shrimp fishery. The adult shrimps enter the estuary from sea for laying eggs and the juveniles hatching out of these eggs spend their juvenile phase in the estuary and later swim back to the marine environment. This benefit was evaluated using replacement cost approach by considering the artificial hatcheries as an alternative for this service. This function of Ashtamudi estuary was valued at Rs. 1.02 million per annum.

Carbon sequestration, by the mangrove vegetation in the estuary, is yet another major indirect use value which was assessed by considering the carbon content of the different species of mangroves and assigning universally accepted value per tonne of carbon sequestered by plants. This service accounted for Rs.0.023 million.

Monetary values of indirect benefits assessed as part of the study throws light on the need to create mass awareness about such benefits and to conserve the estuary in a sustainable manner by undertaking participatory action plans.

**Keywords:** Carbon sequestration, indirect use, replacement cost

# New approaches in animal husbandry

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## Use of TrypTectCIATT to Determine the Effectiveness of Treatment of *Trypanosoma brucei rhodesiense* Infections in Vervet Monkeys (*Chlorocebus aethiops*) and Man

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The vervet monkey (*Chlorocebus aethiops*) model of sleeping sickness was used to evaluate the effectiveness of TrypTectCIATT in assessing the success of trypanocidal therapy. A retrospective study was therefore conducted on sera collected from monkeys infected with *Trypanosoma brucei rhodesiense* and treated either curatively with melarsoprol or sub-curatively with diminazene aceturate. In the human survey, 440 sera collected from 96 human patients were tested. These patients were treated with either suramin or melarsoprol depending on the stage of the disease. An extra 56 parasitologically positive pre-treatment samples were also tested to aid in determination of the test sensitivity. Results indicated that between 21–28 days post-infection, the test detected trypanosomal antigens in 84.2 % (16/19) of animal samples that were parasitologically positive by the haematocrit centrifugation technique (HCT). In curatively treated animals, 77.8 % (7/9) exhibited positive reaction up to 9 months post-treatment. One animal was positive for trypanosomal antigens for the entire 12 months while one was a non-reactor. From the sub-curatively treated group, 80 % (8/10) were detected positive for the entire 12 months while, 2 animals were non-reactors. In the human survey, three patterns of antigen profiles were observed. In some patients, there was fluctuation of antigen levels throughout the 12 months follow-up period. In others, antigens were detected for the entire 12 months but in decreasing levels. The last group was that of patients with antigens decreasing at different rates to undetectable levels at 12 months post-treatment. The presence of trypanosome positive but antigen negative samples during the study raises a few questions with regards to the sensitivity of the test. It is however evident that the test was able to detect trypanosomal antigens in over 80 % of positive monkey and human serum samples. Consequently, TrypTectCIATT may be an important additional tool in reduction of the follow-up period and determination of success of chemotherapy in sleeping sickness.

**Keywords:** Agglutination, sleeping sickness, *Trypanosoma brucei rhodesiense*, TrypTectCIATT, vervet monkeys

## Effects of Different Weaning Protocols on the Immune Function in Buffalo Calves and Prophylactic Application of Levamisol®

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A total of 60 buffalo calves of either sex aged 3 months, were used in this study. Total contingent was divided into three groups viz., treated, placebo and untreated comprising of 10 calves (5 male and 5 female) for each type of weaning protocol. Blood samples were collected 2 and 1 day before and 1 and 14 day after weaning in all groups. Levamisol® was given orally two days before weaning after collection of first blood sample.

Statistical analysis revealed that gradual weaning method did not affect any of the parameters. Contrary to the gradual method, abrupt weaning method affected seven parameters namely, PCV, Hb conc., RBC, leukocytes, lymphocytes, neutrophils, and eosinophils. These parameters however, turned to normal by the day +14. The values of leukocytes, neutrophils, red blood cells, Hb conc., PCV, rose on day 1 after weaning, while the percentages of eosinophils, lymphocytes ( $p < 0.05$ ) decreased one day following weaning. These parameters returned to preweaning values on day 14 postweaning. Three hematological parameters namely, Hb conc., RBC and TLC differed because of sex. Males showed higher hemoglobin concentration whereas RBC and TLC were found higher in females. Levamisol® treated buffalo-calves presented higher PCV, RBC and leukocytes.

Abrupt weaning protocol affected significantly ( $p < 0.05$ ) six parameters including 4 metabolites (AP, activity of  $\gamma$ -GT and concentrations of cholesterol and triglycerides) and 2 electrolytes (Na and Cl). The values of activity of gamma-GT and concentrations of cholesterol, Na and Cl rose on day 1 after weaning, while serum concentration of triglycerides decreased one day following abrupt weaning. These parameters returned to preweaning values on day +14 postweaning except serum cholesterol, which declined to a significantly ( $p < 0.05$ ) lower level on day 14 postweaning than preweaning value. Serum AP declined markedly on 14 day after weaning. Sex made significant effect only on cholesterol concentration among all serum biochemical parameters. Abrupt weaning caused an acute rise in serum conc. of cortisol, triiodothyronine (T3) and thyroxine (T4) in buffalo-calves on day 1 postweaning. Females presented higher values of serum cortisol and triiodothyronine as compared with preweaning values. Immune measures lymphocyte stimulation assay and Ig-A remained unaltered throughout study.

**Keywords:** Buffaloes-calves, haematology, hormones, weaning

## Antibacterial Activity of Standard Eugenol against *Salmonella* spp.

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Eugenol (C<sub>10</sub>H<sub>12</sub>O<sub>2</sub>), is an allyl chain-substituted guaiacol, i.e. 2-methoxy-4-(2-propenyl) phenol. Eugenol is a member of the allylbenzene class of chemical compounds. It is a clear to pale yellow oily liquid extracted from certain essential oils especially from clove oil, nutmeg and cinnamon and bay leaf. It is slightly soluble in water and soluble in organic solvents. It has a pleasant, spicy, clove-like odor. Eugenol has been used at least since the nineteenth century and is still used in perfumeries, as flavourings, in analgesics, biocides, antiseptics, and in local anaesthetic due to its anti-inflammatory, and antibacterial effects. The aim of this study was to determine the in vitro antibacterial activities of standard eugenol against *Salmonella* spp. Forty eight samples of pig feces (n=16), sewage (n=3), pen floor (n=3), water (n=2) and pork (n=24) were treated with several concentration levels (0.0061 to 6.25  $\mu\text{l ml}^{-1}$ ) of standard eugenol in Mueller Hinton Agar (MHA). The minimal inhibition concentration (MIC) of the standard eugenol was lowest (0.0976  $\mu\text{l ml}^{-1}$ ) in 70.8 % of pork samples for *S. risen* and in 12.5 % of pork samples for *S. lagos* and *S. krefeld*. At 0.1953  $\mu\text{l ml}^{-1}$  eugenol showed antibacterial activities of *S. risen* in 4.2 % of pork samples and at 0.3906  $\mu\text{l ml}^{-1}$  eugenol showed broad antibacterial activities of 7 strain of *Salmonella* spp. (*S. risen*, *S. krefeld*, *S. weltevreden*, *S. stanley*, *S. derby*, *S. salamae*, *S. bovismorbifican*) in all types of samples (100% of feces, sewage, pen floor and water). We further intend to determine effectiveness of standard eugenol as feed supplement in weaned pig diets for controlling diarrhoeal bacteria.

**Keywords:** *Salmonella* spp, standard eugenol, antibacterial activity

## Vaginal Cytology in Timor Deer Hind (*Cervus timorensis*) under Natural Estrus Cycle

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The vaginal epithelium is influenced by hormonal changes during the oestrous cycle, allowing cyclic monitoring of the various reproductive stages. Hormonal fluctuations, especially of oestrogens, cause changes in the vaginal cellular profile. Increasing oestrogen concentrations cause cells proliferation, with thickening, of the vaginal epithelium and subsequent cell differentiation. The vaginal cytology of Indonesian hind deer has not been reported before.

Determination of the oestrous cycle especially the length of oestrus and time of ovulation plays an important role in improving fertility and reproductive performance of farm animals. This study investigated the length of oestrous cycle and oestrous period in order to estimate the time of ovulation, hence the right time for insemination.

Adult and healthy timor hind aged three years were used in this research. Vaginal smears were collected every morning for 90 days by gently passing a sterile cotton swab into the vaginal canal followed by a quick 180° rotation. Smears were transferred to 1-5 slides, air dried, and immediately fixed with 100 % ethanol and stained with Giesma. Smears were examined under a light microscope at magnification of 400 X. Two hundred epithelial cells from each slide were evaluated and classified.

Results of this research showed that there were four highest point (20, 18, and 16 days, averaging 18 days) superficial cells (85.75 %), and four lowest point parabasal epithelial cell (14.25 %), during 88 observation days. Under oestrus condition, the cell population consists of ca. 90 % superficial cells and < 5 % parabasal or intermediate cells, while under metoestrus the cytology was characteristic with a dramatic ?shift? to 80-100 % of parabasal and intermediate cells.

This change is produced in about 24-28 hours. We conclude that monitoring the cellular pattern of the vaginal epithelium of hind deer with natural oestrus is an efficient tool to determine the length of the oestrous cycle, which in timor hinds is 18 days.

**Keywords:** Estrus cycle, timor deer hinds, vagina cytology

## **Anatomy and Morphometry of Timor Deer (*Cervus timorensis*) Stags Reproductive Organs**

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The purpose of this research was to study the anatomy of male reproductive organs to support breeding programmes for timor deer as a new livestock commodity. Two Deer stags of about 3 to 4 years old and weighing 98 to 102 kg in hard antler stage were used in this experiment. Testes of the timor deer were symmetric with elastic consistency. The reproductive organs of male deer was observed, measured, weighed, and documented. The collected data were tabulated and analysed descriptively. Results of this experiment showed that the length, diameter and weight of testes of the stags were  $82.04 \pm 3.53$  mm,  $36.55 \pm 4.13$  mm, and  $108.11 \pm 5.95$  g, respectively. Weight of the scrotum and epididymis were  $50.75 \pm 1.77$  g and  $15.01 \pm 0.97$  g, respectively. The length of epididymis, vas deferens, and ampulla were  $158.99 \pm 4.14$  mm,  $45.20 \pm 0.44$  cm, and  $72.53 \pm 2.39$  mm, respectively. The length of the vesicular gland which was located at the same level with the ampulla of the vas deferens were  $45.36 \pm 1.42$  mm. Corpus prostate could be observed clearly with its length of  $20.61 \pm 0.33$  mm. There was no sigmoid flexure at the body of penis, while the form of the glans penis was round. It is concluded that the anatomy and morphometry of the reproductive organs of male deer are almost the same as in goats and sheep. The body of penis of timor stags do not have the sigmoid flexure, and the glans penis was round. No bulbourethral gland was found.

**Keywords:** Anatomy, deer, stags



## Characteristics and Preservability of Timor Stags (*Cervus timorensis*) Semen in TRIS Extender with Various Sources of Carbohydrates

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Semen stored at ambient temperature – where spermatozoal metabolism is almost maximal – needs additives to provide nutrition and buffering capacity for metabolic waste products (lactic acid, CO<sub>2</sub>) to prevent permanent damage. The present study investigated the intactness of the plasma membrane (IPM) and the acrosomal cap (IAC) of Timor stag spermatozoa kept at 27-28°C in Tris egg yolk (TEY) extender with different carbohydrate additives (glucose, TEYG; fructose, TEYF; and sucrose, TEYS).

Five deer stags aged three to five years in hard antler stage with symmetrical testicles were used. Semen was collected by electro-ejaculation after sedation with a combination of 1 mg xylazine and 2 mg ketamin i.m. kg<sup>-1</sup> body weight. Raw semen was evaluated every 3 hours for the percentage of motile spermatozoa, live spermatozoa and IPM using the hypo-osmotic test, and for IAC using triphan blue. Data were analysed and means were compared by the least significant difference test.

The fresh semen had an average volume of 2.06 ml, pH 7.03, with yellow white to creamy colour and normal to thick consistency. The percentage of motile spermatozoa was 75.83 %. The spermatozoal concentration was 842.35 × 10<sup>6</sup> ml<sup>-1</sup>. The percentage of live spermatozoa was 87.67 %, with a spermatozoa abnormality of 7.31%. IPM was 76.83 %, and IAC was 80.17 %. After 24 hours of preservation, percentage of IPM in TEYF (4 %) was significantly lower than in TEYG (21.67 %) and in TEYS (28.83 %). The percentage of IAC in TEYS (25.33 %) and TEYG (22.67 %) was significantly higher ( $p < 0.05$ ) than in TEYF (4%). The rapid decline in fertility of spermatozoa stored at ambient temperature is probably due to extracellular oxidative stress, effects of seminal plasma and endogenous free radical production. We conclude that deer liquid semen preserved at 27-28°C in TEYS has better IAC and IMP than semen preserved in TEYG or TEYF.

**Keywords:** Deer, glucose, fructose, semen, stags, sucrose

## First Isolation of *Aspergillus flavus* from a Calf with Eye Infection in Sudan

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This study was performed in Sudan as a part of a study research project about infectious bovine keratoconjunctivitis, the most economically important disease in dairy farms. We realised that there was annual outbreak of the disease in dairy farms in Khartoum state–Sudan after each rainy season, that could be due to the increasing number of insects.

There was no published data about the prevalence and incidence of the disease. However, we observed that the outbreaks among cattle in Khartoum state were very common and the percentage of infected calves reached up to 60 % at one farm .

In this individual case, *Aspergillus flavus* was isolated from a 4 months old calf with eye infection characterised by bilateral keratoconjunctivitis, corneal opacity, corneal ulcer and loss of vision.

No bacterial growth realised after inoculation into blood agar, but there was a fungal growth, then an eye swabs were inoculated into Sabouraud dextrose agar, after incubation for 72 hours there was a fungal growth on the medium.

Microscopic slides were prepared and stained using lactophenol cotton blue to demonstrate the fungal parts which were typically *Aspergillus flavus*.

As a finding, *Aspergillus flavus* could –separate or mixed with bacteria– be one of the causative agents of infectious bovine keratoconjunctivitis in Sudan. The disease leads to a drop in milk yield, accidents due to loss of vision and deterioration of meat quality and thus, decreasing the individual's income and increasing the poverty specially in rural areas where people mainly depend on their animals as a main source of nutrition and income.

**Keywords:** *Aspergillus*, bovine, eye infection

# Carcass and meat quality of farmed animals

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## Water Losses by Meat Processing of Meat from Native Cattle from Lamphun and Lampang Provinces, Thailand

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The major part of beef cattle produced by small farmers in northern Thailand is native cattle either of the breed White Lamphun Cattle or general native cattle. Although some farmers can produce meat of good quality generally the produced meat is of poor quality and not suitable to meet the yearly increasing demand for good quality meat. A comprehensive improvement of the quality of native cattle meat is necessary. The objective of this research is to evaluate the meat quality especially the water loss in meat of 1-2 years old White Lamphun Cattle and general native cattle (n=25) from Lamphun and Lampang provinces in northern Thailand. Data was collected in the summer season and in the rainy season. The results show that there was no effect of season on percent drip loss of meat of general native cattle from Lamphun province but the drip loss of their meat was lower than of the meat from White Lamphun Cattle of the same province and of meat from both groups of native cattle from Lampang province ( $p < 0.01$ ). The percent of thawing losses in meat of White Lamphun Cattle was lower than in meat of general native cattle ( $p < 0.01$ ). The thawing losses in meat of White Lamphun Cattle were lowest ( $p < 0.01$ ). Cooking losses (%) in meat of White Lamphun Cattle was not different to the cooking losses in rainy season meat from native cattle from Lamphun province but the losses were lower than for other groups ( $p < 0.01$ ). These results show that both the genetic difference as well as some environmental factors especially temperature and moisture which prevail in different seasons can affect some meat quality parameters.

**Keywords:** Native cattle, water losses, White Lamphun cattle

## Detection of a Mutation in RYR1 Associated with Meat Quality in Commercial and Thai Native Pigs

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Porcine Stress Syndrome (PSS) is a heredity disease caused by the C1843T mutation of the Ryanodine Receptor 1 (RYR1) gene. The mutation is also associated with an increased lean meat content but at the same time detrimental meat quality better known as PSE (pale, soft and exudative) pork (PSE). The aim of this study was to detect the mutation in commercial and Thai native pigs and finally to estimate possible associations with carcass composition and meat quality traits. The PCR-RFLP technique was used to identify the mutation in Duroc (DU) (n =25), Large White (LW) (n =47), Landrace (LR) (n =23), Pietrain (PT) (n =26), Thai native pigs (n =38), the commercial crossbred (LW × LR) (n =49), the commercial crossbred (DR × LW × LR), and the commercial crossbred (Line A × DU × PT) (n =155). Analysis of the genotype frequencies (CC, CT, and TT) revealed no significant differences within the group of commercial pigs but between them and Thai native pigs ( $p < 0.05$ ). However, allele frequency analysis showed significant differences ( $p < 0.05$ ) between Thai native pigs (C:T=1:0), Landrace, Pietrain LW × LR and DR × LW × LR (C:T = 0.85:0.15, 0.87:0.13, 0.85:0.15 and 0.86:0.14, respectively). The effect of the halothane gene mutation on cured meat was investigated for the DR × LW × LR pigs (CC=73, CT=25, TT=2). No significant differences were found for all meat quality traits between animals with the CC and CT genotype. Contrary to that, pH45min and pH24 hr post mortem in *Musculus Semimembranosus* (SM) and in *Musculus Longissimus Dorsi* (LD) were significantly lower, whereas, percentage of drip loss, lightness ( $L^*$ ) and yellowness ( $b^*$ ) at LD 48 hr after slaughter were significantly higher for the homozygous recessive genotype ( $p < 0.05$ ). However, redness ( $a^*$ ) was significantly higher for the TT ( $10.54 \pm 0.14$ ) and CT ( $8.90 \pm 1.39$ ) compared to CC pigs ( $8.33 \pm 1.58$ ) ( $p < 0.05$ ). This study shows breed differences against PSS resistance in Thai native pigs and commercial pig breeds in Thailand, as well as associations of the RYR1 genotypes with several meat quality parameters.

**Keywords:** Commercial pig, meat quality, RYR1, Thai native pig

## **Assessment of Quality Beef Production in Northern Thailand: Meat Quality of Brahman Crossbred and Charolais Crossbred Cattle**

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Cattle farming has a long tradition in Thailand. The growing demand for high quality beef did lead to the introduction of exotic beef breeds causing an increased number of crossbred cattle. For the further improvement of beef quality, marketing strategies based on quality aspects have to be developed. Therefore more information about the meat quality of beef breeds and crosses in Thailand are needed. It was the aim of this study to assess the meat quality of the most famous beef cattle breeds (Brahman- and Charolais-crossbred cattle) under practical farm conditions in northern Thailand.

The study was conducted on a commercial beef cattle farm in Chiang Mai, Thailand. In total, 34 Brahman- and 34 Charolais-crossbred cattle were randomly selected and slaughtered at different body weights (500, 550 and 600 kg). After slaughtering, carcasses were chilled at 2–4°C for 24 h before a Longissimus dorsi muscle (Ld) was removed for subsequent meat quality evaluation.

Ld from Brahman crossbreds had more moisture and less crude fat than that from Charolais. Compared to Charolais, the muscle of Brahman crossbreds had lower concentration of cholesterol and triglyceride. Ld from cattle slaughtered at 600 kg had higher concentrations of insoluble collagen when compared with animals slaughtered at 500 and 550 kg. Except for lightness ( $L^*$  value) of meat which was similar between the genotypes, meat from Charolais crossbreds had more redness ( $a^*$  value) and yellowness ( $b^*$  value) than meat from Brahman. Drip loss and cooking loss were not affected by genotype. However thawing loss and grilling loss were higher for meat from Brahman crossbreds. Shear force value was lower for meat from Charolais crossbreds. It can be concluded from this study that meat from Charolais crossbreds had better quality than meat from Brahman crossbreds in terms of intramuscular fat, water holding capacity, tenderness and meat colour.

**Keywords:** Beef, Brahman crossbred, Charolais crossbred, fattening cattle, meat quality, Thailand

## Population Genetic Structure of Northern Thai Indigenous Pigs and their Utilisation as Genetic Resources

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The study of genetic information in indigenous and wild animals has recently become a topic of highest importance worldwide. The aim of this study was to investigate the population genetic structure of Thai indigenous pigs and Thai wild boars. The complete mitochondrial DNA control region was sequenced using 72 Thai indigenous pigs and 11 Thai wild boars collected at twelve locations in five provinces in Northern Thailand. To assess the population genetic structure, Thai indigenous pigs were grouped into five population zones defined by the sampling areas (zone-I to zone-V). Thai wild boars were grouped into one population. In total, 24 different mtDNA haplotypes have been described in the Thai pigs. The distribution of individuals/haplotypes showed 6/2, 20/9, 14/2, 11/5, 21/9 and 11/4 respectively per group. Median joining network analysis revealed similarities between Thai indigenous and Thai wild boar haplotypes. A high haplotype (mean  $\pm$  SD;  $H = 0.938 \pm 0.011$ ) and nucleotide diversity ( $\pi = 0.007 \pm 0.003$ ) of Thai pig populations was observed. Published D-loop sequences of other Asian and European haplotypes assessed from GenBank were used to compare their genetic relationships with our data. The average pairwise difference within populations (PiX) ranged from 1.828 to 6.207 in Thai pigs. Moreover, the average pairwise difference between populations (PiXY) ranged from 5.362 to 9.481 among Thai pigs and other Asian pigs, and ranged from 21.312 to 27.261 among Thai pigs and European pigs. The population demographic parameters such as Tajima' D-values and Fu's Fs test revealed negative values ( $p < 0.05$ ) between Asian and European pigs and suggested a population expansion occurred in the past. This investigation proposes that Thai indigenous pigs are closely related with Thai wild boars and may eventually go back to the common Asian ancestor, whereas Thai and other Asian pigs are distinctly different from European pigs. Our study describes the first approach to apply mtDNA sequence information for population structure analysis in Thai indigenous pigs and Thai wild boars, and it will be a benefit for the conservation and utilisation of indigenous pigs as an important genetic resource in the future.

**Keywords:** Genetic resources, mitochondrial DNA, Northern Thailand, population structure, Thai indigenous pigs

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## Effect of Slaughter Age on Carcass and Meat Quality of Rainbow Trout (*Oncorhynchus mykiss*)

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In Thailand, the rainbow trout (*Oncorhynchus mykiss*) was introduced by His Majesty King Bhumibol Adulyadej of Thailand in 1969 to induce trout farming in the northern highlands as a cash income source for the hill tribe people to enable them to abandon opium poppy cultivation. In 1998, comprehensive experiments with rainbow trout were started within a DAAD sponsored subject related partnership between the Universities of Goettingen (Germany) and Chiang Mai (Thailand). Today successful brood stock management under the specific environmental conditions in the highlands of northern Thailand has been achieved at the Chiang Mai Inland Fisheries Research and Development Center (Royal Project Foundation). In the present investigation, progeny of this brood stock was reared under these specific environmental conditions, slaughtered at the age of 10 (group1), 12 (group2), and 24 months (group 3) and carcass and meat quality of the fish was studied. The mean slaughter weight of group 1, 2, and 3 fish was 339, 500 and 1133 g, respectively. As expected, carcass parameters increased with increasing slaughter weights. The highest carcass percentage, however, was found in group 2 fish (86.48 %,  $p < 0.001$ ), whereas group 1 fish had the highest viscera-somatic index ( $VSI = 11.23$ ,  $p < 0.001$ ). The hepato-somatic index (HIS) did not differ significantly between the groups. The meat quality was determined in the dorsal part (DP) and ventral part (VP) of the fish muscles. The pH value measured 5 min., 45 min. and 24 hours post mortem decreased with time in both muscle portions. The lowest pH value was found in DP (6.24) and VP (6.26) in group 2 fish 24 hours post mortem. Group 2 trout showed the highest lightness of muscles ( $DP = 49.1$ ;  $VP = 50.6$ ), whereas group 3 fish showed the highest values for redness ( $DP 3.7$ ,  $VP 5.5$ ) and yellowness ( $DP 14.2$ ,  $VP 16.1$ ). The highest protein percentage (26.8 %) and the lowest fat percentage (5.5 %) were found in group 1 fish. In contrast, trout of group 3 had a lower protein percentage (20.8 %) and the highest fat (14.7 %) and moisture (73.8 %) percentages. TBARS (thiobarbituric reactive substance) was high in older trout and after longer periods of storage (6 days). In conclusion trout of group 1 and 2 were judged more favourable due to low fat and high carcass percentages.

**Keywords:** Carcass, dorsal portion, aquaculture, rainbow trout, ventral portion

## Identification of Single Nucleotide Polymorphism on MC1R Gene in Thai Native Cattle

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Melanocortin receptor 1 (MC1R) gene is an important gene in the regulation of pigment synthesis and responsible for coat colour in mammals. The polymorphism of MC1R gene in *Bos taurus* has been characterised as four alleles (ED, E+, E1 and e). In this study was carried out to identify single nucleotide polymorphism (SNP) of MC1R gene in Thai native cattle (*Bos indicus*). The coding region of MC1R gene in Thai native cattle namely White Lamphun cattle (white coat colour) was sequenced and compared with Holstein and Charolais breeds. The MC1R sequence of White Lamphun cattle has high homology with the *Bos taurus* (99 % identity). Four polymorphic sites were found in MC1R gene of the White Lamphun at position 296, 416, 663 and 725 bp of open reading frame. Out of these, three SNPs were identified as missense mutation, consisting of (1) a single base substitution (T296C) resulting in an amino acid change from leucine to proline (E+ allele) (2) a single base substitution (C416T) leading to an amino acid change from alanine to valine and (3) a single base substitution (A725C) leading to an amino acid change from asparagine to threonine. Moreover, a non-synonymous mutation was located at position A663C of bovine MC1R coding region. Based on this observation, two novel SNPs at position 416 and 663) were found only White Lamphun cattle breed. This result indicated that the MC1R gene of White Lamphun cattle breed was E+ allele and these two novel SNPs may be used as allele specific markers for the White Lamphun cattle breed.

**Keywords:** Marker, Thai native cattle, White Lamphun cattle

## Proteomic Profiling Analysis of Pectoralis Muscle in Thai Indigenous Chicken using two-Dimensional Gel Electrophoresis

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The pectoralis muscle in particular, growth at a greatly enhanced rate in chickens selected for meat production. In order to understand the proteome control of this trait, proteomic profiling in pectoralis muscle of Thai indigenous chicken was analysed in during growth periods. The muscle tissues were collected from individual chickens at 0, 3, 6 and 18 week of ages. Extracted muscle proteins were analysed and identified with two-dimensional gel electrophoresis (2-DE) and matrix assisted laser desorption ionisation time of flight mass spectrometry (MALDI-TOF/MS). A total of 360 individual spots were found, ranging from 14 to 97 kDa (pH 3–10). Allowing seven well-resolved protein spots were identified by MALDI-TOF/MS. In this investigation, the profiling of seven protein spots changed significantly in quantity in during growth periods could be divided into three groups: (i) the expressed protein markers showed a significant increase of levels ( $p < 0.05$ ), as the following: Phosphoglycerate mutase1 (PGM1), Ribosomal protein S2 (RPS2) and Triosephosphate isomerase1 (TPI1); (ii) the expressed protein markers showed a significant decrease of levels ( $p < 0.05$ ), as the following: Apolipoprotein A-I (APOA1), Putative dihydrofolate reductase (DHFR) and Fatty acid binding protein3 (FBP3); and (iii) the Heat shock protein 25kDa (HSP25K) represented the up-regulate and down-regulate. Five protein spots as the following: PGM1, APOA1, TPI1, HSP25K and FBP3 were associated with chicken muscle metabolism. The mRNA expression levels of these five protein spots were evaluated using quantitative real-time PCR; Fatty acid binding protein 3 was shown to increase significantly during growth periods ( $p < 0.05$ ). In addition, TPI1 was tended to be increased of mRNA levels during growth periods, especially at 6–18 week-olds. Moreover, an increasing of TPI1 mRNA levels is consistent with its protein expression levels.

**Keywords:** Protein expression, proteomics, real-time PCR, Thai indigenous chicken, two-dimensional gel electrophoresis

## Assessment of Genetic Variability and Genetic Structure of Vietnamese Chicken Breeds

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In Viet Nam, 11 local chicken breeds have been reported but the definition of these breeds is not fully standardised. It appears rather unlikely that comprehensive survey based on large scale phenotypic characterisation can be achieved considering the wide range of local chicken breeds and the diversity of local production systems. Therefore, there is a need to investigate genetic diversity using alternative source of information as molecular markers as a prerequisite for the development of effective conservation programs. The project aims at the molecular assessment of genetic diversity within and between Vietnamese local chicken populations and to analyse Vietnamese diversity in this species in relation to chicken populations from various continents and production systems. Twenty-nine microsatellites were genotyped in 353 individuals of nine Vietnamese local breeds and two Vietnamese exotic breeds. The latter populations originated from China and have been kept as conservation flocks at the institute of Animal Husbandry, Hanoi, Viet Nam since 1995 and 2003, respectively. The Vietnamese chicken populations were located in both the northern and southern part of Viet Nam. On average, 32 individuals were randomly collected for each population. As reference populations, 32 populations ( $n = 1121$ ) from Asia, Africa, and Europe, as well as commercial purebred lines and three Red Jungle fowl populations were included from previous studies. Overall, Vietnamese populations showed high genetic variability within and between breeds. In a global context, Vietnamese chickens contributed high diversity to the global gene pool. A phylogenetic tree indicated that Vietnamese chickens clustered closely together with the Red Jungle fowl populations and one Chinese native breed. The results corresponded to known breed history and geographical distribution. A structure analysis is on the way to verify the results obtained.

**Keywords:** Genetic characterisation, microsatellite characterisation, genetic diversity, phylogenetic structure, local chickens

# Livestock systems: health, breeding and feeding

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## **Characteristics of some Camel (*Camelus dromedarius*) Production Traits and Constraints in the Butana Area, Sudan**

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This field survey was conducted in Butana area, northeastern Sudan, to study the main features and characteristics of the dromedary camel production traits and constraints in the study area. The study revealed that most of the camel palatable and preferred forage plants and trees had disappeared and were replaced by non-palatable forage plants whereas the few remaining camel preferred forage plants were now restricted only to remote inaccessible areas. The study also showed that the classical mode of nomadism among camel herders in Butana area was sharply declining, giving way to settlement as a new emerging mode of camel husbandry. Regarding the level of education among camel herders in Butana region, it was found that majority of older herders were illiterate while 47.8 % of the younger ages were illiterate. The average size of the camel herder's families was found to be composed of seven persons with 57.2 % of the family members was males while the remaining percentage (42.8 %) was females. When the mean total annual income of the camel herding tribes was compared with the mean total annual expenditure, it was found that the income was lower than the expenditure for all the tribes except for the Bawadra group which was the only group practicing agropastoralism among all other camel keeping tribes in Butana area. Therefore, the study proposed that agropastoralism characterised by sedentary production system based on land ownership should be encouraged as the most suitable and profitable alternative available for the traditional camel nomads in Butana area of Sudan.

**Keywords:** Camel, Sudan, traits

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## **Evaluation of Factors that Influence Animal Pedigree and Performance Recording in Kenya**

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An effective animal recording system aims at collecting information on uniquely identified animals in production units, processing of the information and dissemination of the results for use in decision making at various production levels. In Kenya, a centralised recording system does not exist, however livestock recording is done voluntarily by producers at varied scale and intensity. To enhance recording, three organisations namely the Livestock Recording Centre (LRC), the Dairy Recording Services of Kenya (DRSK) and the Kenya Studbook (KSB) were set up to do pedigree recording and animal registration, and data collection on performance traits and evaluation which, consequently led to establishment of an animal recording scheme to facilitate nation animal genetic evaluation. At onset, the producers were motivated to send records to the recording organisations for evaluation, however with time the enthusiasm waned resulting into withdrawal from the recording scheme by some producers and some stopping on farm recording too. This paper aims at evaluating factors that influence animal recording at farm and national level with a view of getting possible ways of intervention. Using quantitative, qualitative and participatory methods, SWOT analysis is performed. Animal recording is divided into three stages; animal identification and registration, pedigree and performance recording, and genetic evaluation and data utilisation. Factors within the recording system that facilitate animal recording are considered strengths whereas those which limit animal recording were classified as weaknesses. On the other hand, factors outside the recording system are considered as opportunities if they facilitate animal recording and as threats if they undermine recording. A SWOT matrix is used to derive strategic combinations of factors that are then evaluated as possible interventions to enhance system's efficiency. Results from this study will be used in the definition of action arena in the subsequent institutional analysis of the system.

**Keywords:** Animal recording, SWOT

## **Milk Production Capacity of Dairy Cattle under Limited Resources and Distribution Pattern in Peri-Urban Area of Southwest Nigeria**

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In Nigeria, animal protein intake from milk production by dairy cattle is low. The modest milk production is still in the hands of the pastoralists, who are either sedentary or itinerant. Fresh milk consumption is rare but is largely processed into products that are highly relished by Nigerian consumers. In this regard, a study was carried out using 50 dairy cattle farmers to appraise the trend of dairy production and the distribution channels of milk and its products for local consumption. The study showed that the most favoured breed in the area was White Fulani cattle accounting for 80 % of total milk production whereas N'Dama and Keteku breeds accounted for (15 %) and (5 %), respectively. Grasses and browse trees were the major forages for feeding the cattle in the rainy season while there was an inclusion of crop residues in the dry season. In the study area, milk collection was usually done by hand milking. The average milk production per cow per day was 1.3 l and 1.02 l in the wet and dry season, respectively, totaling 240 days lactation length. About 40 % of the total milk produced was consumed by the dairy farmer household member during rainy season but increased by 10 % in the dry season. The remaining 50–60 % milk produced was processed into local cheese (wara) and distributed for immediate consumption. Sales person were house wives (59 %) and female children (41 %). Selling of the products was through hawking (52 %), rural markets (37 %), homestead (6 %), urban markets (3 %) and collection point (2 %). Mode of distribution to sales points were by pedestrians (63 %) and road (37 %). Buyers were mainly the direct consumers (70 %) and the traders (30 %). It was concluded that the dairy cattle in the peri-urban area were marginal in milk production due to the type of breed and poor feeding pattern but the milk and its product are resourceful for rural consumption.

**Keywords:** Crop-livestock, dairy cattle, marketing, milk production, peri-urban



## Optimising Breeding Organisation for Small-Scale Pig Producers in Northwest Viet Nam

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In the last decades, the government of Viet Nam has been striving towards commercialisation of pig production, promoting the use of imported, high-yielding breeds. Main development incentives to intensify pig production focus on the Red River Delta and areas surrounding big cities in order to meet the demand of the growing urban population. Smallholders in the mountainous province Son La, however, face various problems to take part in this process and to intensify their production. High quality breeding animals are difficult to find and have to be imported from other provinces, as state breeding farms were dismantled having gone bankrupt, and private breeding farms providing local breeds are absent. Overcoming the constraints that smallholder pig breeding are facing is a prerequisite to the successful integration of this sector in market-oriented pig production.

Starting from the situation in Son La province, the present study attempts to explore the organisational feasibility of community-based breeding programmes and possibilities for their integration into provincial, regional and national structures. An institutional analysis is used to provide a descriptive assessment of institutions involved in pig breeding organisation in North Viet Nam and their interrelations. Information was collected from group discussions with smallscale producers and personal communication with experts from the Ministry of Agriculture and Rural Development, departments and research institutes of the National Institute Animal Husbandry (NIAH), as well as other public institutions; in addition information was taken from documents, particularly legal documents.

Results indicate that links between public pig breeding institutions used to be strong, NIAH being the most important institution involved in pig breeding, while the link between smallholders and state institutions has been limited. Farmers would prefer a stronger support for their pig breeding by the state. Few village groups performed activities directly related to pig breeding. The degree of organisation of farmers in production cooperatives is low. In general, farmers attitude towards cooperatives are positive due to perceived advantages like risk sharing, labour sharing, better access to loans. The description of the actual breeding organisation will be complemented by a SWOT analysis to derive recommendations for alternative models of breeding organisation at village level.

**Keywords:** Breeding organisation, institutional analysis, pig breeding, SWOT

## Awassi Sheep Production Systems and Feeding Strategies in Syria

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In Syria sheep are an important source of income due to the large proportion (55 %) of semi-arid areas with less than 300 mm average annual rainfall. The 11.5 million heads of Awassi sheep (the only sheep breed kept) contributes 78 %, 30 % and 100 % of the country's total red meat, milk and wool production, respectively (FAO, 2006). The objectives of this study are to analyse production systems of Awassi sheep in Syria and to identify the feeding strategies.

A study was carried out during summer 2006 and 2007, involving 105 sheep keepers of four different eco-zones through individual questionnaire guided interviews. Grazing of rangeland and crop residues is the main activity and feed resource across the eco-zones. Supplementation of concentrates is becoming increasingly necessary to maintain feeding levels over expending periods of the year. Grain barely, bran and cotton cake are most important in all study areas (91 %, 98 % and 98 %, correspondingly). Maize is often used in southern area (27.3 %) compared with 3.9 %, 5.4 % and 0 % in the northern, middle and eastern region. Cotton seed is used in all areas (35 %, 23.1 %, 13.6 %, and 13.5 % in eastern, middle, southern, and northern area, respectively). The use of dried bread is increasingly common in the eastern area (35 %) compared to 9.1 %, 3.9 %, and 2.7 % in the southern, middle and northern area. Purchase of feed from government sources and general markets (96 % of sheep keeper) is the main access to feed, but 57 % of the sheep keepers do also cultivate barley or wheat to produce some additional feeds. The negative trend in availability of rangeland and crop residues does increase the demand for concentrate supplementation which links the sheep industry in Syria to the effects of globalisation in feed trade .

**Keywords:** Concentrate feed, feed resources, sheep production, Syria

## Quantitative Risk Assessment for *Cryptosporidium parvum* Associated with Dairy Cattle in Urban and Peri-Urban Nairobi, Kenya

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Urban agriculture involves around 1 billion people, generating income and employment and providing cheap and nutritious food to poor city dwellers. However, this new farming system involves new risks, including novel diseases and increased transmission potential. Risk analysis is a powerful tool for assessing and managing these risks.

*Cryptosporidium parvum* is an emerging zoonotic disease which mainly affects malnourished children and people with HIV. Cattle are believed to be the major reservoirs for human infection and city dairying is a possible 'hot spot' given the close proximity of animals to people and difficulties of livestock waste disposal in urban areas. We carried out a quantitative risk assessment to assess the risk of infection with *C. parvum* in a peri-urban community in Nairobi, using the Codex Alimentarius framework, which comprises hazard identification, hazard characterisation (including dose-response assessment), exposure assessment, and risk characterisation.

A questionnaire was administered to 300 dairy-keeping households selected from a sampling frame of all dairy farmers in the Dagoretti administrative area and to 100 neighbouring households. This included questions on husbandry, hygiene, consumption of dairy products, and manure management. Cattle faeces were tested for *C. parvum*, and of the 78 households with positive cattle, 20 were selected based on meeting pre-defined criteria for a more detailed study mapping pathways of *C. parvum* from cow to person at risk.

Five major transmission pathways were identified and an event tree constructed to assess disease exposure in the two most vulnerable populations (malnourished children and people with HIV). Based on this, a deterministic quantitative risk assessment model was developed and parameterised with data from the questionnaire survey, detailed mapping and data from literature. This suggested a daily risk of 2 exposures to *C. parvum* per 1000 people in the at risk groups. Contra-intuitively, although cattle are the source of disease, the risk from eating vegetables was almost 3 times that associated with consuming milk. This was largely explained by good milk-handling practice and poor manure handling practice.

Information on risks associated with different pathways was used to develop community-based interventions for decreasing risks associated with city dairying.

**Keywords:** *Cryptosporidium parvum*, quantitative risk assessment, urban dairying

## What People Worry about and What Makes them Sick are Rarely the Same: Risk Ranking for Raw Milk in Ethiopia

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Food safety is of increasing concern in developing countries, not only as a major cause of avoidable sickness and death but also as a barrier to smallholder participation in markets.

Existing food safety systems are based on tradition and convention; they focus on visible problems (which may be less important), manage safety by command and control regulations, and often disadvantage small-scale farmers and processors. In contrast, a science based food safety system would prioritise food safety problems and preventive interventions using the best available data on the distribution of risk and on how risk can be reduced most effectively and efficiently.

Risk-ranking is particularly challenging in developing countries where data are scarce and difficult to collect. We have developed a conceptual framework which combines epidemiological, microbiological and behavioural data to rapidly, cheaply and imprecisely rank the hazards associated with animal-source foods. Key elements of the framework are: a stakeholder approach where those involved in a hazard (whether risk makers or risk takers) negotiate an acceptable level of risk; consideration of other positive and negative externalities (*e.g.* income generation) associated with the health hazard; supplementing or replacing conventional quantitative data by qualitative (PRA) data; use of rapid diagnostic tests using innovative technology (*e.g.* lateral flow).

We present the results of a proof of concept study applying the framework to assessing the hazards in raw milk in Ethiopia. After literature review and stakeholder engagement, rapid appraisals were carried out with 4 farmer and 5 consumer groups, and key informant interviews with doctors, veterinarians and farmer managers. This was followed by a cross-sectional survey of six high priority milk hazards. Finally a stakeholder workshop used risk matrices to assign priorities. We compare the results from this ranking with stakeholder perceptions of milk-borne hazards and show how these were often inaccurate and unhelpful.

The method is contrasted with conventional epidemiological studies and wider applicability is discussed.

**Keywords:** Ethiopia, milk-borne disease, raw milk, risk ranking

## Nutrient Fluxes in Intensive Urban Sheep Production in Niamey, Niger

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Sheep fattening is an important economic activity in the West African Sahel, especially before the Islamic festival of Eid-al-Kabir. This study therefore, focused on the nutrient intake of Sahelian type sheep during the cool dry, hot dry and rainy season in 8 intensive urban sheep production enterprises in Niamey, Niger. In the selected households animals were offered bush feeds, concentrates and cultivated feeds. Intake of dry matter (DM), nitrogen (N), potassium (K) and phosphorus (P) was quantified every 6 weeks and the effect on animal performance was assessed for the weight categories I:  $\leq 10$ , II:  $>10 \leq 20$ , III:  $>20 \leq 40$  and IV:  $>40 \leq 60$  kg. Average daily dry matter intake per animal of cultivated feeds was  $1102 \text{ g} \pm 286.5$  in the cold dry season and differed ( $p < 0.05$ ) from that of the hot dry season ( $269 \text{ g} \pm 77.9$ ) and rainy season ( $238 \text{ g} \pm 132.8$ ). For concentrates and bush feeds, no differences ( $p > 0.05$ ) were found in DM intake across seasons. Daily intake (g) of N, K and P averaged  $37 \pm 10.4$ ,  $34 \pm 8.8$  and  $8.7 \pm 3.6$  per animal during the rainy season and  $32 \pm 5.8$ ,  $29 \pm 5.8$  and  $5.6 \pm 1.0$  during the cool dry season ( $p > 0.05$  in all cases). In the hot dry season, N, K and P intake (g) decreased to  $12 \pm 2.4$ ,  $13 \pm 1.8$  and  $2 \pm 0.3$  per animal ( $p < 0.05$  in all cases). The animals' average daily weight gain (AVDG, g) in categories I, II, III and IV was  $92 \pm 8.8$ ,  $54 \pm 6.1$  and  $43 \pm 6.2$  and  $-15 \pm 15.5$  in the cool dry season as opposed to  $72 \pm 14.4$ ,  $54 \pm 8.0$ ,  $5 \pm 6.7$  and  $-39 \pm 16.4$  in the hot dry season ( $p > 0.05$  for I, II, IV,  $p < 0.05$  for III) and  $74 \pm 27.2$ ,  $42 \pm 7.3$ ,  $33 \pm 8.1$  and  $3 \pm 29.0$  in the rainy season ( $p > 0.05$  in all cases). The results indicate that, irrespective of season, fattening sheep above a live weight of 40 kg is inefficient under the given feeding practices and underline the need for a change in fattening rations if sheep of higher live weight are to be produced for specific marketing occasions such as Eid-al-Kabir.

**Keywords:** Nutrient fluxes, animal performance, sheep, urban agriculture



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## **Cow and Camel Milk Production and Marketing in Agro-Pastoral and Mixed Crop-Livestock Systems in Ethiopia**

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The study was conducted in Mieso district, 300 km south east of Addis Ababa, Ethiopia. Participatory rural appraisal (PRA), focus group discussions, formal survey and monitoring were used to characterise the traditional milk production and marketing system and to identify constraints and opportunities for development. A total of 120 farmers / agro-pastoralists from five rural Kebeles (Dire-kalu, Welda-jejeba, Hunde-misoma, Gena, and Huse-mendera) were involved. Milk marketing was monitored in Mieso and Asebot towns. Indigenous breeds of cattle, camels and goats are used for milk production, and natural pasture and crop residues (sorghum and maize stover) are important feed resources. Mineral soil salt (haya) is used by about 40 % of the respondents. Average cow milk yield per head/day in the wet and the dry seasons was estimated at  $3.26 \pm 0.07$  and  $1.63 \pm 0.04$  liters, respectively, while the respective values for camel were  $7.12 \pm 0.33$  and  $3.85 \pm 0.20$  liters. Average milk produced per household per day in the wet and the dry season was  $4.80 \pm 0.22$  and  $2.37 \pm 0.11$  liters for cows and  $13.19 \pm 0.95$  and  $7.63 \pm 0.82$  liters for camels. Milk and milk product sale is a major sources of income for 96 % of the respondents. The amount of cow and camel milk supplied to the market decreases during the dry season by 39 % and 28 %, respectively. The amount of cow and camel milk sold per day was higher in Mieso ( $496.6 \pm 19.12$  liters) than in Asebot market ( $187.89 \pm 19.12$  liters). Milk is sold by women organised in traditional milk associations (locally called Faraqa Annanni) or on individual basis. Distance to markets and availability of Faraqa Annanni were important factors on decision to participate in milk marketing. Feed scarcity, water shortage, security problem, and limited access to veterinary services were the major problems identified by 41 %, 30 %, 14.5 % and 8 % of the respondents, respectively. Mortality rate due to diseases was identified as a major cause of loss in cattle (65 % of respondents) and camels (67 %). Feed resources development, animal health care, strengthening the traditional milk marketing groups and capacity development in all aspects of milk production and marketing will enhance market participation of farmers and agro-pastoralists.

**Keywords:** Agro-pastoral, camel, cow, crop-livestock, Ethiopia

## Proximate Composition, pH Value and Microbiological Evaluation of 'kundi', (dried meat product) from Beef and Camel Meat

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'Kundi' is a typical Nigeria meat product obtained by smoking beef and camel meat. Meat from 2 to 3 years old male camelous dromedarius and white Fulani were used for this study. The beef used for this study was purchased soon after slaughter from the slaughter house of the department of Animal science, University of Ibadan in Ibadan. The lean hind quarter of cow was used (semimembranosus muscles). In like manner camel meat (semimembranosus muscles) was purchased from an open market within 1 hour postmortem and taken to the meat science laboratory where the experiments were carried out. The meat was trimmed free of fat, nerves, blood vessels and excess connective tissues with a sharp knife. The meat chunks were cut into smaller pieces about 6 to 8 cm, kept overnight at 4°C and seasoned during processing. Ingredients used for seasoning include thyme, curry, salt, monosodium, glutamate and onions. Changes in pH values and microbiological counts at storage are reported.

The result of the study showed that protein content obtained for camel 'Kundi' 63.07 % was significantly ( $p < 0.05$ ) higher than protein content in beef 'Kundi' 58.10 % while the moisture content was higher ( $p < 0.05$ ) in beef 'Kundi' than camel 'Kundi'.

The microbiology value obtained had significant ( $p < 0.05$ ) differences for either samples i.e seasoned or unseasoned products. Microbes identified at 6 month storage interval were significantly ( $p < 0.05$ ) higher than microbes identified at 0 and 3 months respectively. The pH values obtained had no significant differences ( $p > 0.05$ ) at 0, 3 and 6 months of storage for both meat type respectively

**Keywords:** Kundi, beef, camel, Meat dried

## **On-Farm Comparison of Milk Production and Body Condition of Purebred Ankole and Crossbred Friesian–Ankole Cattle in Southwestern Uganda**

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Increasing land pressure due to the rapidly growing population, growing demand for livestock products in urban centres and new land policies in Uganda are changing the life styles of the hitherto extensive grazers of the long horned Ankole cattle in southwestern Uganda. A production system where two separate herds are kept on one farm, a pure bred Ankole herd and a herd of Friesian-Ankole crosses is emerging. The Friesian-Ankole crosses are kept as a source of milk most of which is sold to generate income. The Ankole are kept for cultural reasons, a buffer against shock in case of prolonged drought and disease outbreak and for income through sale of live animals. This study investigates the life cycle efficiency of the different genotypes on farm. Twenty farmers have been selected and in each farm up to 30 animals have been selected per herd covering the complete age/sex range of the herd. During the selection the crossbred status was evaluated based on information from the farmer and phenotype. All selected animals were tagged. The animals are currently followed up on monthly intervals and this will last for a period of two years. During the visits body condition, tick count, health status, milk production of cows, growth parameters in young animals (weight approximated by the measurement of chest circumference) are recorded. Other information collected includes disease and parasite control measures (methods and costs involved), labour costs, calving dates, supplementation, as well as rainfall and temperature patterns.

This paper discusses preliminary results on performance traits of the different genotypes for the first year of the study.

**Keywords:** Ankole cattle, crossbreeding, on-farm experiment, Uganda

## **Situation of Fattening-Cattle Farms in Chiang Mai, Thailand**

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In the past years, demand for beef had been grown up because of the increase in domestic population and the number of tourists in Thailand. Chiang Mai is one of the most important tourist areas in Thailand. Therefore the demand of quality beef is above average. Meanwhile, some of the beef farmers involved in beef enterprises are producing high quality beef for this market.

The main purpose of this study was to investigate the situation of the farms that are fattening cattle in Chiang Mai, Thailand. Thirty-seven farmers were interviewed at their farms during August 2006 to January 2007 by using questionnaires to get information of cattle and farm management.

The results showed that all the farm managers were males with an average age of 54 years. Fifty-seven percent of the farmers raised fattening cattle as their secondary occupation. Each farm was run by a family member. The main genotypes of cattle on the farms were Brahman crossbreed and/or Charolais crossbreed. Half of the farms had an average herd size of 4–6 cattle. In the rainy season, 60 % of farmers used forage from their own pasture while the remaining 40 % gained forage outside of their farms. The main forages in the dry season were corn silage and rice straw. Most of the farmers used commercial feed supplied by a private company based on a credit system. Therefore, the farmers had to sell the animals to this company. The price was pretended by the company. The basic price for finishing cattle, during the study period, was 55 and 52 Bath per kg live weight for Charolais and Brahman crossbreed cattle, respectively (48.39 Bath = 1 Euro). The prices were related to dressing percentage and amount of marbling of the carcass.

**Keywords:** Cattle farm, farm management, fattening cattle, Thailand

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## **Attributed Importance for Consumers from Santa Maria (RS-Brazil) to Lamb Characteristics - A Fuzzy Approach**

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To evaluate the preferences of the Brazilian consumers with regard to the properties of the available meats in the market has been the focus of several works. However, works evaluating the case of the lam/mutton are rare in national and international literature. Models that represent the opinion of meat consumers in relation to its expectations and perceptions can be an efficient indicator in the determination of technological trajectories or market to be followed concerning the improvement of the quality, productivity and profitability of the producers and industry. The conventional approach assumes that the properties of a product and the values of the consumer are linked and that this connection can be explicated through the collection of data derived from one technique of qualitative interview called laddering. Laddering assumes that the knowledge of a homogeneous group of respondents is organised in a multidimensional set of hierarchies and that this knowledge is categorical, that is, nominal values (0 or 1) arranged in categories. Although it establishes the relations between the product and the consumer, the use of nominal values limits the capacity of the methodology to deal with vague or inexact knowledge. As far as the action of the consumer is not always directed by an only value of consumption and that the degree of adhesion to these values can be variable, fuzzy numbers and intervals can be used as tool of description and aggregation of these values.

Initially introduced in the analysis of complex systems, fuzzy intervals allow the modelling of systems with badly distinguished borders and fit to the linguistic representation of phenomena of a determined universe of discourse.

Several works use fuzzy intervals in the research of consumers' behaviour .

In this work data from the behaviour of consumers of lamb were analyzed, considering the uncertainties (vague or inexact knowledge) present in the speech (linguistic terms) used by the consumers through a fuzzy inference method.

**Keywords:** Consumer perception, fuzzy number, lamb

## Current Practices and Future Prospective in Pre-Urban Camel Farming in Khartoum State, Sudan

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Camels (*Camelus dromedarius*) are animals with special importance for nomadic communities in tropical and subtropical areas, as they have the ability to maintain milk production under harsh environmental conditions, under scare of water and feed. Camels represent the back bone in the economical live of abbala (tribes known by rearing camel) in Sudan, either by selling male camels in local markets or by exportation. Moreover, the recent awareness of the medicinal value of camel milk, give way to more commercially oriented attitude by abbala in Khartoum State. This not only lead to food security but also improving abbala's style of life (milk of camels sold in more than double prize (3.0 \$/ liter compared to milk of cows). However the milk which produced by those abbala is of less quality as was observed during the present survey, which addressed a total of hundred camels farms. The obtained information includes the socioeconomic status of camel herd owners and some practices used in production of milk from she camels (*nagas*). Camel owners were found to practice less hygiene as little rotational health care (4 %), less udder washing (8 %), washing milker hands and equipment (76 and 58 % respectively) were observed in addition no special area for milking was found. This might be because of that the majority of camel owners were illiterates (84 %).

Frontline extension staff is needed to demonstrate improved husbandry practices to the farmers. Focusing dairy development efforts to abbala will provide great potential in improving public health through production of good quality milk, moreover, it will provide a good opportunity for trade of camel milk, which would increase the families income. It could be concluded that more attention is needed to put milk production from nagas in Sudan in the right track. This could be done by introduction of proper collecting points supported by cooling facilities and processing units.

**Keywords:** Abbala, *Camelus dromedaries*, milk, Sudan, Camel

## **Milk Yield and Lactation Management of Goats kept by Gabra and Rendille Pastoralists in Northern Kenya**

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Although meat production is the main function of small ruminants in African pastoral systems, especially goats are also an important source of milk in these systems. Therefore a study was carried out to assess the milk yield of does that are kept by the Gabra and Rendille pastoralists, both during wet and dry seasons. Sampling took place from June to November, 2006. For each goat a single test day sample was taken, and the lactation month recorded. Milk was measured in 230 and 268 randomly selected does in goat populations of Gabra and Rendille, respectively. Daily milk yield per doe was estimated by measuring the milk of half udder after 10 hours of does separation from their kids. The amount obtained was multiplied by 4, since goats are milked twice a day. The practices of the pastoral communities relating lactation management were also determined using focus group discussions. Gabra and Rendille keep lactating goats in both homestead and satellite flocks. The results show that in both seasons the milk yield of does kept in the homestead flocks is significantly higher than of the ones kept in the satellite flocks (Gabra: Wet - Home (WH) 621ml (n=47), Wet - Satellite (WS) 261ml (n=78), Rendille: WH 486ml (n=19), WS 114ml (n=53)). Since fodder conditions are better around the satellite, thus the results indicate that pastoralists select the higher yielding animals to be kept in the homestead flocks for supplying milk to the household. Milk yield of Gabra goats was significantly higher than that of Rendille goats during the wet season in both flock types, and during the dry season only in the homestead flocks. The Gabra and Rendille pastoralists manage the lactation of their does by both routine and problem solving measures, which include for example separation of bucks from the homestead flocks to prolong the lactation period and migration of animals to areas of higher feed availability, respectively. The ability of the does in the two goat populations to resume production immediately after a drought period, and maintaining milk yield during the dry season demonstrate their high productive adaptability.

**Keywords:** Adaptability, goats, management, milk, pastoralists, productive, season, yield

## The Beef Chain in Costa Rica: Identifying Critical Issues for Promoting its Modernisation, Efficiency, and Competitiveness

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The objectives of this study were to (1) describe the economic agents of the chain and their commercial and legal relationships; (2) identify the articulations between links, technological levels, indicators of efficiency, installed capacity (scale), and degrees of occupation; (3) characterise and estimate the costing and pricing structures, and the generation of value in different links of the chain; (4) identify those critical costs that can be modified through technological interventions, policy, or other activity; (5) determine the biological and economic risk factors throughout the chain; and (6) develop a methodology to identify and estimate the costs and benefits in each segment and evaluate the generation of value throughout the beef chain.

Data at the farm level was obtained from a national livestock survey (CORFOGA 2005b), which provided data on production systems, inventories, productivity, culling, and labour. In addition, surveys were carried out in different segments: (1) auction houses, (2) slaughterhouses, (3) butcher shops, and (4) supermarkets. The aim of these surveys was to describe behaviour, determine risks and costs, and identify problems.

The best performance in terms of efficiency and profitability is found in the retail sector of butchers and supermarkets. The rate of profits, expressed as the fraction of the final price paid by the consumer that remains in the butcher's hands as remuneration of his work, ranges widely between 3 % and 40 %, with an average of 32 %. If these profit rates are compared with those of other retail businesses, which are about 8 %, then this type of activity presents excellent profit margins with relatively low risk.

The value generated throughout the chain, as a percentage of the final value of the young steer at retail price according to activity, is distributed as follows: fattener (34 %), retailer (33 %), breeder (19 %), slaughterhouse (7 %), transporter (6 %), and auction house (1 %). The distribution of value throughout the beef chain is totally inequitable and incongruent with the level of individual risk confronted by the actors who form it.

**Keywords:** Beef value-chain, competitiveness, consumer, marketing, meat quality

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## Social Inclusion: A Driving Force for Dairy Sector Development in Nepal

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Nepal is a multi-ethnic nation with diverse languages, religious and cultural traditions. There are more than 100 ethnic groups with distinct languages and cultures. More than 85 % of the population resides in rural areas. About 65 % of the total population is engaged in agriculture. A 20 years long Agricultural Prospective Plan (APP) has been effective in the country since 1997/98 which targets an annual growth rate in Agricultural Gross Domestic Production (AGDP) of 5 %. Livestock sector has been taken as one of the most potential sectors with an expected average annual growth rate at 5.5 % as a whole in livestock sector and 6.1 % in the dairy sector. However, the social exclusion of some of the ethnic groups, especially the scheduled castes, in the dairy co-operatives in rural areas has been seen as one of the constraints to achieve the targets. Still now, milk produced by some of the scheduled castes of the country has not been bought by the dairy cooperatives in the rural areas of the country.

Present study was conducted in one of the districts of Far-western Development Region of Nepal, Dadeldhura, to find out the socio-economic status of the ethnic groups, reasons of social exclusion and possible measures to increase the social inclusion of the marginalised groups in dairy co-operatives. 80 households, 40 each from scheduled and non-scheduled castes, were directly surveyed by using semi-structured questionnaires. In addition to that Participatory Rural Appraisal (PRA), focus group discussion and consultation with the key informants were also carried out. Data were analysed by using appropriate statistical tools. It has been found that prevailing traditional thinking of untouchability to some of the scheduled castes, sanitation and personal hygiene were found most causative reasons. In addition to that, lack of awareness and social empowerment among the scheduled castes had been hindering to enter as members and share holders of the co-operatives. Proper package of education, trainings, awareness campaigns and enforcement of the prevailing laws and regulations would mainstream the marginalised people which ultimately might result as a driving force for dairy sector development in Nepal.

**Keywords:** dairy co-operatives, empowerment, ethnicity, livestock, Nepal, participatory rural appraisal, social inclusion



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## Does the Future Hold for Transhumance Cattle Production System in North Western Ethiopia?

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This study was conducted in three highland (Chilga, Dembia, Gondar Zuria) districts that practice transhumance and one lowland (Metema) district that receives the transhumance in North Gondar Zone, Amhara Region, Ethiopia. The objectives were to characterise the rainy season transhumance cattle production system, assess the constraints and forward suggestions for future interventions. In the highlands, the mean family size per household was  $7.4 \pm 0.17$  and 42.2 % of the household heads were illiterate. The average land and cattle holdings per household were  $2.2 \pm 0.18$  ha and  $8.7 \pm 0.48$  heads, respectively. The proportion of households that practice transhumance was 91.7 % in Chilga, 77.6 % in Dembia and 55.2 % in Gondar Zuria. Metema was the preferred destination for 84 % of the respondents due to availability of good quality feed. Movement to the lowlands commences in May (69.5 %) and June (29.6 %), and depends on availability of feed and labour and cattle holdings. About 60 % of the cattle are trekked to the lowlands during the rainy season. Herder groups are formed among relatives and neighbours at village level to optimise labour use and protection against theft. The average herd size per herder group was  $58.8 \pm 3.88$ . The transhumance return back home in October (45.8 %) and September (35.9 %), and the major triggering factors are high temperature (43.0 %), availability of crop aftermath in the highlands (25.1 %) and high infestation of flies in the lowlands (10.6 %). The major constraints identified and prioritised by the transhumance highlanders were conflict with the lowlanders, theft, human and livestock diseases, lack of markets. Most of the respondents (86.3 %) estimated that the trend of transhumance has been increasing due to feed shortage (50.4 %), expansion of crop cultivation (27.4 %) and increasing human and cattle population (21.2 %) in the highlands. Human population has been increasing both in the highlands and lowlands and the current development of infrastructure in the lowlands (tarmac road, electricity, phone, etc) will further encourage more migration to the lowlands. The conflict over resources will intensify, probably leading to the demise of this production system unless alternative development strategies are devised.

**Keywords:** Cattle, Ethiopia, transhumance

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## **Risk Attitudes and Risk Management Strategies among Swine Producers in Northern Thailand**

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The purposes of the study were to examine (1) the consistency of the 2 common risk attitude elicitation methods, (2) the socio-economic factors and risk sources affecting risk attitudes, and (3) risk management strategies that determine risk attitudes among the swine producing groups in northern Thailand.

In July–October, 2007, 408 swine farmers from Chiang Mai, Chiang Rai, and Lamphun Provinces were given questionnaire-interviewed. The Subjective Expected Utility model (SEU) and attitudinal likert-scale were used, to measure risk attitudes. Descriptive statistics, multiple- and logit regression analysis tools were applied for the study.

The research findings showed that most of the respondents are male, with an average age of 45.31 years, and 6.13 years in school. The family size is 4.37, with 10.97 years in pig farming experience, and own about 310 pigs per farm. While, 29.2 %, 30.9 %, 19.6 %, and 20.3 % of them are subsistence farmers, cooperative members, contract farmers, and independent farmers, respectively. The study confirmed that the risk attitudes of both risk attitude elicitation methods are significantly correlated at the 0.01 level.

It was also found that the socio-economic characteristics; pig farming experience (years), and farm size (number of pig) are significantly affecting swine producers' risk attitude. While, risk sources that influencing risk attitudes are production risk from animal diseases and personal risk from capability to manage pig farm ( $p < 0.05$ ). The key risk management strategies that significantly determining risk preferences among the swine farmers are; (1) the risk reducing inputs use of animal drug & chemical, and evaporative cooling system, (2) cost flexibility; (3) holding reserve from cash saving; (4) insurance of personal health and life; and (5) diversification.

**Keywords:** Likert scale, risk attitude, risk management strategy, risk source, subjective expected utility, swine producer

## Indigenous Buffalo Farming and its Improvement: A Potential Drive for Rural Development in Nepal

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Eighty-six per cent of the population of Nepal lives in rural areas. Agriculture, engaging about two-third of the total population, contributes 38 % of gross domestic product (GDP) in the country. Livestock is an integral component of Nepalese farming system that contributes more than one-third of the total agricultural GDP (AICC, 2005).

Buffaloes are raised for supply of animal protein, draft power and manure. Buffalo farming has got the utmost important as they have been reported to contribute 52.9 % of the livestock share in the national GDP. The government of Nepal has adopted an agriculture perspective plan (APP) as a 20 years priority focused forward looking strategy. APP has given first priority to milk and then to meat. Buffaloes contribute 71 and 65 % of the total annual production of milk and meat, respectively. Because of more positive attributes of buffaloes than cattle, farmers of Nepal prefer buffaloes over cattle. However, there have been only limited studies relating to improvement of their production potentialities. In spite of three decades of government's programs for upgrading local animals, almost 90 % of the buffalo population still remained untouched. This study was conducted to find out the possible reasons that had hindered improved buffalo farming in Nepal. One-hundred and five farmers from three districts, 35 from each district, of western development region of Nepal were randomly surveyed based on the pre-structured questionnaires.

It has been found that bigger body size, need of more input per unit of output, problems during calving, late in first calving, long calving interval, more repeat breeding problems and high sensitive to disease and parasites were found as contributing factors for not increasing the number of improved buffaloes. Use of locally selected elite bulls in breed improvement programs, training for the needy people, gender mainstreaming in buffalo farming, programs for round the year forage production, were suggested by the farmers as the measures to be incorporated in the annual programs of the Department of Livestock Services to make the buffalo farming enterprise more profitable which could be considered as a potential drive for rural development in Nepal.

**Keywords:** Agriculture perspective plan, buffaloes, elite bulls, gross domestic products, Nepal, rural development

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## Gender and Forage Resource Use in the Transitional Zone of Ghana

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Small ruminants are kept as an adjunct to crop farming in the transitional zone of Ghana. Not much has been done to catalogue the forage resources of this zone and their extent of utilisation by men and women farmers, for gender specific interventions. This study, conducted in the Ejura-Sekyedumasi District of Ghana, bridges this information gap. Items eaten by small ruminants were elicited from 22 men and 19 women by the freelisting method. Data analysis was with Anthropac and SPSS software. Smith's salience index was calculated for each item. The 175 items mentioned included 37 wild trees and shrubs, 37 natural grasses and forbs, 19 cultivated trees and shrubs, 28 crops, 38 crop residues and 12 crop by-products. Pairwise ranking of all feed categories based on the most used by stock was done using a men and a women focus groups. Again, eighteen men and twelve women listed feeds they usually fed to small ruminants. Wild browse species constituted 22 % and 18.5 % respectively of what men and women used. The most salient was *Margaritania discoidea* for men (0.398) and women (0.278), followed by *Pterocarpus erinaceus* with 0.256 for men and 0.210 for women. Both men and women ranked natural pasture species first on a scale of 8, constituting 22.2 % of what women fed but none by men. Cultivated tree species accounted for 18.2 % and 18.5 % respectively of what men and women fed. The most salient was *Ficus* spp for men (0.209) and women (0.309). Crop residue accounted for 27.3 % and 11.3 % of what men and women fed respectively. The most common, banana leaves, had a salience of 0.254 for men and 0.138 for women. Cassava peels were the most salient crop by-product for men (0.361) and women (0.646). Though 28 crops were listed as feed, and 13.6 % and 11.1 % of what men and women fed respectively were crops, pairwise comparison by both groups ranked crops last. The most salient feed was maize grains for men (0.749) and women (0.657). Farmers fed maize grains to tame stock. It was concluded that women would rely more on feeds obtained near the homestead.

**Keywords:** Feed, freelisting, gender, salience, small ruminants, transition zone



## Seasonally Changing Activity Patterns of Free-ranging Criollo Cattle in Subtropical Mountain Forests of Southern Bolivia

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In southern Bolivia, cattle are often kept in transhumant systems. At the beginning of the dry season in April/May the cattle are moved from the open valleys to the forests in the Boliviano-Tucumano formation where they stay until the rainy season starts in October/November. Little knowledge exists about the activity pattern of the cattle in these subtropical mountain forests. The present study was conducted in two different areas, Rio Tarija (RT) and Meringal (M), located within the Reserva Nacional de Flora y Fauna Tariquía by observing 15 adult Criollo cows during two periods (P1=May-July; P2=Aug.-Nov.). Observation of the activity pattern of the cattle was made by following one animal/day (during 4–5 days per month and study site) and recording the activity types “grazing”, “resting”, “locomoting” and “other activities” every 6 min. Only data obtained between 08:00 h and 16:00 h was used, and only days with at least 71 observation minutes were considered (max. 81 min). Data was analysed per animal, and for animals observed during more than one day per period the mean was calculated. During P1, a period with lower temperatures compared to P2 (13.5°C vs. 18.4°C), the cattle spent most of the time in the forests, where the main activity recorded was grazing and browsing. This behaviour was noted at both study sites, but cattle at RT spent only 51 % of the time observed in the forests, while the cattle at M stayed almost the entire time in the forest (97 %). Both, habitat use and main activity patterns were reversed in P2. At both study sites in P2, the animals spent most of the time on the open river banks (RT: 74 %, M: 84 %). Almost 90 % of the time spent on the river banks in RT and over 90 % in M were used for resting activities. A more moderate wind-chill factor in the open, sandy habitat along the streams as well as relief from biting insects (mainly horse flies) and ticks are assumed to have been the main reasons for the intensive use of the river bank habitats in P2.

**Keywords:** Behaviour, forest grazing, resting, silvopastoralism

## Geographical Certification as Production and Commercialisation Strategy for Smallholder Sheep Farming in Ceará, Brazil

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Producing high quality sheep meat under a geographical certification label has been suggested as alternative production and marketing strategy for Brazilian smallholder farmers. Under certain frame conditions such protections may contribute to rural development by enabling the farmers to remain competitive. Within the framework of a broader study of the Embrapa Caprinos (Brazilian National Corporation for Research on Plant and Livestock Husbandry, section for small ruminants) on supporting sheep farming by the certification of their products, this study is aimed at the characterisation of smallholder sheep farming in Ceará (Northeast of Brazil) and the identification of the production chain of salted, dried sheep meat ('Manta de Tauá'). Information from previously conducted standardised interviews with 129 sheep producers in the Tauá municipality on their socio-economic conditions, production techniques and commercialisation characteristics is classified into different farming systems. The variables for the multivariate data analysis are reduced applying multiple correspondence analysis followed by a non-hierarchical cluster analysis based on k-means. The clusters are tested for differences in socio-economic aspects including income sources and resource allocation, sheep production techniques and levels, and commercialisation strategies for live sheep or sheep products. In each cluster 20 % of the farmers are randomly sampled and a profit margin analysis of the sheep production based on additional in-depths interviews is undertaken. To describe the production chain of the dried meat, interviews with retailers and processors follow up the farmer information. The marketing channels of the sheep meat are mapped using GIS (Global Information System). The economic analysis of sheep production by the different farm types complements the specific information on their production techniques and socio-economic frame conditions. The overview about the existing local marketing networks serves as applicable information for the development of the quality chain and thus the certification process. Identified restrictions and opportunities of the current production allow predicting whether the farmers belonging to the different clusters can profit from the certification concept in sheep production or not.

**Keywords:** Brazil, cluster analysis, geographical certification, sheep farming

## Importance of Small Animal Production as Animal Source Food for the Nutritional Wellbeing of Children in Resource Poor Households in Central Ethiopia

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This study examined the effects of small animal production on household level animal source food (ASF) consumption and its association with nutritional status of children and their biological mother.

Keeping a few numbers of small animals with the exception of chickens for eggs had an insignificant contribution to household ASF consumption. Egg consumption in households keeping small animals was larger ( $p < 0.05$ ) than in households without. Significant quantities of chickens and eggs consumption of small animal producers were from their own production. Annual per capita consumption of egg was 1 kg, chicken 0.7 kg, red meat 3.7 kg, and milk 18.5 kg. There was a positive and strong ( $p < 0.05$ ) association between per capita milk and egg consumption and child nutritional status. Average per capita income increased the likelihood that household members consumed a large ( $p < 0.001$ ) quantity of ASFs, whereas consumption decreased with larger family size ( $p < 0.05$ ) the consumption. Mean z-score values for stunting (HAZ, height-for-age) was -2.32, for wasting (WHZ, weight-for-height) -0.70, and for underweight (WAZ, weight-for-age) -1.63. All the indicators were better ( $p < 0.001$ ) for urban sample children than rural. Per adult equivalent food expenditure and biological mother's education are positive and strongly ( $p < 0.05$ ) associated with HAZ and WAZ, while body mass index (BMI) is significantly ( $p < 0.001$ ) associated with WHZ and WAZ. Living near public institutions like clinic, school and market is positively associated with child's nutritional status, indicating the importance of these infrastructures.

The findings of this study showed that the per capita ASF consumption of sample households was low, highlighting the modest contribution of small animal keeping to household animal source food consumption. Nevertheless, there was a significant positive association between nutritional status of children and per capita milk and egg consumption. Thus, to effectively tackle undernutrition and micronutrient deficiencies, production of own ASF especially by the resource poor community complemented with nutrition education could be an effective approach.

**Keywords:** Animal source food, child nutrition, small animal production

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## Overview of Traditional Beekeeping in Sudan

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Sudan is the largest country in Africa. Agriculture is of particular importance to the gross national product (GNP). Main agricultural crops are cotton, peanuts, sorghum, barley, sesame, wheat and gum Arabic produced from *Acacia senegal* trees. Moreover, traditional beekeeping plays regionally an important socio-economical role in Sudan. The honeybee, *Apis mellifera* L., occurs naturally in Europe, the Middle East and Africa. This diverse range of habitats has required adaptation to a variety of ecological and climatic conditions and historical separation has caused the evolution of over 24 named subspecies. On the basis of morphology, these subspecies have been grouped into four distinct evolutionary branches, namely the African, the western and northern European, the southeastern European, as well as the Middle Eastern. Molecular analyses have broadly supported this classification.

In Sudan along the two Niles, honey bees (*Apis mellifera*) occur rarely North of Ed Dueim and Wad Medani. At Kosti, they are compelled to utilise densely foliated mango trees and build combs on horizontal branches. The little bee (*Apis florea*) of the Middle East was first recorded in Sudan in 1987 in Khartoum, where it utilises thick shady trees and shrubs for building its small single multiuse comb. Although placid, it is not very adaptable to apicultural practices; the honey is not easy to harvest without detaching the entire comb and thereby destroying the swarm, so it is of limited commercial significance.

Bee keeping in Sudan has not been practised on a highly developed level with conservation and optimum yields in view. Most of the honey is gathered from wild swarms located in hollow trees, using traditional destructive methods.

Spray programs along the Nile against tree locusts or desert locusts within the range of the apiaries will need to ensure the application of pesticides which are non toxic to bees.

In most of the gum belt though, bees are either not present or are too infrequent to require special precautions. In addition there is a need for inhibition of various practices to collect honey wildly like firing, smoking by using non-target chemicals and felling of trees.

**Keywords:** *Apis mellifera*, beekeeping, Sudan

## **Cattle Performances and Socio-Economic Contribution in Different Farming Systems in Northern Mountainous Viet Nam**

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In Viet Nam, cattle are kept at small, medium and large scales. Different systems for beef cattle production have to be evaluated for prospective increase in supply of beef. This study aims to analyse the performance and socio-economic contribution of cattle in different systems in the northern uplands to compare their suitability, efficiency and sustainability of beef production.

The fieldwork was conducted from May to October, 2007 in Son La province by using household and key person interviews, PRA tools and cattle body measurements. 73 farms were selected, including: 58 Thai and H'mong smallholders raising 2 to 3 Yellow cattle or crosses of Laisindh (small farms); 10 Thai farms raising Yellow cattle in their own livestock farms in the remote pastures with an average of 9 heads per farm (medium farms); and 5 large breeding farms raising each hundreds of exotic and Laisindh cattle.

The results show that Yellow cows of small farms had better reproductive performances than those of medium farms, with the first calving age (FCA) at 3.0 years compared to 3.3 years, and calving interval (CI) of 13.5 months compared to 17.2 months, respectively. Within small farms, FCA and CI of Yellow cows in remote H'mong farms were slightly higher than those in Thai farms (3.1 years and 2.8 years; 15.1 months and 12.6 months, respectively). In Thai villages, Yellow and Laisindh cows performed similarly. In large scale farms, Laisindh had a shorter CI (16 months) than Droughtmaster (18.6 months), with CI of Brahman in between. Cattle play important roles in providing work force, manure, and income to small farms, while a major function of cattle in medium farms is bank saving. Gross margin from cattle keeping was low in all systems. Medium farms had high net benefits 32 mVND per farm), followed by small farms (19 mVND per farm). In contrast, the net benefit of large scale farms was negative (-167 m to - 278 mVND per year) mainly because of high feed input and poor breeding and marketing management. Medium farms still showed the highest potential for beef production.

**Keywords:** Cattle performance, cattle production, northern mountainous, socio-economic functions, Viet Nam

## Feedback Seminars as a Tool to Contextualise Research Findings in Low External Input Systems

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Results of applied livestock research are supposed to have a meaning in both the scientific and the farmers' real life context. The former consists of conditions set by the discipline and the research community, such as formal criteria for scientific methodology, while the latter consists of the bio-physical and the socio-economic conditions in which farmers establish, maintain and develop their production systems. Especially in low external input systems, production has to be adjusted to these conditions. Considering the semantic dimension of information, something gains a meaning because of either having an inner pattern or because of being connected to a context.

This paper draws on 10 years of experience with feedback seminars in different MSc and PhD studies on low external input livestock systems. Feedback seminars are group discussions in which research findings are presented to and discussed with the farmers involved in the study. The seminars follow a systematic procedure which is adopted from scientific presentations and adjusted to the experience of the livestock keepers. This adjustment is reflected in the content of the introduction (outlining the importance of the research questions for the farmers), the description of the methods (using analogies to explain observation methods), the presentation of the results (visualising findings to be comprehensible to farmers), and interpretation of the results (discussing their relevance in the real life context). The challenges that these adjustments pose are presented along with possible solutions.

Various feedback seminars showed that livestock keepers are interested in learning about scientific results which are obtained by observation methods beyond their reach, help them to compare their own observations within a wider context exceeding their own observation range, and are based on aggregation of quantitative data hence provide additional analysis and evaluation options.

In feedback seminars, livestock keepers provided feedback on the validity of the research and on the meaning of the research findings in the local context. This feedback helps to contextualise research findings which is of prior importance in low external input systems. Furthermore this process lets the livestock keepers take part in the negotiation of meaning of research findings.

**Keywords:** Feedback seminars, livestock keeper, low external input systems

# Animal nutrition: ruminants

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## Ensiling Pasture Grass with Pods of Browse Plants is Potential to Solving Dry Season Feed Shortage for Ruminants in Nigeria

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All year round forage is difficult in Nigeria due to often protract dry season. Ensiling forage offers a strategic solution to the off-season feeds for ruminants. The study was undertaken to assess the performance of WAD sheep fed ensiled Guinea grass (GG) with *Albizia saman* pod (ASP). Guinea grass and *Albizia saman* pods were ensiled as 10 % ASP + 90 % GG, 20 % ASP + 80 % GG, 30 % ASP + 70 % GG and 40 % ASP + 60 % GG. Quality and chemical composition of silage were verified. Also, using a completely randomised design, twenty four rams were allotted to the silages for determination of intake, growth and nutrient digestibility by West African dwarf (WAD) rams. The pH of silage ranged between 4.2 and 4.8. Silage structure was observed to be firm and in-destructive. The colour ranged from olive green in 10 % to yellow in 40 % ASP inclusions. Smell of silage was characterised by nice in 10 %, pleasant in 20 % and 30 % and fruity in 40 %. Crude protein contents (ranged 14–17.5 g DM/100 g) significantly increased with increasing level of ASP but decreased the proportion of CF. Values for NDF, ADF, ADL and cellulose increased with increasing level of ASP. Hemicellulose was noticed to decrease with increasing amount of ASP. Dry matter intake (g/d), daily weight gain (g/d) and nutrients intake (CP, CF, NDF, ADF, ADL and cellulose) increased significantly ( $p < 0.05$ ) with increasing inclusion of ASP. The apparent digestibility of dry matter (ADDM), organic matter (ADOM), crude protein (ADCP), crude fibre (ADCF), ether extract (ADEE), NDF (ADNDF), ADF (ADADF), ADL (ADADL), cellulose (ADC) and hemicellulose (ADH) respectively ranged from 65.5–70.2, 65–69.4, 54.8–70.1, 59.9–68.1, 74.0–80.1, 59.8–65.3, 55.8–65.8, 47.4–70.5, 14.8–82.9 and 43.3–68.7. The ADDM, ADOM, ADCP, ADCF, ADEE, ADNDF, ADADF, ADADL and ADC significantly ( $p < 0.05$ ) increased due to increase of ASP except that of ADH that decreased with increasing amount of ASP in the silage. It is concluded that *Albizia saman* pods can replace Guinea grass up to 40 % for silage as dry season feed and without detrimental effects on performance of WAD ram.

**Keywords:** *Albizia saman* pods, roughage, performance, silage, WAD ram

## Effect of Protein Supplementation on Rumen Environment and *in sacco* Rumen Degradation in Bali Cows

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Five non-pregnant Bali cows were used to study the effects of supplementation of graded levels of urea or fishmeal on rumen environment and ruminal feed degradation in Bali cows fed low quality tropical grass hay (crude protein, CP = 3.53 %). In a 5 × 5 latin square experimental design, the animals were given *ad libitum* access to grass hay (G) or supplemented daily with two levels of urea, *i.e.* 38 g (GU38) and 74 g (GU74), or two levels of fishmeal, *i.e.* 156 g (GFM156) and 312 g (GFM312). At each corresponding level, urea supplement was equal to fishmeal at CP base. The measured parameters included rumen pH, ammonia and VFA concentration, and *in sacco* rumen DM and Protein degradation. Rumen pH largely fluctuate during the day but the diurnal pattern of rumen pH did not differ among treatments, *i.e.* being the lowest after few hours post feeding and increasing thereafter. Supplementation of both urea and fishmeal reduced significantly ( $p < 0.01$ ) the average rumen pH from 6.89 in G to 6.74 in GFM156. Rumen ammonia concentration increased linearly ( $p < 0.01$ ) with levels of supplementation and the increase was more pronounced with urea than with fishmeal supplementation. Rumen ammonia concentration was significantly higher ( $p < 0.01$ ) in Bali cows supplemented with urea than with fishmeal at both level of supplementation.  $\text{NH}_3$  concentration was improved from consistently below 50 mg l<sup>-1</sup> to more than 100 mg l<sup>-1</sup> in supplemented animals. Ruminal total as well as individual VFAs (Acetate, Butyrate and Propionate) concentration were not affected by increasing level of supplementation of both urea and fishmeal. The proportion of individual VFAs expressed as percentage of the total VFA also did not differ among treatments. Supplementation improved significantly *in sacco* degradation of DM but not protein in the rumen. Ruminal DM effective degradability was increased significantly with increasing level of fishmeal supplementation but not with increasing level of urea supplementation. Supplementation of increasing level of both urea and fishmeal improved rumen environment and DM degradability in Bali cows maintained on low quality tropical grass hay with fishmeal was proven to be the better supplement over urea.

**Keywords:** Rumen environment, degradation, fishmeal, Bali cows, low quality hay, urea

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## Effect of Calf Starter Supplementation on Mortality Rate and Performance of Bali Calves

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Two onfarm experiments were conducted for two consecutive years to reduce calf mortality and to improve the productive performance of Bali calves in the propince by supplementation of calf starter during dry season. Eightteen Bali cow-calf pairs were randomly allotted during the first year to receive three treatments of six replication with balanced sex of calves. The treatments were : calves were grazing natural pasture with their dam as control group (C), calves were separated while cows grazing and given ad libitum access to high quality and leucaena leaf (CG), and calves were separated while cows grazing and given ad libitum access to high quality grass hay and leucaena leaf and supplemented with 0,5 kg calf starter (CGS). Calf starter was formulated using locally available feeds consisting of pumpkin, refused corn meal, coconut cake and snail meal to contain 16 % crude protein (CP) and 11 MJ ME/kg dry matter. In the 2nd year, twenty four Bali cow-calf pairs were involved and the calf starter was offered to six calves in each rearing systems, i.e. dams were thertered during the day (CGSt) or dams were grazing natural pasture (CGSg). Paramaters measured were calf mortality rate and live weight gain (LWG). Results showed that supplementation of calf starter significantly reduced ( $p < 0.05$ ) calf mortality from 33,3 % in control group (C) to 0 % in supplemented groups (CG and CGS) in the first year. Calf mortality was also absent in both CGSt and CGSg, while 50 % calves in control group (C) were died during the second year. Supplementation of calf starter significantly increased live weight gain of Bali calves from  $133 \text{ gd}^{-1}$  in C to  $379 \text{ gd}^{-1}$  in CGS during the first year. LWG of Bali calves were also significantly ( $p = 0.006$ ) improved in the second year from  $35.7 \text{ gd}^{-1}$  in C to  $152 \text{ gd}^{-1}$  and  $279 \text{ gd}^{-1}$  respectively in CGSt and CGSg. Thus, the result of the research strongly indicates that supplementation of calf starter formulated from locally available feeds is an effective strategy to reduce calf mortality and to improve the productive performance of Bali calves.

**Keywords:** Bali calves, calf starter, mortality rate, supplementation, weight gain

## Performance and Nutrient Digestion of Lambs Fed Incremental Levels of Wild Cactus (*Opuntia leucotrichia*)

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In northern Mexico *Opuntia leucotrichia* (OL) is abundant and widely distributed. Traditionally, OL cladodes are used as emergency feed for livestock during dry seasons; however, scarce research has been carried out using OL cladodes on high production diets for sheep. The aim of this study was to evaluate growing performance, nutrient digestion and rumen parameters of lambs fed incremental levels of OL. Two simultaneous trials were conducted to evaluate five isoenergetic and isonitrogenous diets containing different levels of OL: 0 %, 10 %, 20 %, 30 % or 40 %, dry matter basis. In a performance trial one, fifty intact Rambouillet × Dorper male lambs (10 lambs × diet) of  $19 \pm 2.8$  kg of body weight, were randomly assigned to experimental diets. Data was analysed as complete block design. In trial two, five ruminal cannulated Rambouillet male rams were used in a digestion study. Ruminal pH, and ammonia-N were also estimated. Data was analysed as a  $5 \times 5$  latin square design. About 25 % of immature cladodes of each plant were harvested then were singed-off of spines by burning, chopped in a  $\frac{3}{4}$  HP helicoidal mill and mixed to diets. Dry matter intake of lambs was significantly higher for 0 % ( $1344 \text{ g d}^{-1}$ ) diet than 10 % (1153), 20 % (1098), 30 % (955) or 40 % diet (982). The average daily gain of lambs was also significantly different among diets ( $329 \text{ g d}^{-1}$ , 227, 212, 185 and 253, respectively). Feed efficiency was significantly higher for 20 % diet (5.2) followed by 30 % (4.5), 10 % (4.3), 40 % (4.1) and 0 % (4.1) diet. As could be expected, water intake ( $3.8 \text{ l d}^{-1}$  3.3, 2.1, 1.3 and 0.8, respectively) decreased as consumption of OL increased. Digestibility of dry matter, organic matter, cell wall and lingo-cellulose was not significantly different among treatments; however, crude protein was digested higher ( $p < 0.05$ ) in lambs fed 40 % diet (72 %) than other lambs (mean = 69). Ruminal pH (mean = 6.1) and ammonia-N ( $13.8 \text{ mg dl}^{-1}$ ) were not significantly different among treatments. Inclusion of OL on feedlot lambs diets is a good option for production systems where this resource is available.

**Keywords:** Growing performance, lambs, nutrient digestibility, *Opuntia leucotrichia*

## The Effect of Tannin Supplementation on Lamb Ruminal Biohydrogenation

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Several feeding resources used for livestock farming in the tropical and sub-tropical areas contain tannins. Tannins are polyphenolics compounds able to bind with proteins and to interfere with ruminal fermentations. Polyunsaturated fatty acids (PUFA) ingested by ruminants are biohydrogenated in the rumen to form saturated fatty acids (SFA). The biohydrogenation of C18:2 n-6 leads to the formation of trans-11 C18:1 and of cis-9 trans-11 C18:2 (CLA) which exert nutraceutical properties in humans. In a preceding in vitro experiment we have found that tannins reduced the activity of ruminal microorganisms and the complete development of biohydrogenation. However, disputes arised whether or not tannins could affect the biohydrogenation in vivo. To assess this hypothesis, 28 lambs (age 45 d) were divided into two groups: 14 lambs received an herbage while the other 14 lambs were fed a barley based concentrate. Within each group, 7 lambs were supplemented with quebracho tannins (6 % of diet DM). At slaughter (age 105 d) the ruminal fluid was sampled for fatty acid analysis. Tannins reduced ( $p < 0.05$ ) the production of total iso BCFA (-24 %) and increased ( $p < 0.05$ ) the percentages of C18:2 cis-9 trans-11 and of total PUFA (+45 % and +29 %). There was an interaction diet x tanin supplementation. In particular, Trans-11 C18:1 and the total trans C18:1 were increased by two-folds ( $p < 0.01$ ) and C18:0 and the total SFA were decreased (-50 % and -22 %, respectively;  $p < 0.05$ ) when tanins were included in the concentrate. This effect was not observed when tanins were added to the herbage. This study shows that tannins reduce the biohydrogenation of PUFA in lamb. According to these results, it is likely that the inclusion of tannins into ruminant feeds could be a useful strategy to improve the healthy properties of meat and milk.

**Keywords:** Biohydrogenation, fatty acids, in vivo, rumen, tannins

## Opportunities of an Adjusted Feeding of Goats in Traditional Farming Systems of Al Jabal al Akhdar, Oman

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Goat husbandry is an important component of the agropastoral mountain oasis systems of Al Jabal al Akhdar, Oman. The vegetation of natural pastures surrounding the villages is the main source of fodder for goats. Due to its low nutritional value and serious overgrazing, performance of goats is limited, although farmers offer dates and dried sardines as well as cultivated fodder such as green maize and barley at the homestead.

To determine organic matter (OM) intake of goats on pasture in response to different feeding at the homestead, a study was conducted in the village Qasha' in October 2006. The first ration (C) was rich in dates and dried sardines and contained only little prebloom maize. The second ration (R) contained a high proportion of maize and low amounts of dates and sardines. The rations were similar in metabolisable energy and crude protein content, but differed in the content of neutral detergent fibre. Each ration was offered to 6 male goats during a 9-day adaptation and 7-day experimental period, thereby weighing the amounts offered and refused. Faecal excretion was determined using the external faecal marker  $\text{TiO}_2$ ; diet digestibility was calculated from the nitrogen concentration in faecal OM.

Goats' daily intake ( $\text{g OM kg}^{-0.75}$ ) varied between 84–110g. While group C ingested 30g (SD 3.5) of dates, 2.5g (SD 0.5) of fish and 19g (SD 2.7) of maize, group R consumed 15g (SD 0.1) of dates, 1.6g (SD 0.5) of fish and 30g (SD 3.5) of maize at the homestead. OM intake on pasture ranged between 34–61g, equivalent to 40–57 % of total intake and did not differ ( $p > 0.05$ ) between both treatments. However, values for intake ( $\text{g OM kg}^{-0.75} \text{ d}^{-1}$ ) from pasture were lower than those determined for goats in Qasha' under farmers' feeding practices (76g, SD 24.2; October 2005), when hardly any cultivated fodder was offered (2g, SD 1.4). Results suggest that the amount of green fodder consumed at the homestead reduces feed intake on pasture, easing the grazing pressure on the pastures. Hence, an appropriate supplement feeding is needed to simultaneously conserve the natural resources and improve livestock production.

**Keywords:** faecal marker, feed intake, grazing, Oman

## ***Moringa oleifera* Seed Fractions and the Inhibition of Proteolytic Activity *in vitro***

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The seed of *Moringa oleifera* Lam, a multipurpose tropical tree, is believed to harbour potential to overcome the excessive breakdown of proteins in the rumen for a 'protein sparing effect' of the seed extract was reported *in vitro*. To avoid laborious processing and associated yield losses during extraction, this study aimed at characterising the whole *Moringa* seed and its various fractions for example: kernel, defatted kernel, defatted seed and shell, with respect to rumen proteolysis *in vitro*, on a standard substrate background representing a concentrate rich diet. The bioactivity of seed fractions, included at 18 % (w/w), was investigated in 12 h batch incubation, with regular sampling and determination of general parameters (gas production and SCFA yield) and protein specific parameters (iso-SCFA, soluble protein concentration, protein degradation rates and ammonium). While all tested fractions had some impact on fermentation parameters; the defatted kernel stood out as fraction with highest efficacy. It significantly ( $p < 0.001$ ) reduced iso-SCFA yields to 45 % and ammonium ( $p < 0.05$ ) to 80 % compared to control. Soluble protein concentration at 12 h were significantly ( $p < 0.001$ ) increased to 325 % while protein degradation rates were significantly ( $p < 0.001$ ) reduced to 20 % compared to control. The effects produced by defatted kernel were similar to those obtained from monensin, a feedlot antibiotic used in this study as a positive control. When dosages of other *Moringa* seed fractions were increased to obtain equivalent amounts to 18 % (w/w) inclusion of defatted kernel, similar effects to defatted kernel were obtained for rumen fermentation parameters. These results suggest that *Moringa* seed fractions when included *in vivo* diets could improve nitrogen utilisation, decrease the input cost by sparing protein in the diet thereby enhancing animal productivity. As a potential alternative to antibiotic feed additives previously applied in intensive livestock production systems; the tropical *Moringa* plant could become an export item from developing countries in future.

**Keywords:** *Moringa* seed fractions, proteolysis, rumen fermentation

## Effect of Partial Substitution of Commercial Concentrate by Cowpea (*Vigna unguiculata*) on Smallholder Milk Production and Net Income in Honduras

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Dry season feed constraints often force Honduran smallholders to supplement forage with expensive commercial concentrates in order to prevent livestock production losses. This increases production costs significantly. It is suggested that integrating legumes such as cowpea can alleviate the problem. This contribution seeks to evaluate the effect of partial substitution of commercial concentrate (CC) by farm-produced (i) cowpea hay (CpH), and (ii) a cowpea/concentrate mixture (CpC) on milk production and net income.

Two collaborative farmer-led feeding experiments were conducted using a 3-period, 2-group crossover experimental design with two treatments. For the first experiment (A), 1.8 kg (33 %) of CC was substituted by 2.7 kg of CpH. Total feed costs per cow were 1.78 and 1.43 US\$ for treatments with CC and CpH, respectively. For the second experiment (B), 2.8 kg (66 %) of CC was substituted by 1.4 kg of CpC and 1.4 kg of maize. Total feed costs were 1.13 and 0.75 US\$ for treatments with CC and CpC, respectively. Eight and six crossbred cows with similar milk production were used in experiments A and B, respectively, which were evenly divided into two groups. The experimental period was 42 and 30 days, respectively. Milk production data from the last seven days of each of the three periods were taken for statistical analysis (Mann-Whitney Test).

Experiment A showed a significant ( $p < 0.05$ ) difference in milk production (12.5 vs. 13.2 kg cow<sup>-1</sup> day<sup>-1</sup>) in favour of treatment CC. However, net income was significantly ( $p < 0.001$ ) higher for treatment CpH compared to CC (16.7 vs. 14.6 US\$-cents kg<sup>-1</sup> milk). In Experiment B, milk production did not differ significantly ( $p > 0.05$ ) between treatment CpC and CC (7.7 vs. 8.3 kg cow<sup>-1</sup> day<sup>-1</sup>). But again, net income was significantly ( $p < 0.001$ ) higher for treatment CpC compared to treatment CC (19.1 vs. 14.7 US\$-cents kg<sup>-1</sup> milk).

Results show that partial substitution of commercial concentrate by cowpea hay or a cowpea/concentrate mixture can contribute to increased farmer income through reduced feed costs. In view of increasing prices for commercial concentrates, it is recommended to promote the production, processing, commercialisation and use of locally produced high-value feed supplements such as cowpea-based products.

**Keywords:** Cowpea concentrate, cowpea hay, income increase

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## Effect of Garlic (*Allium sativum*) Supplementation in Diets of Broilers on Productive Performance, Meat Cholesterol and Sensory Quality

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The objective of this study was to investigate the effect of garlic (*Allium sativum*) supplementation in diets of broiler as a replacement antibiotic on productive performance and meat acceptability test. Four hundred one-day-old chicks were randomly allocated to 4 groups consisting of 4 replications with 20 chicks. The groups were assigned to receive the treatment diet as follows: balanced diet with 0.01 % antibiotic (T1), balanced diet supplemented with 0.7 % garlic powder (T2), balanced diet supplemented with 1 % garlic powder (T3) and balanced diet supplemented with 1.3 % garlic powder (T4). The balanced diet was formulated according to the growing period; 0–3 weeks, 3–6 weeks. There were no significant differences ( $p > 0.05$ ) in feed intake and weight gain and FCR across treatment was observed in this study. The garlic supplementation treatment tended to have higher weight gain compared to the treatment supplementation with 0.01 % antibiotic. A slightly better FCR was also observed in all garlic supplementation treatment compared to the treatment supplementation with 0.01 % antibiotic. The mortality rate of the broilers in treatment 1, 2, 3 and 4 was 3.5, 5 and 3.5%; respectively. In term of carcass quality, there were no significant difference ( $p > 0.05$ ) in abdominal fat, meat cholesterol among treatment. To evaluate the sensory quality, the 9- point Hedonic Scale was used. The result showed no significant ( $p > 0.05$ ) differences in an overall liking of meat among treatment. It was suggested that replacing of garlic powder for antibiotic growth promoter could maintain productive performance of broiler and have no effect on sensory quality.

**Keywords:** Broiler, garlic, productive performance, sensory quality

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## Drinking Behaviour and Water Intake of Boer Goats and German Blackhead Mutton Sheep

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The aim of this investigation was to study differences in average daily water intakes between small ruminant species differing in their adaptation to climatic conditions. Boer goats were chosen as arid adapted species and compared to German Black Head mutton originating from temperate climates. Sixteen non-lactating female animals (8 Boer goats, BW of  $64.7 \pm 3.7$  kg and 8 German Black Head mutton ewes, BW:  $67.5 \pm 8.8$  kg; mean  $\pm$  SD) were kept under controlled stable conditions (room temperature:  $13.6 \pm 0.4^\circ\text{C}$ ; light schedule: 10 h dark : 14 h light). Animals had access to hay and water ad libitum. Diurnal drinking behaviour was recorded by video. Individual water intake was estimated from water kinetics using the deuterium dilution technique during 2 wks. Simultaneously, water intake was directly measured by weighing water buckets every 24 h. Additionally, individual hay intake was measured daily.

The average daily water intakes (l) differed significantly ( $p = 0.01$ ) between the two species, with higher intakes in sheep ( $4.68 \pm 1.54$  l) than in goats ( $2.34 \pm 0.86$  l); these significant differences were maintained when relating water intake to metabolic body weight resulting in  $195 \pm 60$  (sheep) vs.  $104 \pm 39$  (goat)  $\text{g kg}^{0.75}$  BW. Daily hay intake differed significantly between sheep and goats, whether expressed as kg per day ( $1.64 \pm 0.50$  vs.  $1.29 \pm 0.50$  kg DM;  $p = 0.011$ ) or as g per metabolic weight ( $68 \pm 20$  vs.  $57 \pm 23$   $\text{g kg}^{-0.75}$  BW;  $p = 0.040$ ). The higher amount of water intake in sheep was also reflected by the drinking behaviour: sheep spent approximately 2 % of 24 h ( $31 \pm 19$  min per day) drinking while Boer goats spent only 0.7 % ( $10 \pm 9$  min per day). It is suggested that the lower water intake in Boer goats seems to be an adaptive mechanism to arid climates.

**Keywords:** Deuterium, goats, sheep, water intake, water turnover

## Utilisation of Aquatic Plants in Natural Wetland (Thalae-Noi) as Animal Feed

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The objective of this study was to investigate the utilisation possibility of the aquatic plants in the natural wetland (Thalae-Noi) as animal feed. The aquatic plant samples were collected in November 2006 for identification and pending for chemical analysis. 16 aquatic plant samples were gathered and classified according to their location in the water and separated into 4 groups.

1) Marginal plants: The collected samples were *Hymenachne pseudointerrupta* C.Muell, *Leersia hexandra*, *Eragrostis tenella* (L.) and *Hanguana malayana* (Jack) Merr. 2) Floating plants: The collected samples were *Eichornia crassipes* (Mart) Solms, *Salvinia cucullata* Roxb. and *Pistia stratiotes* L. 3) Emerged plants: The collected samples were *Nymphoides parvifolia* (Griseb.) O. Kuntze, *Nymphaea lotus* L. and *Nymphaea stellata* Wild. 4) Submerged plants: The collected samples were *Vallisneria spiralis* L., *Najas graminea* Del., *Chara zeylanica* Kl. ex Wild., *Ceratophyllum demersum* Linn., *Hydrilla verticillata* (L.f.) Royle. and *Utricularia aurea* Lour.

The chemical composition was determined by proximate analysis and Van Soest method. The results showed that the aquatic plants had a high moisture content, which ranged from 64.36–96.43 %. The crude protein, crude fat, crude fiber, ash, NDF and ADF content were 7.18–19.12 % DM, 1.04–3.49 % DM, 13.70–44.96 % DM, 6.31–24.56 % DM, 31.82–83.16 % DM and 23.01–62.93 % DM; respectively. The NFE ranged from 25.85–53.52 %. Ca and P content were 0.14–1.54 % DM and 0.11–0.46 % DM; respectively.

According to the high crude fiber content, the utilisation of these aquatic plants as feed for monogastric animals is limited compared to the ruminant. However the reduction of moisture and appropriate processing is needed for efficient utilisation as animal feed.

**Keywords:** Animal feed, aquatic plants, Thailand, wetlands

## Effect of Feed Diets on Milk Production and Yogurt Quality

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Cost reducing diets (CRD) were tested on 56 Awassi ewes in Syria, at the International Center for Agricultural Research in the Dry Areas to counterbalance high and increasing feeding costs faced by farmers during the milk production period in Middle Eastern countries. Milk production and yogurt firmness produced under the traditional diet used by farmers (control) was contrasted with production under 6 CRD that included barley, ammoniated wheat straw and other unconventional locally available feedstuffs: molasses cotton seed cake, wheat bran and sugar beet pulp. Animals in all CRD treatments were kept on grazing as a basal diet, supplemented with the same level of crude protein (229 g) and energy (18MJ). Under the traditional feeding ewes received less protein (190 g/d) and similar energy levels as in the CRD. Milk production of ewes under 5 out of the 6 CRD was 48 % higher than that of control ewes. One CRD containing 34 % molasses caused a decrease in milk production. Texture profile analysis (TPA) on a set type of yogurt showed an effect of diets on hardness which reflects on yogurt firmness ( $p < 0.001$ ), an important characteristic of yogurt pricing in the Middle East. In 4 out of 6 CRD, hardness increased from 6–23 % over the control group, whereas in two CRD diets, including the molasses-CRD, the hardness declined from 9 to 10 %. A trend to increase hardness as the milking period advances, was observed in three CRD and the control ( $p < 0.05$ ). Organoleptic and visual characteristics affecting yogurt price (texture, smell, taste and appearance) were assessed by local dairy product middlemen in yogurt produced under all diets. The sensory data analysis using a link to a cumulative logits revealed that texture, smell and taste were positively improved by the CRD over the control. A lesser effect on appearance was observed and a decrease in this trait recorded in yogurt produced under the molasses-CRD. The proposed CRD containing the tested byproducts and urea treated wheat straw are apparently options for resource-poor small-scale farmers in the Middle Eastern region to increase their productivity and income without affecting the main quality components of yogurt.

**Keywords:** Feed costs, milking ewes, Syria, yogurt

# Animal nutrition: monogastrics

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## Effect of Time of Incorporation of Tuna Oil in Finishing Swine Diet on Pork Characteristics

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The objective of this study was to determine the effect of time of incorporation of tuna oil in the diet of finishing swine on meat quality. Previous studies had shown that when tuna oil was fed to pigs throughout the growing-finishing period, meat characteristics changed significantly ( $p < 0.05$ ) at lower slaughter weight (90 compared to 100 and 110 kg) but there were no sex differences ( $p > 0.05$ ). In this study, four hundred and eighty crossbred (Large White  $\times$  Landrace  $\times$  Duroc) pigs averaging 60 kg were allotted to 12 treatment combinations (40 pigs per treatment combination) in a completely randomised design with a  $2 \times 2 \times 3$  factorial arrangement of treatments. The treatments were: dietary tuna oil supplementation (0 and 2 %); sex (barrows and gilts); and slaughter weight (90, 100 and 110 kg). Eight pigs/treatment (four of each sex) were randomly selected and slaughtered as they reached the predetermined slaughter weight for that treatment. The meat quality was evaluated. *M. longissimus dorsi* was sampled for further meat quality assessment. Tuna oil-fed pigs had significantly ( $p < 0.05$ ) lower luminosity ( $L^*$ ) and yellowness ( $b^*$ ) values and cholesterol content but higher water holding capacity than the control group. Within treatment, meat from barrows had similar  $L^*$  and  $b^*$  values, fat percentage, cholesterol content, shear force value and sensory scores to those of gilts. Higher slaughter weight (110 kg) resulted in unfavourable meat quality. Results from this study indicate that late incorporation of tuna oil in diets fed to gilts combined with low slaughter weight (90 kg) result in meat with lower cholesterol and more appealing to consumers.

**Keywords:** Finishing swine, meat traits, pork, tuna oil

## Rice Mill Feed: An Agro-Industrial By-Product with Potential for Rural Development

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Rice mill feed is the by-product of rice (*Oryzae glaberrima*) milling in West Africa and Nigeria in particular. It is often referred to as rice husk, rice bran or rice offal by rice millers and feed millers. Most rice farming communities have small scale rice mills or the rice is taken to the city centres for milling. To the farmers, the waste has no economic value. Rice mill feed is made up of bran plus hull and some broken rice. Its crude protein (CP) concentration ranges from 50 to 60 g kg<sup>-1</sup> dry matter (DM) and crude fibre ranges from 300 to 400 g kg<sup>-1</sup> DM, whereas its total digestible nutrient concentration ranges from 30 to 40 %.

This study evaluated the nutrient composition of rice mill feed as a potential source of feed for monogastric animals. Amino acid profile, water insoluble and water soluble non-starch- polysaccharides (NSP) and mineral concentrations of rice mill feed were determined using standard methods. Organic matter content of rice mill feed was 688 g kg<sup>-1</sup> DM with glutamic acid representing 13 % of CP. Gross energy was 16.59 MJ kg<sup>-1</sup> DM. Water insoluble NSP were 57.6 %, while water soluble NSP were 1.3 %. Mineral analysis indicated high phosphorous concentration (5.35 g kg<sup>-1</sup> DM) compared to maize (0.9 g kg<sup>-1</sup> DM) present as phytate. Calcium, magnesium, sodium and potassium were 0.96, 3, 0.14 and 3.53 g kg<sup>-1</sup> DM respectively. A digestibility trial with broilers after phytase supplementation showed improved total tract mineral digestibility and significantly ( $p < 0.05$ ) reduced phosphorous excretion (data not shown). The presence of glutamic acid (a glucogenic amino acid) which is involved in gut health might indicate that including rice mill feed in monogastric diets has a potential of influencing energy metabolisability, while enhancing gut health.

Rather than have their animals scavenge for food, rural rice farmers can utilise rice mill feed as a concentrate supplement for small ruminants or in addition to household left over food, feed it to pigs and indigenous poultry. This way, their income as well as protein intake can be increased. Appropriate strategies need to be employed to alleviate poverty in rural rice growing communities.

**Keywords:** Monogastric animals, nutrient composition, rice mill feed, rural development



## Effect of Supplementing Fungi Degraded Cowpea Seedhull in Broiler Diets

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The primary objective of this study was to determine the response of broiler birds to different levels of fungi (*Aspergillus niger*) degraded cowpea seedhull. The cost benefit of including the biodegraded seedhull in the diets of broilers was also investigated. One hundred and twenty day-old broiler chicks were assigned in a completely randomised design to 0 %, 5 %, 10 %, 15 % and 20 % inclusion of degraded seedhull in the diets. The experiment lasted for eight weeks. Birds on dietary 5 % inclusion had the highest body weight of 2125 g bird<sup>-1</sup>, followed by birds fed 20 % inclusion of the degraded seedhull (2025 g bird<sup>-1</sup>) while those fed control diet gave least (1675 g bird<sup>-1</sup>). The weekly weight gain showed that birds fed 5 % and 10 % inclusion levels gained slightly similar weights of 392.5 and 380.0 g bird<sup>-1</sup> respectively, while the highest feed consumption was observed with birds fed 20 % (809.3 g bird<sup>-1</sup>). An improvement in the Total Protein (TP) of finisher birds over the starters was observed in the entire dietary group. No significant difference was observed in the globulin content and these values obtained ranged between 2.13 mg per 100 ml and 2.81 mg per 100 ml. The highest cholesterol value was observed in birds fed 5 % inclusion of degraded seedhull (88.9 mg per 100 ml) while the least was observed with birds fed 20 % (73.6 mg per 100 ml) at the starter phase. Although no significant differences were observed in the weights of kidney, liver, spleen and abdominal fat of birds in all the dietary treatments, the weight of the lungs of birds on the control diet (0.69 %) was higher than in birds fed supplemented diets. Cost benefit of 26.8 % was realised when broiler birds were fed 20 % inclusion of *A. niger* degraded cowpea seedhull as compared to 20.3 % and 20.7 % obtained in feeding 15 % and 10 % inclusion respectively. No histopathological lesion was observed in the selected organs (kidney, liver) as a result of feeding fungi degraded seedhull to broilers.

**Keywords:** *Aspergillus niger*, biodegradation, cowpea seedhull

## Effect of Fermentable Liquid Diets Based on Wet Brewers Grains on Performance and Carcass Characteristics by Growing Pigs

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Benefits of feeding fermentable liquid diets (FLD) include its positive effects on the gastrointestinal microflora and its potential to utilise byproducts from the food and brewing industry. Fermented liquid feed denotes a mixture of feed and water stored in a tank at a certain temperature and for a certain period of time before it is fed to the animals, and is characterised by high levels of lactic acid bacteria, yeasts, and lactic acid, low pH, and low enterobacteria counts. However, data on the effect of feeding FLD to growing pigs on growth performance is scarce. This study was conducted with the aim to evaluate growth performance and carcass characteristics of pigs fed a growing diet with graded levels of FLD based on wet brewers grains (WBG). Thirty-two male pigs of the cross Landrace × York ( $32 \pm 4$  days of age;  $9.7 \pm 1.2$  kg body weight) were allotted to one of the following treatment diets containing: 0, 15, 30 and 45 % WBG (dry matter basis). Animals were evaluated during three periods: post-weaning, growing and finishing. Individual weight of animals was recorded every 20 days and feed intake (DMI) by pen was recorded daily. When animals reached 95 kg of weight then were slaughtered and carcass characteristics were measured. The data were statistically analysed by one-way analyses of variance using the GLM procedure of SAS, means were separated by the Tukey test. The average daily gain of pigs was significantly different among treatment groups being higher for the diet with 0 % WBG ( $660 \text{ g day}^{-1}$ ) followed by 15 % (553), 30 % (537) and 45 % (507), similar trend was observed for DMI ( $1895 \text{ g day}^{-1}$ , 1881, 1823 and 1771, respectively). Moreover, carcass dressing was significantly different among treatments (71.5 %, 70.1, 68.9 and 67.8, respectively). Even though, growth performance was negatively affected by FLD, feeding costs were reduced even when the fattening period was longer. It is suggested that animals may be fed with 30 % WBG diets in post-weaning periods and 30 or 40 % during growing and finishing periods.

**Keywords:** Carcass dressing, fermentable liquid diets, growing performance, growing pigs, wet brewers grains

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## ***In vitro* Assessment for Prebiotic Potentials of Some Carbohydrate/Fibrous Feedstuffs Fed in Broiler Diets**

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This experiment was conducted to test possible prebiotic characteristics of ten carbohydrate/ fibrous feedstuffs fed in broiler diets. The following criteria were tested: **(a)** resistance to gastric acidity, hydrolysis by digestive enzymes, **(b)** fermentation by intestinal microflora.

In the first part of the experiment, the test feedstuffs were pre-digested in a 3-step pepsin-pancreatin *in vitro* digestion to establish resistance to gastric acidity and hydrolysis by digestive enzymes of the foregut. In the subsequent study, the degree of fermentation by microflora of the hindgut was measured *in vitro* using the cumulative gas production technique. Incubations were carried out using caecal inoculum from specially raised broiler birds fed diets devoid of copper and antibiotics at 4, 6 and 8 weeks of age and gas production was measured as an indicator of the kinetics of fermentation. Incubations were carried out until maximum gas production was achieved for all substrates. Fermentation parameters such as pH, ammonia of fermentation and organic matter loss were measured. Most of the test feedstuffs showed resistance to gastric acidity and hydrolysis by digestive enzymes as over 60 % of the test samples were recovered in residue post-enzymatic digestion. Four carbohydrates; cassava starch, cassava starch residue, cassava root sieviete and sweet potato flour showed potentials for fermentation by caecal inoculum of broiler birds at different ages. Significant ( $p < 0.05$ ) differences were recorded for gas production, pH and organic matter loss for all substrates at different ages, however significant ( $p < 0.05$ ) differences in ammonia production were only observed in the study at 8 weeks. This study has established that cassava starch, cassava root sieviete, cassava starch residue and sweet potato flour are able to resist hydrolysis by enzymes in the gastrointestinal tract of broiler birds but are fermentable in the caecum. Further studies to establish that these feedstuffs can be used to manipulate intestinal microflora populations *in vivo*, to satisfy their use as prebiotics, are in progress.

**Keywords:** Digestive enzymes, fibrous feedstuffs, foregut, hindgut, intestinal microflora, prebiotic characteristics

## **Effect of Long Term Feeding of Raw and Sun-Dried Garlic (*Allium sativum*) on Performance and Lipid Metabolism of Broiler Chicks**

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The effects of garlic on performance and lipid metabolism were examined in Anak breed broiler chicks. A total of 147 day-old chicks were randomly distributed into 7 dietary treatments, each treatment consisting of 3 replicates of 7 birds. Treatments 2, 3 and 4 contained 1 %, 2 %, and 3 % of sun-dried garlic while treatments 5, 6 and 7 contained 1 %, 2 %, and 3 % of raw garlic. Treatment 1 was the control and contained 0 % garlic. The duration of the experiment was 56 days. Feed intake and weight gain were measured weekly while analysis of blood samples was carried out on the 2nd, 4<sup>th</sup>, 6<sup>th</sup> and 8<sup>th</sup> weeks of the experimental period. The birds were sacrificed at the end of the 8<sup>th</sup> week. Samples of the liver were taken and analysed for hepatic cholesterol while the weight of abdominal fat deposit was obtained. Both raw and sun-dried garlic had a reducing ( $p < 0.05$ ) effect on serum triglycerides, total cholesterol and low density lipoprotein. The highest hypocholesterolemic effect of garlic was observed in birds fed 2 % raw garlic for which total serum cholesterol was 96.1 mg dl<sup>-1</sup> compared to 116.5 mg dl<sup>-1</sup> for the control diet. High density lipoprotein was significantly ( $p < 0.05$ ) increased in response to feeding of sun-dried and raw garlic. The inclusion of garlic in the diet also significantly ( $p < 0.05$ ) reduced both liver cholesterol and abdominal fat deposition in chicks. Feed intake, weight gain and feed conversion ratio were not significantly ( $p > 0.05$ ) affected. Haematological parameters also showed no significant differences ( $p > 0.05$ ). The results confirm that both raw and sun-dried garlic exert hypocholesterolemic effect in broiler chicks but have no negative effect on the performance

**Keywords:** Broiler chicks, cholesterol, garlic, lipid metabolism

## Number of *Salmonella* spp. in Feces of Weaned Pigs Fed Diets Supplemented with Betel Vine Leaves

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Antibacterial activities of crude extracted betel vine leaf have been shown in different experiments to reduce the number of *Salmonella* spp. in feces of pigs. This study therefore was conducted to determine if betel vine leaves feed as supplement in weaned pig diets can help to control diarrhea.

Sixty cross bred weaned 28 day old pigs were randomly divided into six groups for dietary treatments in a completely randomised design. The groups were fed as follows: 1) control basal diet, 2) basal diet with tylosin 500 g/100 kg, 3) basal diet with standard eugenol at 7.5 ml/100 kg (standard eugenol 3.906  $\mu\text{g kg}^{-1}$  bw day<sup>-1</sup>; 10 times of standard eugenol MIC). Diets 4), 5) and 6) were 30 ml crude extracted, 50 g fresh and 3.7 g dry betel vine leaf/100 kg basal diet (eugenol 0.0154  $\mu\text{g kg}^{-1}$  bw day<sup>-1</sup>; 10 times of eugenol in crude extracted betel vine leaf MIC). The number of *Salmonella* spp. in the feces was counted according to the most probable number technique (MPN) at day 0 and 35 of the experiment.

The results showed 90, 70, 60, 50, 50 and 60 % of the pigs had *Salmonella* spp. on day 0 ( $p > 0.05$ ) then reduced to 50, 44, 25, 30, 40 and 33 % on day 35, respectively ( $p > 0.05$ ). There was no significant difference in the number of *Salmonella* spp. on day 35 among the groups. Comparison of *Salmonella* spp. on day 0 and 35 within the groups showed a slight reduction of *Salmonella* spp. However, only the pigs fed with tylosin had a significant lower value ( $p < 0.05$ ) on day 35. There were no significant differences in body weight and average daily gain at day 0 and 35 among the treatment groups. This study showed that standard eugenol, crude extracted, fresh and dry betel vine leaf can be supplemented in weaned pig diets to reduce the number of *Salmonella* spp. in the feces and discharge into the environment. For more efficiency, it is suggested to increase the concentration of eugenol in pig diet more than 10 times of MIC.

**Keywords:** Betel vine, eugenol, *Salmonella* spp., weaned pig

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## **Silage Quality of the Legumes *Vigna unguiculata* and *Canavalia brasiliensis* solely and with Sweet Potato Roots as an Alternative Pig Feeding**

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As prices for feed concentrates are rising alternative options for small and medium pig producers in the tropics are searched. Locally grown legumes could contribute to the protein supply. Starchy roots and tubers such as sweet potato (*Ipomoea batatas*) could add to the energetic value.

*Vigna unguiculata* CIAT9611 and *Canavalia brasiliensis* CIAT17009 were evaluated at four different ages. *Vigna* was cut at 6 (pre-florescence), 8 (florescence), 10 (post-florescence) and 12 (pods ripening) weeks of growth; *Canavalia* was cut at 8, 12, 16 and 20 weeks of growth (no distinct generative stage observed). The forages were wilted to a target dry matter (DM) of 35 % and then chopped. On each occasion sweet potato roots were harvested, washed, chopped and dried for several hours.

The samples were ensiled in PVC tubes of 1.8 l Volume in triplicates.

Three treatments were applied: *Vigna* or *Canavalia* only, *Vigna* or *Canavalia* mixed with sweet potatoes in the ratio 1:1 on fresh matter base, sweet potato only.

The silages were evaluated after storage of approximately 3 months at 25 °C assessing their smell, structure and colour according to the DLG key. The DM content was determined in triplicates at 105 °C and corrected. The pH was measured and judged according to the DLG key 1998 for evaluation of silages based on chemical analysis. Results indicated that when ensiling *Vigna* or *Canavalia* alone, the best fermentation results were achieved at 12 weeks age in both cases, with *Vigna* silage having a more desirable low pH. The mixture with sweet potato improved fermentation. The best *Vigna*-*Ipomoea* silage, however, resulted when sweet potato with an unintentionally high DM was used at 12 weeks age of *Vigna* (silage DM 57 %). The best *Canavalia*-*Ipomoea* silage was obtained with 16 weeks old *Canavalia*. *Ipomoea* only silages with DM contents ranging from 22–40 % had the lowest pH values from 3.6–4.2. It can be concluded that the legume harvest age plays a role in the suitability for ensiling and that addition of sweet potato improves legume silages.

**Keywords:** *Canavalia brasiliensis*, cutting age, *Ipomoea batatas*, silage, *Vigna unguiculata*

## Rapid Assessment of Ensilability of *Vigna unguiculata* and *Canavalia brasiliensis* as an Option for Alternative Pig Feeding

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In view of increasing prices for grain based concentrates, alternative feeds are sought to improve competitiveness of smallholder pig production in the tropics. Ensiled forage legumes are seen as an option.

The “Rostocker Fermentation Test” allowed a quick evaluation of the ensilability of forage legumes per se and its possible improvement by additives.

*Vigna unguiculata* and/or *Canavalia brasiliensis* resp. were harvested at 4 different ages (Martens et al., this volume), chopped and minced. 50 g fresh material was weighed in a sterile glass beaker (600 ml) and 200 ml of distilled water were added. Four treatments applied in triplicates: control, control + 2 % sucrose on FM base, control + *Pediococcus acidilactici* preparation ( $3.0 \times 10^5$  cfug<sup>-1</sup> FM), control + *P. acidilactici* + 2 % sucrose. The preparations were incubated at 35C for 2 days. The pH as indicator for the ongoing acidification was measured at 0, 22, 28, 52 and 58 hours.

With *Vigna unguiculata*, after an initial sour fermentation, the pH of the control rose again during the second day of fermentation until 10 weeks of age. The addition of the lactic acid bacteria preparation slightly improved the fermentation. A significantly better pH development was achieved by adding sugar from 8 weeks onwards. The most promising treatment, independent from the plant age was the combination of the *P. acidilactici* preparation with sugar, fermenting most rapidly and always leading to a final pH of  $\leq 4.0$ . Best results without additional sugar were achieved at 12 weeks age, the ripening beans probably providing additional carbohydrates (WSC), confirming with findings for lab scale silages (Martens et al., this volume).

The pH development of silage cultures with *Canavalia* without sugar addition was not acceptable throughout the weeks 8–20 hardly going below pH 5.0. The best age for ensiling *Canavalia* when adding sugar and preferably combine that with lactic acid bacteria inoculation was at 12 and 20 weeks. By this method it was revealed, that in general, the ensilability of *Canavalia* was worse compared to *Vigna*, probably due to less WSC and to a higher buffering capacity.

**Keywords:** Additives, *Canavalia brasiliensis*, fermentation test, *in-vitro* ensilability, *Vigna unguiculata*

## Nutritive Value of Cashew Apple for Growing Duck

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Cashew apple is a waste after collecting the nuts. The study was conducted to evaluate the feeding quality of cashew apple as feed ingredient for growing duck. 180 of one week old local ducks (Khaki Campbell) with average initial weight 114.93g were used. The ducks were divided into four dietary treatments and three replication with 15 animals in each experimental unit. The four treatments were T0, T1, T2 and T3 that cashew apple meal incorporated into a standard grower diet at 0, 5, 10, and 15 percent for respectively. Cashew apple was dried under the sun before grinding and mixing with other ingredient. The experiment lasted for 60 days. Cashew apple contains crude protein 8.3 % and crude fiber 4.45 %. All dietary treatments contained 22 % crude protein for first stage (0–6 weeks old) and 20 % in the second stage (6–8 weeks old). There were no significance effect ( $p > 0.05$ ) on average daily gains (ADG), but it was relatively high for diet contained 5 and 15 % cashew apple. The ADG were 14.87, 16.94, 14.86 and 15.52 g per head and day for T0, T1, T2 and T3 respectively. Daily feed intake was not significantly ( $p > 0.05$ ) affected by the treatment. However, feed conversion ratios (FCR) were significantly affected ( $p < 0.05$ ). The FCR were 5.95, 5.65, 4.74 and 5.07 respectively. Including cashew apple in the growing diet of duck until 15 percent improved FCR as well as weight gain. However, further study should be done to maximise the level of cashew apple meal for diet and study its effect on carcass characteristics.

**Keywords:** Cashew apple, duck



## Effects of Feeding Desert Locust Meal (*Schistocerca gregaria*) on Performance and Haematology of Broilers

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Locust and grasshoppers have been some of the greatest agricultural pests since the beginning of civilisation. Plagues of locusts devastate crops, pastures, orchards and entire countries or even continents. At unpredictable intervals locust invasions occur, with swarms moving into neighbouring areas of Africa, Asia and Europe and occasionally beyond. Despite this fact however, locusts could have beneficial effects as a source of protein in animal nutrition like some other insects.

A study was conducted to determine the effect of replacing fishmeal with desert locust meal at 0 %, 1.7 %, 3.4 %, and 6.8 % as replacement for the equivalent protein supplied by fishmeal in the control diet of a broiler experiment, on their performance from day-old till the end of starter phase (0–28 days). Diets were formulated to contain 2980 kcal ME and 23 % crude protein at the starter phase. Ninety-six day-old unsexed broiler chickens (Abor acre) were randomly distributed to the four diets.

The treatments had no significant ( $p > 0.05$ ) effects on the weight gain, feed intake, feed conversion ratio (FCR) and the haematology of the birds.

However, the best result was obtained in the treatment with 50 % replacement of fishmeal with desert locust meal. The average weekly feed intake, weight gain and feed conversion ratio (FCR) for the treatment with the best result were: 1090 g per bird, 561 g per bird and 1.94 respectively as compared to 957 g per bird, 457 g per bird 2.09 for the control at the starter phase.

Furthermore, the result of the average live weight, plucked weight and eviscerated weight for the same treatment were: 2360 g, 2155 g and 1700 g respectively, which were not significantly different ( $p > 0.05$ ) from those obtained for the control at the end of the finisher phase. This showed that replacing half the fishmeal in the control diet with locust meal gave better body weight gain, feed intake and feed conversion ratio.

The results of this experiment indicated that desert locust has great potential as a protein source in broiler starter diets without causing any physiological disorder as reflected in the haematological analysis.

**Keywords:** Broiler, haematology, performance, locust meal

## The Antinutritial Effect of Different Dietary Fibre in Pig Nutrition

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Dietary fibre is discussed to act as an anti-nutritional factor by reducing apparent prececal protein and amino acid (AA) digestibility due to reduced absorption and/or increased endogenous secretion. In the present study the reduction of protein retention caused by fibre supplementation to a threonine (thr) limiting diet is taken as an estimate for increased endogenous thr losses.

**Methods:** Two experiments with twelve castrated male pigs each between 37 and 75 kg of body weight (BW) were conducted to measure the effect of 150 and 300 g per day fibre intake from wheat bran (WBF) (exp.1), and of 150 g per day fibre from rape seed (RSF), cassava leaves (CLF) and cassava roots (CRF) (exp. 2) on nitrogen (N) retention, respectively. Two balance periods were performed in exp. 1, and three periods in exp. 2 where animals were subjected to the dietary treatments according to a cross-over design. All animals received 1.35 kg per day of a basal diet (B) in thr was the first limiting AA. To determine the effect of thr on N retention the basal diet was reduced to 1.15 kg per day (diet B, 1.15) and supplemented with corn starch to reach equal energy intake and an unchanged AA pattern. The different fibre sources were received by a treatment of the respective feeds similar to that of NDF-determination.

**Results and conclusion:** N retention decreased by 2.4, 4.8, 2.4, 0.8, and 0.8 g for WBF (150), WBF (300), RSF, CLF and CRF, respectively. Because diets were thr limited the fibre associated thr losses can be estimated and amount for 3.2, 3.3, 3.4, 1.2 and 1.1 g per kg WBF (150), WBF (300), RSF, CLF and CRF, respectively. In many feedstuffs, fibre contributes to a significant proportion of the energy value, however their maintenance is enhanced and thr supply has to be increased to achieve the same level of growth.

**Keywords:** Dietary fibre, pigs, threonine, N retention, endogenous losses

## Natural resources

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# New perspectives for sustainable forest management

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## Amazon Rainforest Current Threats: The Soybean Boom

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Amazon Rainforest is endowed with a wide range of natural resources. Ancestral communities depended on the forest for their livelihoods and displayed a good repertoire of imaginative forms of resource management, adapted to climate extremes in temperature and rainfall. From the midst of the 1900's, however, the Amazon Rainforest became a labour safety valve, perceived as a gigantic reserve of soil for the landless and unemployed households. Simultaneously, large-scale agro-industrial projects have been promoted, major public and private efforts to develop Brazilian northern frontier, seen as good opportunities for socioeconomic advancement in the whole country. Brazil is one of the most successful cases of Green Revolution in the developing world. In 1998, Amazonian Pará state exported its first shipment of soybeans produced at Marabá municipality, next to the Trans-Amazon highway (BR 230). Currently soybean cultivation has been expanding via Cerrado (Centre-Western Region) to the Amazon Rainforest alongside Cuiabá-Santarém highway (BR 163) that connects the interior capital of Mato Grosso state with a fluvial port city located on the mouth of Tapajós River, exactly where it meets the Amazon. The soy boom has been provoking a massive soil conversion within Pará state due both to International Corporation's favourable credit system as to scarce national control over deforestation. The research followed the procedural sequence listed: (i) Literature survey, comprising historical documentation available on the Amazon forest environments; (ii) Fieldwork, including fifty in-depth interviews to four categories of informants in the municipality of Santarém. This contribution assesses mono-cultivation to be impacting negatively the vulnerable forest ecosystem, aggravating land degradation and generating climate change.

**Keywords:** Amazon rainforest, deforestation, soil conversion, soybean boom

## **Is Community Forestry a Solution or a Problem? Literature Review with Examples of Indonesia, Namibia, Nepal and Thailand**

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Community forestry (CF) has been recognised as a viable option for effective conservation and management of forests. Scholars in forest resource management often proclaimed that community based forest management (such as community forestry) can be more efficacious than other practices. The approach to community forestry is expected to have positive economic, ecological and socio-political outcomes at various levels. Failure of state-centric approaches, the increasing number of stakeholders and their multiple interests, economic opportunities, national legislation and international obligations, financial crunch for public forest sector investment are the commonly refereed drivers towards the emergence of community forestry in developing world. While community forestry practices appears to be successful in devolving power from the national to the local level, the empowerment effects on the community level favoured local elites and a “central power-group” tended to (more or less) seize benefits and decision-making capacity. Various case studies indicate that this practice assist to improve the quality of forests to varying degrees. Logically, improvements in forest resource availability should lead to improvements in the flow of those resources to local users and thereby improved livelihoods of those who are dependent on forest resources. However, various studies confirm that improved forest resources may not benefit all members of a user group where the most powerful actors control the use of forests in order to ensure their own interests. The existing empirical studies give the mix signals of community forestry outcomes, there are success as well as failure stories. Based on empirical studies of four countries, we identify contextual conditions that help to explain why full participation of local people alone is not enough to archive a successful community forest management.

**Keywords:** Community forestry, poverty reduction, stakeholders

## **Comparative Advantage of Myanmar's Export Items in China Market: Likely Impact on Natural Forest**

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The tightening sanctions imposed by US and western countries on Myanmar make the country closer to neighboring countries especially China which says Myanmar's situation is only an internal affairs. Because of this enforcement the economic and technical cooperation between two countries is increased. Chinese companies are favored to lay down projects in Myanmar covering hydropower plants, commercial network projects, cement and paper plants, agricultural machinery factories, bridge projects, processing of forest and marine products and so on. Trade between Myanmar and China is also increased in recent years. Myanmar's export to China are mainly constituted of natural resources such as wood, pearls, crude rubber, ores, vegetables, roots and tubers. Myanmar's export to China was only US\$ 124.82 million while import from China was US\$ 496.44 millions making trade deficit of US\$ 371.62 millions. This trade deficit was US\$ 740.70 millions in 2003 and US\$ 954.77 millions in 2006. In this paper, the revealed comparative advantage for Myanmar's major export items especially forest products to China is calculated. The pattern of comparative advantage differs across different levels of dis-aggregation and sectors based on HS classification system. The export share of SITC 24231 (Saw-logs), SITC 2433 and SITC 24331 (Lumber) are highest among the forest products. The trend of the revealed comparative advantages for these products is stagnant through 2000 to 2006 implying that if systematic logging is not done, export earning from forest products of Myanmar could be lost in near future. Moreover, it may also happen environmental impact on Myanmar and China as well as on neighboring countries.

**Keywords:** China, Myanmar, natural forests, revealed comparative advantage



## What Role Can Carbon Payments Play in Poverty Alleviation? Analysis of a Forestry Carbon Project in Mozambique

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In climate change policy, forestry carbon sequestration has emerged as a potential mitigation strategy. While implementation of land use, land use change and forestry (LULUCF) projects into the framework of the Kyoto Protocol is still underway, a market for voluntary emission reductions (VERs) has evolved. Though generally VER-producing projects try to combine carbon sequestration with rural, sustainable development objectives, relatively little research exists on possible trade-offs between these two policy goals. This paper undertakes a cost-benefit analysis of the financial incentives in a forestry carbon projects in Mozambique. The Net Present Values (NPVs) of seven, different eligible land-use systems are calculated. While some systems focus on carbon sequestration, others combine sequestration with the cultivation of cash crops. The results show that, compared with the potential income from cash crop sales, the income generated by carbon sequestration during the early years of the project is relatively small. For all but one option, the benefits do not outweigh the costs over the first nine years, resulting in negative NPVs over this time horizon. Over 15 years, systems combining sequestration and fruit production produce high potential returns, while land-use systems based on carbon sequestration alone are hardly viable. This is particularly true for the environmentally most favourable reforestation system. Thus, the predicted trade-off can also be seen at a project-scale. Regarding payments' role in poverty alleviation, they do contribute significantly to cash income, but are too little in magnitude to substitute income from other land-uses. Nevertheless, they might play a key role by enabling smallholders to afford the investment costs of agricultural income sources. During the early years, additional non-financial incentives are important to turn the NPVs into a positive range. In the long-run, a major task for project developers will be to create land-use systems that combine both carbon sequestration and other products on the same plots, which are attractive for smallholders while ensuring permanence of carbon storage.

**Keywords:** Carbon sequestration, climate change mitigation, cost-benefit analysis, forestry carbon project, Mozambique, poverty alleviation, trade-off, voluntary emission reductions

## Collaborative Forest Management: It Takes two to Tango!

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To millions of local communities in developing countries, forests play important roles for their means of subsistence and source of safety net. Limited access, lack of knowledge and skills of powerless people make them difficult to express their interest to involve in managing the forest. In the other hand, the dominant stakeholder tends to exclude local communities' perspective and concern in forest management practice which somehow generates problems in maintaining the forest productivity. This situation creates gap among stakeholders with potential of conflict in the long term.

Collaborative Forest Management (CFM) as partnership scheme is not a new concept; but to link with the empowerment and negotiation functions to less-power people provides an added dimension. Our goals were to have sustainable forest management and to improve local communities' well-being.

Participatory action research and environmental mediation process were implemented to improve local communities' power and capacity. Our focus is on the processes where multi stakeholders are collaborating in managing forest; how to engage powerless people in ways that it would empower rather than dominate them, to explore with them the existing resources, potential market and opportunities to generate income, and how to develop such institutional arrangements to govern these activities.

This paper describes the process and some key elements to levelling the multi stakeholder's playing field for collective action toward fair collaborative forest management, and evaluates the key questions of how and to what extent collaborative forest management could address poverty issues of local community who live in and depend on the forests.

**Keywords:** Collaborative forest management, empowerment, negotiation, participatory action research, partnership

# Non-timber forest products and agroforestry

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## **Economic Assessment of Different Improved Fallow (IF) Strategies Using the Water, Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS) Model**

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Scarce financial capital resources and low soil fertility are the major agricultural crop production constraints of small scale farmers in Sub Saharan Africa. These constraints have a negative effect on household income, livelihood and food security. Improved fallows (IF) are promoted as a low cost alternative to the sole use of costly chemical fertilisers to raise crop productivity. Several studies have demonstrated that IF can enhance soil fertility, carbon stocks, and biomass production suggesting that IF are a potential means to overcome the problem of low soil fertility and poor crop yields in a sustainable way. The biophysical long term effects of IF have already been quite well simulated with the Water, Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS) model. However, its' socioeconomic sub-model has not yet been properly tested under different IF scenarios. The socioeconomic aspects include the sensitivity of the IF production system to household-specific production factors (e.g. labour input) and external factors such as changes in crop and fertiliser market prices, climate change, and a potential remuneration of carbon sequestration under the Clean Development Mechanism (CDM). To address this knowledge gap, the objective of this study is to assess the profitability of two IF species (*Tephrosia candida* and *Crotalaria paulina*) in promoting crop production of maize in relay cropping and rotation under different short and long term IF-crop rotation scenarios. Based on data from several project sites in Western Kenya, a cost-benefit analysis was conducted, and the WaNuLCAS socioeconomic sub-model was applied. The study highlights the strengths and limitations of the simulation capacity of the sub-model. Furthermore, the results demonstrate which IF alternatives, in both short and long terms, 1) result in a balance of the trade-offs occurring between increase in soil fertility, crop yield, and income for the small-scale farmer, and 2) maximise farmers' profits if one takes the external factors mentioned above into consideration.

**Keywords:** Crop modelling, Improved fallow, cost-benefit analysis, WaNuLCAS

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## **Afforestation for Improving Productivity of Degraded Agricultural Land and Rural Livelihoods in the Amu Darya Lowlands of Uzbekistan**

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Land degradation in the Aral Sea Basin is a major concern because of its adverse impact on the environment and rural livelihoods. In the Khorezm region of Uzbekistan, one of the most densely populated areas affected by the Aral Sea desiccation, 15–20 % of arable land became unsuitable for agricultural practices and some can be considered for afforestation with appropriate tree species.

Physiological characteristics and socio-economic importance suggested *Elaeagnus angustifolia*, *Ulmus pumila* and *Populus euphratica* as most promising for afforestation. Under deficit irrigation of 80–160 mm yr<sup>-1</sup>, these species successfully established on highly saline soils with a root-zone electrical conductivity (EC) of over 20 dS m<sup>-1</sup>, underlain by shallow (0.9–2.0 m) groundwater with EC ranging within 1.2–4.8 dS m<sup>-1</sup>. Following the cessation of irrigation after two years, the trees effectively used the groundwater producing 10–60 t ha<sup>-1</sup> yr<sup>-1</sup> of shoot biomass.

Besides increasing productivity of land abandoned from cropping, afforestation can improve livelihoods by providing useful products. Fuelwood, as an alternative energy source, would offer some relief to over 50 % of the rural population which has no or reduced access to gas supplies. Four years after planting, the energy value of 1 ha plantation (2,300 stems ha<sup>-1</sup>) averaged 6.4–10.3 tonne of oil equivalent which could satisfy the annual energy need of 55–89 persons.

The production of supplementary fodder would enrich the roughage-based diets fed to the livestock during winter. The foliar crude protein content in trees ranged within 90–150 g kg<sup>-1</sup>, by far superior to that of the commonly used feed. The nutritive value relative to barley (100) varied from 62 (*P. euphratica*) to 97 (*E. angustifolia*) and ranked between molasses and moist barley.

Additionally to these direct benefits, planting N-fixing *E. angustifolia* on degraded land can contribute to soil fertility. Depending on the plantation age, the amount of biologically fixed nitrogen varied from 59 to 475 kg ha<sup>-1</sup> yr<sup>-1</sup>, characterising *E. angustifolia* as an important source of renewable bio-fertiliser.

These observed services supported by positive returns from capital investments in plantations, estimated in an accompanying financial valuation, reveal afforestation is an effective means to mitigate land degradation while improving rural livelihoods.

**Keywords:** land degradation, nitrogen fixation, rural livelihoods, salinity, tree fodder

## Tree Utilisation and Management in Africa: A Case Study from Semi-Arid Tanzania

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Tree products are considered important by local people, but forest area is rapidly decreasing throughout Africa and specifically in Tanzania. A series of interdisciplinary investigations, aimed at understanding tree use in semi-arid Tanzania were undertaken. Use of communal and privately forested areas around Gairo was mapped through a variety of socio-anthropologic methods, including household surveys, ethnobotanical studies and wealth and area ranking. Identification and abundance of woody species was established and livestock use of woody species determined. Extent of woodland conversion to cropland in the past 30 years was measured. Dung beetle frequency and diversity on cropland or forested areas was investigated. All investigations concluded that the local villagers are extremely dependent on woodlands and tree species to maintain livelihoods and that the importance of these species is recognised by the local people. Firewood and construction are the most important uses of trees with indigenous trees used for a wider variety of purpose than exotic species. Woody species diversity and density was greatest in the communal forest closest to the village. This area is most heavily used for grazing and extraction of forest products. Woodland areas contained more diverse populations of dung beetles than farmland, providing a useful ecosystem service for soil fertility. Free ranging small ruminant diets contained an average of 76 % woody species during the dry season and 56 % during the wet season, whereas cattle diets contained only 28 and 18 % woody species in the dry and wet season. Despite the measured and articulated understanding of importance, only 3 % and 57 % of two originally allocated communal woodland areas remained. The rest was converted to farmland. It is concluded that the need for croplands coupled with the continued availability of alternative sources of wood products has reduced the marginal utility value of local woodland areas and woodland species. This prioritisation by local people should be taken into account when advocating reforestation schemes.

**Keywords:** Forestry, Tanzania, grazing management, ecology, ethnobotany

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## Using NTFPs to Drive Rural Development without Threatening Biodiversity? A Concrete Example Concerning Four NTFPs in Central Menabe, Madagascar

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The growing demand for food that especially affects developing countries is the result of a decrease in available arable land and demographic growth. In this context, non-timber forest products (NTFPs) are suitable alternative foods.

NTFPs are of great importance to the rural populations in Madagascar, providing a safety net when agricultural products are scarce. In Central Menabe (west coast of Madagascar), two tubers (*Dioscorea maciba* and *Tacca pinnatifida*), a mammal (*Tenrec ecaudatus*) and honey (made by *Apis mellifera unicolor* colonies) are the most important NTFPs that underpin livelihood. Knowledge on the NTFPs management, on the impact of local practices on the biodiversity of products, or on the commercial potential of NTFPs is relatively scant and scattered. Only small-scale studies have been carried out and the results remain largely unpublished.

The present interdisciplinary research aims to contribute to filling the wide gaps. Firstly, it aims to identify the traditional NTFPs management. Secondly, it evaluates the current density and regeneration of the four products, in order, thirdly, to deduce whether the products are being—or will be—threatened by traditional practices. Fourthly, it discusses the commercial potentialities of NTFPs and their possible impact on livelihoods. The research concludes with recommendations for NTFPs managements that are likely to meet the needs of local populations while simultaneously decreasing the villager practices' pressure placed on the products.

The NTFPs local management practices were ascertained by means of 9 participative observations and informal discussions; researchers collected the products together with villagers. Biological inventories were established for 20 to 40 plots of 400 m<sup>2</sup> (for the two tubers) and in 6 transects along an average of 3.5 km (for the honey and the tenrec). The discussion on NTFPs commerce is based on 288 questionnaires completed in 6 villages and on 70 interviews carried out at 7 regional markets. Finally, information concerning socially suitable and ecologically reasonable NTFPs managements was gathered in villages by way of 12 groups who participated in scoring exercises.

**Keywords:** Madagascar, NTFPs biodiversity, NTFPs commerce, NTFPs traditional management

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## Assessment of Insect Biological Diversity of Various Land Use Systems in Peruvian Amazon

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Tropical rain forest form one of the most precious ecosystems and provide habitat for more than 75 % of all described plant and animal species. However, this unique ecosystem is disturbed by men causing biodiversity losses. This study is focused on the assessment of species diversity and richness in various land use systems around Pucallpa city (Peruvian Amazon). As the indicative group the class of Insecta was used. Our presumptions were that the species richness and diversity of secondary forest and agroforestry systems are higher than in monoculture cropping and degraded sites with weed vegetation. We supposed that in agroforestry systems there are fewer pests than in other localities. We also expected that ant species composition is helping to the pest control in the agroforestry systems.

Insects were collected on six localities (secondary forest, two types of agroforestry systems, cassava monoculture and two degraded sites covered by weed vegetation) by using 24h-pitfall traps and sweeping net. The insect morphological species were determined and data evaluated according to standard methods and indexes.

Our hypotheses were fully supported excluding the biodiversity. The species richness was highest in the secondary forest and agroforestry, but the values for biodiversity were highest in the secondary forest and surprisingly on degraded sites. The lowest biodiversity was found in the agroforestry systems. The values were probably distorted by the dry season and higher occurrence of antotolerant and pest species on degraded soils. Those species can survive the dry season without high losses. According to the index of similarity, the species composition of secondary forest is highly similar to the agroforestry systems. Agroforestry systems can form insect species reservoir after forest disturbance and also help to the species conservation. This study forms a good scientific background for further monitoring ecological changes and summarises the momentous role of ants in the tropical ecosystem.

**Keywords:** Agroforestry systems, deforestation, insect biodiversity, primary and secondary rain forest, shifting cultivation, species richness

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# Water, soil and crop management

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## Growing Rice in Africa: the Vital Importance of Sound Water Management

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Since the recent food crisis, an important paradigm shift has taken place in rice research. The emphasis shifted from rainfed upland rice to rainfed lowland rice production. For the past ten to fifteen years research at WARDA concentrated on the rainfed uplands, which is the home of the poorest people in Africa. It is here where the greatest opportunity lies of making an impact on tackling poverty. However, by targeting the upland rural poor and alleviating them out of poverty the people living in urban areas will not be fed. The recent food crisis made clear that besides increasing productivity also the total production needs to be raised. A SWOT analysis of the major rice growing ecologies in Africa shows that the most suitable ecology for meeting both requirements, alleviating poverty and feeding the continent, are the inland valley lowlands. If only 10% of the 200 million hectares of Sub-Saharan African inland valleys were successfully developed by installing low-cost water management structures the continent could produce enough rice to meet the rice consumption needs of the entire continent and even have a surplus to export.

**Keywords:** Rainfed agriculture, rice, SWOT analysis

## Lessons from Model Integration and Coupling for Basin-Scale Irrigation Management, Applied to Region VII, Chile

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The scientific knowledge of resource management for food production is embedded with the knowledge domains of various disciplines: The natural sciences often study the effects of human actions on natural systems, while the social sciences study the human causes of resource degradation and its effects on various social groups. Integrated modelling is a means to build bridges amongst various domains, because their knowledge is embedded within computational models and the associated databases. Moreover, integration can generate new insights through the analysis of interactions and feedbacks between biophysical and socioeconomic systems. However, model integration is costly in terms of human resources. Technically it requires computer skills and procedurally it requires an understanding of integration as a step-by-step process that must be realised within complex project environments. Good integration work can add to the soundness of the results of individual disciplines, in addition to the insights derived from the integration itself. Both results ultimately increase the robustness of policy implications.

This PhD was conducted within the project “Integrating Governance and Modelling,” which is part of the CGIAR Challenge Program on Water and Food. To analyse the interactions between an intensely irrigated system, the management regime and the agricultural producers, two models were dynamically coupled; the Mathematical Programming Multi-Agent System (MP-MAS) and the distributed Water Flow and Balance Simulation Model (WaSiM-ETH). Building on a common database, the resulting integrated modelling system can be used at various levels of integration, ranging from simple or iterative data exchange to full dynamic coupling, in order to respond to a multitude of policy-related questions.

The model system is designed to address policy questions in the realm of irrigation management for agricultural production. Unlike optimisation approaches, this system allows for the analysis of policy impacts on individuals and groups.

In this presentation, methodological lessons learned from integrating two complex models from two scientific disciplines will be shared. A framework that summarises our learning and goes beyond technical solutions will be offered for other scientists working in integrated natural resource management.

**Keywords:** Integrated model system, irrigation, lesson learning

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## **Domestic Water Use by Rural Households without Access to Private Improved Water Sources: Determinants and Forecast in a Case Study for Benin**

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Accessibility to safe water remains a major concern in Benin, where only 23 % of the population have improved drinking water within the residence. The problem is even more important in rural areas where households have no access to private improved water sources. Based on Benin's good level of per capita water availability (3815 m<sup>3</sup> per year), it is argued that efficient water management can highly contribute to increase the level of access to safe water. However, better understanding of factors explaining domestic water use, including forecasting how these variables will affect future water use, is an important step of efficient water management policy for rural developing countries. Accordingly, this study combines a Seemingly Unrelated Tobit (SURT) approach and Geographic Information System (GIS) techniques to determine factors affecting domestic water use in dry season, when water is at its scarcest level in rural areas. The focus is on rural households without access to private improved water sources in Benin. These households use either only free water sources, only purchased sources or combine both free and purchased sources. Both socio-economic and geographic data were collected from 325 households in 27 villages.

Results confirm that SURT is appropriate to account for both censored nature of water demand and the correlation of error terms between free and purchased water use equations. Contrary to the importance of price effect on residential water demand, we find that purchased water demand is perfectly own-price inelastic due water scarcity in rural areas. Rather, the important determinants of water use are household size and composition, access to water sources, wealth and time for fetching water. However, the effects are different for households which use only free sources, households which rely only purchased sources and those which combine both free and purchased sources. Moreover, econometric and spatial analysis shows that the effect of population growth on future water scarcity will not be similar for all districts in the study area. We conclude that water management policy at district level is likely to produce better impact as compared to the usual national or basin based approach.

**Keywords:** Benin, censored models, domestic water management, dry season, GIS, rural households, seemingly unrelated regression

## Derived Demand for Water and Substitution Possibilities Between Water and other Production Inputs in the Mining Industry of South Africa

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Despite the fact that industrial water withdrawals represent a large share of total water extraction in most countries, industrial water use has received little attention. This study contributes to the present literature by estimating the derived demand for water for a sample mine in the Middle Olifants sub-basin of South Africa. Production technology is represented by a variable cost function and approximated by a translog form. The variable cost function is based on the assumption that the mine chooses the quantities of all inputs so as to minimise its total variable costs of producing an exogenously determined quantity of output. Total variable costs as the dependent variable are the sum of monthly expenditures on five inputs: water, electricity, labour, capital and diesel. The model is estimated with primary monthly time series data for January 2004 – September 2007. Cost share equations of each input are established and estimated using Seemingly Unrelated Regression (SUR) and Iterative Zellner-Efficient maximum likelihood estimates. Since the five share equations always add up to unity the sum of the disturbances across the five equations is zero, implying that the disturbance covariance matrix is singular and nondiagonal. For this reason one of the share equations has to be dropped and indirect estimates have to be derived from homogeneity restrictions and the directly estimated coefficients. The mean cost share of water in the sample data shows that it is with 2.4 % relatively small compared to the other input cost shares. The estimates are checked for positivity and concavity, which are necessary conditions for a cost function to be well behaved. Expect of the input capital positivity is fulfilled and the Hessian matrix is negative semidefinite. Allen partial elasticities of substitution (AES) can be calculated with the cost shares of each input and respective estimates. Estimation results of own and cross price elasticities of demand for production factors give some insight into changes in factor utilisation which might result from relative price changes.

**Keywords:** Cost function, factor price elasticity, industrial water demand, time series data

## Assessing Strategic Water Availability in the Upper Ing Watershed, Thailand

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Availability of good quality irrigation water throughout a year is a key element for the economic development of the farming families. Even with high precipitation, most of agricultural lands in the northern Thailand are still suffering with unavailability of irrigations water. This paper assesses the strategic water availability and use under different development pathways at a watershed scale using the spatial water budget model (SWBM). First of all SWBM for the study area was develop as part of the methodology. Processes that are simulated are (a) land use water balance (b) water flow to stream (c) water storage in dams and small reservoirs, and (d) water use from reservoirs and streams.

We applied SWBM to the 25100 ha Upper Ing Watershed in northern Thailand and investigated the spatial and temporal variation in location of stream and water yields from different part of the watershed. The base simulation was carried out for the year's 1998–2007 using a DEM and actual land use data at 100 m resolution. Simulated river flow rates at the watershed outlet corresponded well to measured flow rates. The ten year average simulated river flow rate was  $1300 \text{ l s}^{-1}$ , but it more than doubles during periods of heavy rainfall and decreased below  $600 \text{ l s}^{-1}$  in dry seasons. The differences in the total length of the streams (based on flow threshold  $25 \text{ l s}^{-1}$ ) on a typical dry day in the dry season way approximately a factor 1.5.

Agricultural water need and possible extraction was assessed and presented by dividing the watershed into fifteen different zones based on the streams network. Monthly water yields for each zone were computed, results varied from less than 50 % to over 137 % of the per hectare water yield for the entire watershed. This variation was caused by differences in topography and land cover. Two methods of water extraction: directly from stream and harvesting rain water in reservoir and dam during monsoon and supplying in the dry season, were employed. Results shows there are enough possibilities of harvesting small quantity of water in the different spatial gradients where currently there was no irrigation water supply.

**Keywords:** Thailand, spatial water availability, hydrological modeling, spatial water balance model

## Water Cleaning Test in Aral Sea Region with the Purpose of Obtaining Drinking and Irrigation Waters

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Almost all states in Middle Asia face a fresh water deficiency. The problem of the fresh water, especially, drinking water has been a major concern in the Aral Sea region, where desiccation of the Aral Sea has become an ecological catastrophe.

The Aral Sea, once the fourth largest lake in the world, has shrunk more than 60 % since 1960 through the massive cotton irrigation. Drying-out the Aral Sea is resulting in growing concentrations of chemical pesticides and natural salts; these substances are then blown from the increasingly exposed lake bed and contribute to desertification.

Deficiency of quality drinking water is due to the inaccessibility and poor water quality from natural sources, but also due to the poor water treatment technologies in major cities of the region. Within the framework of the project "Improvement of the quality of drinking and irrigation water in the Aral Sea region by cleaning equipment and sorbents produced in the Czech Republic" testing of various types of water treatment technologies has been conducted in order to find the most advantageous method of water treatment, taking into account the quality of water but also considering the maintenance costs of the equipment.

In order to take into account the various seasonal changes of preliminary characters of water, the testing of the water treatment equipment has been conducted during the winter and summer time of 2006.

As a result of these testing and laboratory analyses the optimal water treatment method has been found, which can be used in the region.

**Keywords:** Aral Sea region, dissolved substances, drinking water, irrigation water, reverse osmosis, Uzbekistan, water treatment technologies



## Study on Water Resource Accounting in Hainan

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Water resources are irreplaceable natural resources for subsistence, and they are important as environmental factors and support system for life. Because the water resource crisis in China is aggravating, and the quality of the environment for water is deteriorating, shortage of water resource becomes one of the global-focused problems. In the 'World Water Development' Report (a first UN system-wide evaluation of global water resources) it has been pointed out that water problems will seriously limit global economic and social development in 21<sup>st</sup> century, and might result in inter-state conflicts. In China, most of the rural areas face the threat of shortage of water resource. At one side, available water is reduced, because agricultural chemicals constantly undermine water resources. At the other side, due to unplanned agricultural water usage for a long time, water is wasted, which is quite astonishing. Besides unreasonable management mechanism, it is evident that water resources are valueless or have low value, if polluted. To correctly recognise and evaluate the value of water and solve the problems of water resource by economic leverage, it is greatly significant to promote optimal allocation and sustainable utilisation of water resource. Meanwhile, evaluation of water resource is a main part of integrated environmental and economic accounting, because water resource is quite crucial economic resource for production and living, and environmental resource for maintenance of good ecological environment. This paper offers a water accounting for Hainan. Water is accounted in quantity and value, and we integrate the changing value of water into its GDP component. This offers a Green GDP, to weigh Hainan sustainability of social and economic development. This paper includes three parts:

Part 1: A physical accounting of the quantity and quality of Hainan water resource to reflect the influence;

Part 2: Using the method of restoration costs to evaluate the price of different qualities of water resource in Hainan: then accounting the stock and flow quantity of its value.

Part 3: Calculating the loss of Hainan water resource, and subtracting the costs to compensate the loss from provincial GDP to get the environmentally adjusted GDP.

**Keywords:** Green GDP, Hainan, method of restoration costs, physical accounting, water resource accounting

## **Modelling the Hydrological Balance in the Zou Catchment at Atcherigbe Outlet (Bénin Republic): Contribution to the Sustainable Use of Water Resources**

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A modelling study of the hydrological balance was conducted in the Zou catchment at Atcherigbe outlet, stretching over a total area of approximately 6980 km<sup>2</sup> in the centre of Benin. The objective is to contribute to the sustainable use of water resources in the Zou basin through the assessment of the availability and the annual renewal of the resource.

Thus, the agro-hydrological, physically based model SWAT has been calibrated and validated for this watershed.

The Hydrologic Response Units (HRU), which are homogeneous areas at point of view of soil physical properties and landuse, generated by the model are the units space where the water balance components and the amount of eroded sediment were evaluated before being aggregated. This procedure enhances the accuracy of model's prediction. The runoff was estimated by the SCS curve number procedure. The soil water has been assessed according to the soil moisture (saturated or unsaturated) by using storage routing methodology. The actual evapotranspiration was assessed by Penman's method. As for the erosion, the modified version of the Universal Soil Loss Equation of Williams was used.

The main data used were the DEM of the region, soil characteristics, vegetation cover, climate and cultivation practices.

The adjusted water balance shows a coefficient of surface runoff of 7 %, a total of ground-water recharge (shallow and depth aquifer) of about 18 % and an actual evapotranspiration of 72 % of annual precipitations. Regarding erosion in the basin, the average annual losses are in the order of 5 t ha<sup>-1</sup> and presents disparities depending on the type of land cover: approximately 17 t ha<sup>-1</sup> per year in the agricultural HRUs and about 0.6 tons ha<sup>-1</sup> per year in the classified forests and woodlands.

These results have led to propose strategies for sustainable exploitation of the basin's water as follows:

- building reservoirs to store water (earthen dam, drilling and wells, ponds,...),
- constructing works to fight erosion (hedges, Cordon stony...),
- implementation of intensive politics of mobilisation and training of peasant populations concerned.

**Keywords:** Erosion, hydrological balance, modelling, SWAT, watershed

## **Monitoring Spatial Patterns and Temporal Changes in Air Temperature and Vegetation Growth in the Aral Sea Basin: Decision Support for Improved Land Use and Water Management**

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Matching actual water demand to supply from the irrigation system is crucial for reducing water losses and improving productivity and resource use efficiency of agricultural systems in the Aral Sea Basin (ASB). Air temperature and vegetation growth belong to the major determinants of crop water demand in irrigated agriculture. Considering the impact of global and regional climate change, land and water decision makers in the ASB will greatly benefit from improved information on the spatial patterns and temporal changes of air temperature and vegetation growth to better target land and water management recommendations. This paper describes first the framework for generating temperature indicators as part of a region-wide monitoring system for the irrigation systems in the ASB. Secondly, examples of temperature and space-borne vegetation indicators are presented to illustrate their spatial differences and changes during recent years in the ASB. Thirdly, relationships between temperature and vegetation indicators are shown for different seasonal time sections and areas within the ASB.

For the temperature monitoring system, daily temperature data from 47 meteorological stations in the ASB were analysed over the period 2000–2006. The data from the distributed stations were radio-transmitted and imported into a Geographic Information System (GIS) via web-based tools. Considering vegetation growth, Normalized Differenced Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) were calculated for the area surrounding the stations using 8-day time-series data of the Moderate Resolution Imaging Spectroradiometer (MODIS) over the same period. Time-series plots concisely show temperature indicators that are critical to crop growth and relevant for long-term climate change analysis at the regional scale, e.g. end of frost days, length of growing period, and temperature variability. Similarly, plots show seasonal and annual changes of vegetation growth at different areas within the ASB. The correlations between temperature and vegetation indices show how the relationship changes at different time sections and for different areas in the ASB during the year.

Integrating the temperature monitoring system to crop biomass accumulation and further parameters such as evapotranspiration, and site-specific soil and irrigation system capabilities will enable the decision makers to better match irrigation water supply to actual crop water demands.

**Keywords:** Climate change, indicators, NDVI, regional monitoring, remote sensing, time-series

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## Multi-Agent Modelling for Estimating the Possible Impacts of Irrigation-Related Innovations on Rural Poverty and Sustainable Land Use in Ghana

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The erratic rainfall pattern and degraded natural resource base coupled with unfavourable market and policy conditions cause poverty and hunger in the semi-arid tropics of Sub-Saharan African countries. This is particularly true for the semi-arid areas in northern Ghana, where poverty levels beyond 70 percent have persisted over the last decades and the majority of the poor are food crop subsistence farmers. The key determinants of rural poverty and malnutrition in rainfed semi-arid areas are small percentage of irrigated agricultural land and lack of access to water for productive purposes in agriculture. Irrigation increases the stability and the level of crop yields and gives rise to wider and more diversified cropping systems as well as opportunities for producing high-value crops. To increase the area under irrigation and thereby alleviate poverty, the government of Ghana plans to introduce new small-scale irrigation techniques that could enhance productivity and farm incomes. This paper applied a multi agent-based integrated bio-economic modelling approach, which incorporates a hydrology model component and a socio-economic model component with an extended three stage budgeting systems (including a savings model, a Working-Leser model, and an Almost Ideal Demand System), to assess and evaluate the possible impacts of irrigation-related innovations. The model was validated with stakeholders from the ministry of agriculture and food, Volta basin board and farmers, using empirical data from the Upper East Region of Ghana. Scenarios of small-scale irrigation technology are simulated to demonstrate the usefulness of the model for analysing the *ex ante* impacts on rural poverty and overall surface water demand.

**Keywords:** Multi-agent modelling, rural poverty, surface water demand

## Measuring Crop Coefficient of Guar (*Cyamopsis tetragonoloba* (L.) Taub) under Gezira, Sudan Condition

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A study was planned to estimate the crop water requirements (CWR) of guar (*Cyamopsis tetragonoloba* (L.) Taub) through measuring crop coefficients (Kc) of the Guar under Gezira irrigation conditions as contribution towards the efficient and economic use of water. A field experiment was conducted at Gezira Research Station farm over three seasons (2002, 2003 and 2004), in Wad Medani, Sudan (Latitude 14.23 N, Longitude 33.29 E and Altitude 405 m a.s.l.) in deeply cracking, alkaline heavy clay vertisols. The Kc for guar was estimated by measuring the actual crop evapotranspiration (ETc) and calculated the reference evapotranspiration (ET0) using Penman-Monteith equation. The Kc was derived from irrigation water measurement and gravimetric soil moisture depletion method. Both Kc values were found to have significant relationship with time. The guar final Kc could be derived as a mean of Kc irrigation water and Kc gravimetric, based on the result of the T-test ( $t$  critical  $t > 0.05$ ). Results of this study showed a variation of Kc values with different growth stages. The values were found to be 0.44, 1.03 and 0.63 for Kc ini, Kc mid and Kc end, respectively. Results showed that the peak of the final Kc (1.03) was during the period between 60 to 70 DAS, which coincided with the maximum ETc of 6.3 mm day<sup>-1</sup> and the maximum mean LAI of 4.7 at the mid-season stage. The crop water requirement (CWR) of guar in the study area of Gezira was measured to equal approximately 682 mm for the total growing period. The result of the study indicated that the relationship between Kc and LAI was statistically significant ( $p < 0.01$ ,  $R^2 = 0.83$ ). Kc of bare soil, calculated from the relationship between Kc and LAI at LAI=0, was found to be 0.49. The mean seed yield of the guar variety (HFG53), grown to estimate Kc, was about 1000 kg ha<sup>-1</sup>. The average irrigation production efficiency (IPE) was 0.2 kg m<sup>-3</sup>.

**Keywords:** Crop coefficient, crop water requirements, Guar, Sudan, irrigation scheme

## Households' Preferences for Different Water Service Options in the Middle Olifants Sub-Basin of South Africa

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In South Africa a culture of not paying for any kind of services evolved as protest against the apartheid regime. Supported by the government's policy of providing free basic water of 25 liters per capita per day, many people regard water as a free good. Therefore, little is known about household's willingness and ability to pay for water services. Also, it is not well analysed how households value different water supply options such as private and public taps or boreholes and what they would prefer given different service options. In order to improve current backlogs in water service provision, it is necessary to analyse households' trade-offs between better service characteristics and paying a certain price for it.

The study aims at revealing the current situation of access to water in the Middle Olifants sub-basin in terms of quantity of water used, characteristics of the water source and satisfaction with the current water services.

Using the choice experiment method, households' preferences for different water service options as well as for different service characteristics such as quantity of water, days of water supply per week, distance to water source, waiting time, ease of use etc. are investigated. According to a stratified random sampling, 475 respondents in different villages and one town were asked to pick the most preferred water supply option out of 4 presented options. Each of these options was described by its water service characteristics, whereas these characteristics varied according to an optimal experimental design. Finally, by placing special emphasis on the differences between urban and rural households, whether and how much people in the Middle Olifants are willing to pay for the different kinds of water sources and service characteristics is derived.

Estimation results regarding preference and pricing information will provide the responsible water service authorities with policy options to design adequate water services in urban and rural areas.

**Keywords:** Choice experiment, South Africa, water services

## **Sustaining a Rural Water Supply: The Case of Ngere Kagoro Community Water Project in Nyando District, Kenya**

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The Ngere Kagoro Community Water Project located in Nyando District, Kenya supplies water to the rural community in Ngere Kagoro Village from a borehole and is managed by the rural community through a management committee that runs its day to day operations. GIS techniques were used to map out the water supply and households. Supply to individual homes with the ability to pay for own pipe and metre installation is successful though facing problems in monthly bill compliance. Several community water vending Kiosks are dysfunctional. The failure is attributed to inadequate attention to finance, cultural ties and stakeholder involvement and changes in Kenya's water sector. Many households get their drinking water from ponds that are health hazards if not treated.

The water supply tariffs do not reflect the service provision costs, including equipment replacement, staff salaries and electricity bills. This is due to the feeling that the water project was meant to be affordable to poor rural households. With time, pumping costs rose but is not reflected in the charges. Several households also get water for free from friends since the flat rate per household (Ksh. 300) does not depend on the monthly consumption. The project should re-value the unit for charging; either per unit of consumption (*e.g.* per jerrican) or per consumption unit (*e.g.* per household per month). If the latter is chosen, upper limits to consumption should be established, beyond which a surcharge is applied above 10,000 litres per household. With many homes having extended family households, there is need to create a third category of water users having units within one unit or having a compound unit rate. It should apply for a consistent annual subsidy from the Constituency Development Fund to offset its budget on maintenance costs. This will reinforce that service comes at a cost, preserve community and cultural ties and put the management of the service on a more sound financial footing. The study also recommends the exploration of solar power to subsidise pumping costs and invest in capacity building.

**Keywords:** Community perceptions, rural water supply, stakeholder involvement, water tariffs

## **Livestock and Water Management: Key for Changing Systems and Livelihoods in Africa**

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Livestock is a key livelihood strategy and source of food and income for poor livestock keepers. However, inappropriate livestock management along with poor water management practices often contributes to widespread and severe depletion, degradation and contamination of water and land resources. The negative effect of livestock on water depletion is becoming a global concern, particularly associated with climate change and water scarcity. Livestock-Water Productivity (LWP) refers to a set of ideas that could contribute towards reducing the amount of water needed per unit of output generated. It is a strategy to reverse the inefficient livestock and water management practices, which often contributes to widespread and severe depletion, degradation and contamination of water and land resources. There is compelling need for better understanding of the nature of livestock-water interactions. Yet, great opportunities remain to further reduce domestic animals use of water. Integrating livestock and water planning, development and management has the potential to help reduce poverty, increase food production and reduce pressure on the environment including scarce water resources. Major strategies that could help achieve this are choosing water efficient feed sources, improved *in situ* and *ex situ* water management practices associated with crop-livestock management, improved animal management for efficient resource use efficiency and improved veterinary services. Achieving integrated livestock-water development will also require new ways of thinking about managing water by water and animal sciences professionals. But what does it take to get these ideas adopted by livestock keepers in crop-livestock systems? This paper explores the nature of innovation adoption, and argues that, in the under-regulated crop-livestock systems of eastern Africa, it makes sense to focus in on social institutions as an entry point for adoption.

**Keywords:** depletion, livestock management, water management



## Physiological Responses of Lowland Rice Cultivars to a Water Saving Irrigation System

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With increasing water scarcity and climate variability the demand for water saving crop production is growing. Irrigated rice is one of the largest consumers of fresh water resources.

In Senegal, rice is the most important cereal and its consumption is steadily increasing. In the Senegal River Delta and River zone irrigated rice is grown under Sahelian climatic conditions with an annual rainfall of less than 400 mm. Since irrigation water is pumped from the river to the fields, fuel is an important expense and a reduction of irrigation water would lead to a decline of production costs.

Saturated soil culture (SSC) is one option to reduce the irrigation water input. Soil is kept close to saturated conditions to reduce water losses due to evaporation, percolation and seepage compared to flooded fields. Former studies reported slight yield losses, but also water savings up to 50 %. So far little work has been done on physiological responses commonly associated with water deficits such as reduction in photosynthetic activity and transpiration.

For this study 10 varieties were selected representing the genetic variation in terms of duration, stress tolerance and water use patterns. For SSC, fields were kept under saturated conditions until panicle initiation followed by flooding until two weeks before harvest. Water inflow (irrigation, precipitation) and water loss (transpiration, evaporation, percolation) were determined, variety specific canopy properties, crop growth, photosynthesis, stomatal conductance, leaf chlorophyll content and leaf area were measured and compared to results obtained in fields irrigated traditional way. The aim of the study is the physiological characterisation of genotypic traits enhancing water saving management practices for irrigated rice. Experiments continue in bi-monthly staggered planting dates on two different sites to assess the seasonal variation in physiological and phenological responses to the water saving management practice. First results will be presented and the potentials and risks of saturated soil culture in the Sahel will be discussed.

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



# Soil fertility management

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## Global Soil Spectral Library: A Spectrally Driven Approach for Assessing Soil Quality Using Infrared Spectra

THOMAS TERHOEVEN-URSELMANS<sup>1</sup>, TOR-GUNNAR VAGEN<sup>1</sup>, OTTO SPAARGAREN<sup>2</sup>, KEITH SHEPHERD<sup>1</sup>

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Identification of degraded landscapes, soil fertility constraints or estimates of soil carbon stocks on a regional or national scale need spatially distributed soil information. Diffuse reflectance infrared spectroscopy is a fast, cheap and reliable method for assessing soil quality of large numbers of samples. A constraint up to today is that local calibrations have to be built for new sets of samples and for individual soil properties. Using global soil spectral libraries that cover the main global variability of agricultural soils could help simplify the procedure and obtain a rapid estimate of basic soil properties for an unknown sample. We tested different spectral pre-treatments including smoothed raw spectra, first derivative spectra and continuum removed spectra for near-infrared (1,250 nm to 2,500 nm) and mid-infrared (2,500 nm to 16,700 nm) spectra. Moreover, we tested different analysing approaches including separation of clusters based on the principal components

using the Expectation-Maximization algorithm, interpretation of spectral classes in terms of soil properties using tree based recursive partitioning and partial least-squares regression. The global soil library (n=971) included agriculturally important groups with a wide range of organic carbon concentrations, texture and pH values from soil archives of the International Soil Reference Information Centre (ISRIC). All computations were done using the "R" free software package to facilitate use of the approaches by developing countries. Partial least-squares regression using first derivative spectra performed best in predicting basic soil chemical and physical properties. Validation statistics (n=291) showed better results for mid-infrared compared to near-infrared spectra. Good predictions in the mid-infrared range (coefficient of determination higher than 0.75 and ratio of reference values standard deviation to root mean square error of prediction higher than 2.0) were achieved for pH value, contents of organic carbon and clay and cation exchange capacity. Predictions for contents of calcium, magnesium and sand were satisfactorily ( $R^2$  0.60 to 0.75; RPD 1.4 to 2.0). The positive results could facilitate the wider use of soil infrared spectroscopy, especially in conjunction with satellite images to improve digital mapping of soil constraints to agricultural production and soil carbon levels.

**Keywords:** Model performance, near-infrared, mid-infrared, partial least-squares regression

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## Development of a Generic Model to Quantify Soil Organic Matter Applying Infra-Red Spectroscopy and Thermal Stability of Soil

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Soil organic matter (SOM) plays an important role in improving soil fertility, mitigating land degradation and sustaining livelihoods in tropical regions through food production. Measurement of SOM is therefore important in monitoring soil health. Conventional, frequently used physical and chemical methods for quantification of soil carbon, and hence SOM are very time consuming. Therefore, faster, cheaper and in particular non-destructive approaches are required to quantify and to assess SOM. Diffuse Reflectance Fourier-transform Infrared spectroscopy (DRIFT-IR) offers this possibility. However, due to the presence of both mineral and SOM fractions within soils, superimposition of the mineral signatures with those of the SOM occur when presenting graphical output of absorbance IR spectra. Therefore, DRIFT-IR spectroscopy still requires the development of specific prediction models for each soil dataset in order to link the spectral signatures with quantitative information for the soil components to be predicted (e.g. carbon). This paper aims at assessing/evaluating efficient alternatives to overcome the effect of the mineralogical interference on the spectra to finally develop a new generation of generic models for SOM quantification. For the present study, Luvisols and Lixisols from different geographical locations worldwide were selected from the ICRAF-ISRIC soil world collection. A sub-sample of each selected soil was subjected to sequential heating until 550°C, and another similar sub-sample to wet-oxidation using hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>). Both procedures were used independently to remove SOM in order to separate IR spectra from mineral and organic fractions. All soil samples were analysed by Diffuse Reflectance Fourier-transform Mid-Infra Red spectroscopy (DRIFT-MIRS) before and after soil treatment. Quantitative prediction of SOM and nutrients were based on partial least squares (PLS) analyses. The potential of DRIFT-MIRS to develop generic models applicable for the prediction of total soil carbon from soils of the same classification but of different geographical origin was tested, and both advantages and limitations of this technique discussed.

**Keywords:** Generic model, lixisols, luvisols, mid-infra red spectroscopy, soil organic matter

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## Assessing the Variability of Soil Quality and Crop Productivity at Different Spatial Scales in three Settlement Schemes in NE Zimbabwe by Integrating Mid-Infrared Spectroscopy and Geostatistical Tools

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Understanding spatial variations of natural resources is essential for monitoring and managing agro-ecosystems, making them more profitable and sustainable. However, most of the literature on spatial variability in crop production linked to soil quality generally refers to small or medium spatial resolutions (10–100 m), and rarely incorporates farmers' management and its link with the surrounding landscape. Therefore, three villages representing three settlement schemes in NE-Zimbabwe were studied to understand the spatial variations among cropping fields at different spatial scales, and to determine the main drivers of these changes. Cropping fields in each area were digitalized by using Landsat satellite imagery and field surveys. A nested non-aligned sampling design was subsequently applied by using sequentially grids at different spatial resolutions (750 × 750 m, 150 × 150 m and 30 × 30 m), which resulted in the selection of 159 sampling points in the three villages: 105 points in maize fields, 32 in fallow and 22 in other crops. Sampling points consisted of four sampling plots on a radial arrangement, where information on land, vegetation and soil surface characteristics were recorded. A composite topsoil (0–20 cm) sample and measurements of topsoil resistance to penetration were also taken on each plot. Crops were sampled by selecting two rows of 5 m length per plot and measuring crop response parameters. Fallows were sampled by using a 1 m<sup>2</sup> quadrat per plot. Soil samples were ground (<1 mm) and analysed in the laboratory for pH, texture, C, N, P and cations. Additionally, all soil samples were ball-milled and analysed by mid-infrared spectroscopy (MIRS). Chemometric models were later constructed for predicting the physical-chemical characteristics of all samples. Geo-referenced soil and vegetation datasets were statistically analysed by using conventional (Anova) and geostatistical (semivariograms) methods. Results demonstrated how soil and vegetation varied at each spatial scale in each village under study, and also identified the main drivers behind these spatial changes. We argue that coupling MIRS with geostatistical analyses is a useful tool for assessing spatial variations of natural resources from plot to landscape level.

**Keywords:** Maize performance, scaling-up, soil quality, spatial variations, vegetation productivity

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## **Influence of Conservation Tillage on Soil Microbial Diversity, Structure and Crop Yields in Sub-Humid and Semi-Arid Environments in Kenya**

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Conservation tillage is one of the ways to maximise benefits derived from farming mainly through enhanced soil biological and physical conditions as well as better utilisation of rain water. In a study conducted over 5 to 10 cropping seasons in two agro-ecological zones in Kenya (three sites), the effect of conservation tillage practices on soil microbial diversity, soil structure, water conservation and crop yield were investigated. The on-farm experiments were laid out as split-split plot design involving different cropping systems and crop residue management strategies superimposed on the tillage practices. Clearly, higher soil macro-aggregation was observed in reduced tillage (by up to 18 %) and tied-ridges compared to conventional tillage system. Similarly, application of crop residue had positive effects on soil aggregation indices (increase by 13 %) in clay soil within sub-humid zone while combination of crop residue and manure was better than sole application of manure (by 4 %) in a sandy semi-arid zone. Among the cropping systems, aggregation indices declined in the order: intercropping > continuous maize > rotation. Conservation tillage practices showed higher diversity of bacterial and fungal populations compared to conventionally tilled plots. In the dryland zone, regardless of tillage system, application of 1 t ha<sup>-1</sup> of maize stover and manure each, was the best practice. In the humid zone, although reduced tillage had lower yields than conventional tillage its performance was enhanced when combined with ripping or sub-soiling. Thus from the study, conservation tillage was superior in improving soil microbial diversity and soil structure but low agronomic performance must be overcome though ripping and sub-soiling.

**Keywords:** Conservation tillage, crop residue, manure, microbial diversity, soil aggregation

## Gaseous Nitrogen and Carbon Emissions from Urban Gardens in Niamey, Niger

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Measurements of horizontal nutrient fluxes in African urban gardens show highly positive balances for nitrogen (N) and carbon (C), leading to the assumption that massive nutrients losses occur through gaseous emissions and leaching. To quantify vertical nutrient losses through volatilisation, fluxes of  $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{CO}_2$  and  $\text{CH}_4$  were measured in Niamey, Niger using a mobile INNOVA photo-acoustic infrared multi-gas monitor connected to a custom-made cuvette. For one year in three gardens, two irrigated with river water and one irrigated with sewage water, six replicate measurements were taken in vegetable-plots during 6 days in the coldest (6 am) and hottest (2 pm) period of the day. Measurements were repeated every 6 weeks.

For all measured gases, flux rates were lower in the morning than in the afternoon. Throughout the year seasonal effects on emissions ( $p < 0.001$ ) were more pronounced at midday regardless of ambient temperature.

Within a season, emission rates of  $\text{NH}_3$  and  $\text{CH}_4$  during the morning did not differ significantly between the three gardens and afternoon values varied only slightly. Afternoon missions of  $\text{CO}_2$ , in contrast, were significantly different between gardens, peaking in all cases at the end of hot dry season with  $> 3 \text{ kg CO}_2\text{-C ha}^{-1} \text{ h}^{-1}$  for the low input garden receiving river water, and reaching  $5.5 \text{ kg CO}_2\text{-C ha}^{-1} \text{ h}^{-1}$  in the high input garden irrigated with sewage water. Differences in  $\text{N}_2\text{O}$  volatilisation were largest in the afternoon, when the annual averages for the two gardens using river water ranged from 34 to 43  $\text{kg N}_2\text{O-N ha}^{-1}$ , while the values for the garden receiving sewage water exceeded 100  $\text{kg N}_2\text{O-N ha}^{-1}$ .

The estimated yearly gaseous nitrogen losses were 50  $\text{kg N ha}^{-1}$  for the gardens receiving river water and 90  $\text{kg N ha}^{-1}$  for the one receiving sewage water. High N volatilisation in the urban gardens are reflecting surplus N application and indicate that nutrient management in these very intensive production systems is inefficient.

**Keywords:** Carbon, gaseous emissions, Niger, nitrogen, urban agriculture

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# Soil fertility management: impacts on soil and vegetation

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## Soil Microorganisms Improving Productivity of Agricultural Cropping Systems

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For the last four decades considerable effort has been invested in investigating the potential of soil microorganisms to benefit agricultural production systems. Microorganisms were tested for their properties to increase plant growth and crop yields or control pests, diseases and weeds. *In-vitro* studies and experiments in controlled conditions revealed some of the mechanisms and mode of action effective in stimulating productivity or causing antagonistic effects. However, results of field experiments have been more variable and few products are actually in commercial use (*Rhizobium*, *Trichoderma* etc.) but with the present raise in agricultural input costs beneficial microorganisms might represent an interesting alternative to complete reliance on inorganic compounds.

At the International Potato Center a research project investigates the use of several genera of native Plant Growth Promoting Rhizobacteria (PGPR) to improve crop productivity of different cultivation systems, ranging from rainfed potato based cropping systems to semi-controlled irrigated vegetable systems to fully-controlled aeroponic systems for the production of disease free pre-basic potato seed. Results indicate that PGPR increase fertiliser use efficiency and photosynthetic activity improving plant growth and tuber yields, especially in systems with organic fertilisation. Yield increases range between 10 and 50 %. The effect of PGPR increases with increasing control of growth conditions and reduction of competition from other soil organisms. On-going activities study parameters which might affect microbial performance with the objective to reduce the variability in crop response to the application of microorganisms and develop a low-cost eco-efficient and environmentally-friendly product. Future activities will also consider the role of microorganisms (fungi) in mitigating abiotic stresses or directly improving the quality of organic fertilisers.

**Keywords:** Eco-efficient product, fertiliser use efficiency, photosynthetic activity, plant growth promoting rhizobacteria

## Soil Respiration Rates under Different Land Uses in Northeastern Mexico

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Determinations of CO<sub>2</sub> efflux, soil temperature and soil-water content were monitored between July 3, 2001 and January 29, 2002. At each sampling date, two daily measurements (at 08:00 and 14:00 h local time, named as morning and afternoon, respectively) were carried out. A dynamic closed chamber with a portable system EGM employing a infrared gas analyzer (IRGA) and a soil chamber (SRC) was used to assess soil CO<sub>2</sub> efflux throughout the experimental period in vertisols under different land uses in northeastern Mexico: Pasture (*Dichanthium annulatum*), *Leucaena leucocephala* in an alley cropping system, a native and undisturbed shrubland plot, *Eucalyptus microtheca* plantation, and a *Sorghum bicolor* field.

Results have shown that the *Eucalyptus* and pasture plots showed a highly significant and positive linear relationship between morning and afternoon soil respiration rate and soil temperature, while no significant relationship between any soil temperature and soil respiration for *Leucaena*, sorghum and shrubland land uses was found. Soil temperature alone explained 68 % of the variation in the efflux rate in *Eucalyptus* and 33 % in pasture. During the study period, average morning soil respiration rates for all land uses ranged from 0.7 to 8.4  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$  (in Oct. and Aug., respectively), while afternoon soil respiration rates ranged from 0.6 to 14.4  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$  throughout the experiment. Average morning and afternoon soil respiration rates showed the following decreasing CO<sub>2</sub> efflux order among the five investigated land uses pasture>shrubland>*Leucaena*>*Eucalyptus*>sorghum, indicating that pasture plot showed the highest average morning and afternoon soil respiration rates 3.5 and 5.0  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ , respectively. In contrast sorghum shows the lowest average morning and afternoon soil respiration rates 1.9 and 2.5  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ , respectively.

**Keywords:** CO<sub>2</sub> efflux, *Dichanthium* grass, *Eucalyptus*, *Leucaena*, shrubland, soil respiration, sorghum, vertisol

## Land Degradation in Northern Ghana: Causes and Effects under High Population Pressure and Land Use Competitiveness

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The ability of agricultural production to guarantee food and income security in northern Ghana in the past few years has declined and become less sustainable. The decline is attributed to the depletion of land and water resources of many farm households in northern Ghana. The connection between land degradation and agricultural productivity is well understood. It is generally agreed that land degradation directly results in low productivity of land and water resources, and subsequently causes poverty and reduced standards of living among households. This effect becomes even more critical in agro-based regions like the northern Ghana where over 70 % of the population is directly engaged in agriculture. What causes land degradation in northern Ghana and what are the possible remedies for the phenomenon? Among farmers, researchers, governmental and non-governmental organisations, divergent views attribute the phenomenon to either the emergence of unfavourable climatic conditions in recent times globally, chronic poverty among farm households or their use of unsustainable farming practices. This paper is based on a participatory analysis of the causes and effects of land degradation in northern Ghana. It primarily examines the underlying causes and effects of land degradation on farm households in a relatively highly populated area, and sheds light on the perception of land degradation by farm households as a production problem and their views concerning possible prevention and control measures for land degradation. The study revealed that the degradation of land and water resources in northern Ghana is well understood by farm households in the area. About 99 % of the households experience some form of land degradation *viz.* soil infertility, erosion or compaction; deforestation, overgrazing and weed infestation. Farm households clearly identified the human and natural causes of land degradation, and clearly linked the problem to increased demand for land. Suggested measures for combating the problem encompassed suitable soil and water conservation techniques as well conflict management procedures in land tenure arrangements and land use among households.

**Keywords:** Farm households, land degradation, Ghana, participatory analysis

## Evaluation of some Paddy Soil Properties on Urease Enzyme Activity

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Rice fields using nitrogen-based fertilisers play an important role in the global N<sub>2</sub>O budget. Enormous quantities of urea as nitrogen fertiliser are used into the paddy fields because of its relative low cost per unit of nitrogen. Urea hydrolysis in soils is an enzymatic decomposition process by the enzyme urease. Enzyme urease (urea amidohydrolase) catalyzes the hydrolysis of urea to yield ammonia and carbamate, which spontaneously hydrolyzes to form carbonic acid and a second molecule of ammonia. Urease activity influences optimum use of urea fertiliser, N volatilisation, N leaching and environmental pollution related to N. Laboratory experiments were carried out to evaluate urea hydrolysis, as a function of soil urease activity in 30 different paddy soil samples of Guilan province of Iran and their correlations with some soil physico-chemical characteristics. Soils belonged to different soil series. Cation exchange capacity (CEC), organic carbon (OC), total nitrogen (TN), pH and electrical conductivity (EC) and urease activity of soils were measured. Urease activities range from 19.8 to 68.3  $\mu\text{g NH}_4^+ \text{g}^{-1} \text{soil 2h}^{-1}$ . Simple correlation analysis of urease activity with properties of this rice soils differing widely in pH, C:N and organic carbon indicated that urease activity was correlated highly significantly with organic carbon ( $r = 0.80^{**}$ ) and total N ( $r = 0.73^{**}$ ) and EC ( $r = 0.63^{**}$ ) and CEC ( $r = 0.38^*$ ). pH was also negatively correlated with urease activity ( $r = -0.52^{**}$ ) but was not significantly correlated with clay percentage and C:N. Multiple stepwise regression analysis showed that organic carbon and cation exchange capacity (CEC) accounted for most of the variation in urease activity and 77 percentage urease activity were influence OC and CEC in paddy soils.

**Keywords:** Correlation, laboratory experiments, paddy soils, urea hydrolysis, urease activity

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## Estimation of Medium-Term Soil Redistribution Rates in Ibadan, Nigeria, by using the $^{137}\text{Cs}$ Technique

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Soil erosion is one of the most critical environmental problems in sub-Saharan Africa. It causes on-site degradation of the natural resource base, as well as off-site problems. Reduction of soil loss is therefore important to maintain soil productivity and contribute to food security in the region. Quantitative data on the extent and rates of soil redistribution are necessary to guide the development of effective resource management. The use of fallout radionuclides as tracers can provide the required information, since fallout radionuclides are quickly and strongly adsorbed by fine soil particles after deposition and primarily redistributed by physical processes associated with water and wind.

The contribution represents the test of this technique conducted in Ibadan, Nigeria, (7°30'N 3°54'E) in 2007 and 2008. To describe the spatial and vertical distribution of caesium-137 ( $^{137}\text{Cs}$ ) in undisturbed soils, reference sites were sampled at the beginning. Fields characterised by ridges prepared parallel to slope or by flat bed preparation were sampled according to a grid design to determine the spatial  $^{137}\text{Cs}$  distribution. Cores for depth-incremental sectioning were also taken on the upper and lower slope to describe the  $^{137}\text{Cs}$  depth profiles. All soil samples were analysed by gamma spectrometry using a high-purity Germanium (HPGe) detector. The results obtained from the reference sites show the highest  $^{137}\text{Cs}$  concentration in the upper few centimeters of the topsoil and a decrease with depth. The analyses of the samples collected from the field are still in progress. As soil erosion was observable, it is expected that the  $^{137}\text{Cs}$  inventories will be reduced in the soil of the upper slope and increased in the deposition zone on the lower slope. Different conversion models, including mass balance models, will be used to estimate the rates of erosion and deposition based on the measurements. The  $^{137}\text{Cs}$  inventories will be interpolated to visualise the spatial distribution of soil redistribution within the study area on a map. Hence, the study will provide quantitative data on soil redistribution in the savannah of West Africa and contribute to improved soil conservation in Africa.

**Keywords:** Caesium-137, Nigeria, radionuclide technique, soil erosion, West Africa

## Changes in Carbon Stock as Affected by Land Use Change in West Aceh, Sumatra

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High world market prices for biofuels and accessibility of the region after 25 years of conflict foster the conversion of peatland areas in Aceh – traditionally under ‘jungle rubber’ – into oil palm plantations. Apart from clear-cutting and burning this land use change includes drainage of the organic peat soils. Exposed to aerobic conditions, the rate of soil organic matter decomposition is sharply accelerated. Given the high organic matter contents of peat soil, amounts of emitted CO<sub>2</sub> increased during the last years due to similar processes in Kalimantan and put Indonesia on the third place in the global CO<sub>2</sub> emission ranking.

Embedded in the EU-funded Rebuilding Green Infrastructure (ReGrIn) project, this study is conducted to quantify carbon pools of peat soils under different land uses (rubber, clear-cut, oil palm) in chronosequences (false time series). Data will be used to parametrise and calibrate a crop model (WaNuLCAS) for two different land uses: rubber and oil palm. Sampling plots will be established on sites representing land use chronosequences from rubber forests to oil palm plantations, including both drained and undrained rubber sites. Soil samples are collected along transects using a peat sampler. Carbon contents will be analysed using Walkley and Black and loss on ignition methods. Peat thickness, bulk density and soil respiration rates are also determined to obtain plot carbon balances.

Allometric equations are used to determine above-ground biomass. Root-shoot ratios for rubber and oil palm from literature are used to estimate belowground biomass. Changes in carbon stocks due to land use change on plot level will be aggregated using existing land use classifications based on satellite images from 1990–2006. The conversion area of rubber to oil palm will be quantified using GIS.

Expected results are the determination of amounts of carbon stored in the soil and vegetation on a plot level under different land uses. Combined with spatial analysis, the contribution of land use conversion on peat soils from rubber to oil palm will be estimated on a landscape level. WaNuLCAS will be used to test potentially more environmentally friendly scenarios.

**Keywords:** Jungle rubber, land use chronosequence, oil palm, peat soils

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## Soil Quality Indicators and Weed Infestation in an Amazonian Land-Use System as Affected by Soil Cover and Residue Quality

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In humid tropical land-use systems weed diversity and aggressiveness are extremely high, posing serious limitations to no-tillage agriculture. This paper investigates the effects of combining low- and high-quality organic residues on soil quality indicators and on weed abundance and biomass. For this purpose, a field experiment was installed in January 2002 on-station at Maranhão State University, comprising four legume species: *Leucaena leucocephala* (Lam.) De Wit., *Cajanus cajan* (L.) Millsp., *Clitoria fairchildiana* R.A.Howard and *Acacia mangium* Willd., resulting in the following treatments in a completely randomised block design with 4 replications: *L. leucocephala* + *C. cajan*; *A. mangium* + *C. cajan*; *C. fairchildiana* + *L. leucocephala*; *C. fairchildiana* + *C. cajan*; *L. leucocephala* + *A. mangium* and control (no legumes). Sampling was conducted in 2005 and 2007. It was determined weed abundance and biomass, and N, P, K, Ca, lignin e polyphenol contents of the residues. In the topsoil we determined pH, the contents of organic matter, P, K, Ca, Mg, and H+Al, and soil density, total porosity and aeration capacity. In alley cropping systems, the application of prunings of woody legumes affects chemical soil quality indicators such as the sums of bases and base saturation as well as soil aeration capacity in very specific manners, as a result of the quality and quantity of applied plant residues. The lower life-time of high-quality prunings and the insignificant effects of the residues derived from their decomposition enables weed populations to increase their density and abundance and to take advantage of the improvements of chemical soil quality caused by the application of such legume tissues. Combination of low- and high-quality residues application provides important features of sustainability for no-tillage agriculture with legume mulch: improvements of soil physical quality indicators, efficient nutrient cycling and reduction of weed infestation.

**Keywords:** Humid tropical, legume species, nutrients, sustainability

## Effect of Organic Amendment on Growth and Quality of Vegetables Grown on Tsunami Affected Soil in Aceh Besar, Indonesia

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The tsunami of 25.12.2004 degraded many coastal soils in Aceh/Indonesia by sedimentation of mud and deposition of rubble as well as contamination with salt and harmful chemicals. Upon drying, hardsetting of the soil surface layer hampers tillage and root growth. Contaminants like heavy metals can be toxic to crops or pose a threat to human health upon consumption. Rice straw compost is a local available source of organic amendments that can be used to rehabilitate the tsunami affected soils.

The objectives were to determine if rice straw compost can alleviate tsunami borne soil degradation, as assessed by growth and yield of vegetables as well as to monitor the heavy metal threat in the produce.

The effect of rice straw compost (20 t ha<sup>-1</sup>) amendment to long bean (*Vigna unguiculata* ssp. *sesquipedalis*) and water spinach (*Ipomoea aquatica*) was tested in field plots (2-factorial randomised complete block design) located on tsunami and non-tsunami affected soils from September 2007 to January 2008, in Aceh Besar district. The results show that plant height and leaf number of water spinach and long bean on tsunami affected soil were lower than on non tsunami affected soil. Harvested biomass of water spinach on tsunami soil (1.5 t ha<sup>-1</sup>) was lower than on non-tsunami affected soil (3.5 t ha<sup>-1</sup>). Biomass of long bean pods on soil with organic amendment (4.16 t ha<sup>-1</sup>) was higher than on soil without organic amendment (3.10 t ha<sup>-1</sup>). In both tsunami affected and non affected soil, concentrations of Cd and Pb were lower than 0.1 mg kg<sup>-1</sup> wet weight of plants. The residual limit of Cd in food product is about 0.05–0.2 mg kg<sup>-1</sup> wet weight (WHO/FAO standard). The use of organic amendment improved the production of long bean and water spinach on tsunami affected soil but yield levels are still lower than on non-affected soil. There was no harmful contamination of heavy metal in long bean and water spinach that can be dangerous to human health.

**Keywords:** Long bean, organic amendment, rice straw, tsunami soil, water spinach

## **Charcoal in Sediment Layers: A Way to Estimate Impact of Land Use Intensification on Reservoirs Siltation?**

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Worldwide erosion and runoff are filling up reservoirs rapidly, decreasing the buffer capacity and resulting in irrigation water deficiency or flooding. The degree of sedimentation, however, is not only depending on rainfall patterns and topography but also on the land use around the reservoir. Therefore soil erosion and sediment transport studies in regions with intensive agricultural practises are essential for environment protection. The objective of this study is to understand the impact of land use intensification on sediment transportation and delivery by reconstructing a cultivation chronosequence. Around the Chieng Khoi Lake, Son La province in North West Viet Nam, three fields with various land use systems such as maize/cassava intercropped, agroforestry and secondary forest were selected and augering cores were taken from upper, middle and lower slope position. Below each field, on the lake bank two profiles, one directly underneath and one at 10 m distance, were dugged up to 2 m. Visible distinguishable sediment layers were investigated regarding thickness, colour, pH, particle size distribution, and total organic carbon (TOC) to examine sediment transport capacity. To reveal the fire history attention was paid to charcoal composition of diverse land uses by using differential scanning calorimetry (DSC). For measuring erosion and runoff throughout the rainy season of 2008, Gerlach troughs in upper, middle and lower slope were installed at all three fields. A bathymetric survey of the lake was performed so that the overall sedimentation in the lake over 40 years could be estimated. It is hypothesised that charcoal can be linked to land use history and by its occurrence in sediment layers it can, together with the thickness of the layer, reveal the contribution of different land use systems to the silting up of the reservoir. These findings can be used for model validation, sensitisation of the local population and policy makers and used in decision making processes to develop a more sustainable land use system that is still economically attractive.

**Keywords:** Charcoal, lake sedimentation, land use history

## 15N-DNA-Based Stable Isotope Probing a Suitable Tool to Link Microbial Activity with Identity in Plant Residue Decomposition Process

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DNA-based stable isotope probing (DNA-SIP) is a cultivation independent technique that involves exposing of microbial community to an isotopically labelled substrate; the labelled DNA (biomarker molecule) is an indicator that the community was active in the assimilation of the substrate. This approach allows direct observations of substrate assimilation in microbial communities and represents an interesting new tool for linking microbial identity and function of specific organism or group of organisms. To link activity and microbial identity of communities involved in plant residue decomposition process, an incubation experiment was conducted with highly <sup>15</sup>N-enriched plant residues (90 atom %) incorporated (1 %) in a Vertisol soil, taken from a long-term field experiment carried out in Venezuela since 1997. The crop residues were incubated for 30 days (25°C) at 40 % WHC. A control without residue was also used. Microbial activities parameters (e.g. ergosterol content, enzymes activities) were determined after 3, 7, 15 and 30 days. DNA was extracted from soil samples and the active microbial community was analysed by using <sup>15</sup>N-DNA stable isotope probing (<sup>15</sup>N-DNA-SIP) and molecular (PCR-DGGE, cloning and sequencing) techniques; Sequences information was compared with known sequences deposited in the National Center for Biotechnology Information (NCBI) data bank using BLAST and phylogenetic analysis was done using parsimony (PAUP software). Linking microbial activity parameters with <sup>15</sup>N-DNA stable isotope probing technique revealed the predominant role of the fungal community (e.g. *Mortierella*, *Fusarium* and *Chaetomium*) as early plant residue decomposers contrary to the common bacterial dominance in the initial degradation of easily decomposable products

**Keywords:** <sup>15</sup>N-DNA SIP, microbial activity, microbial community, stable isotope

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## **Assessment of Desertification Processes in a Subtropical Area of Northeastern Mexico**

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The northeastern Mexico is located in a subtropical region, due to extreme climate with scarce and torrential rains, the soil of agriculture and livestock areas are losing their physical, chemical and biological properties which reduce their productive capacity and make it necessary to open up more areas with natural vegetation for agriculture.

We evaluated the soil use changes in a region in northeast of Mexico particularly in the state of Nuevo Leon and identified the areas subject to erosion process using a digital process for 7 Landsat ETM images and 24 SPOT images acquired between 2001 and 2004. The results showed that areas with bare soil involve nearly 3.7% of the state for 2001 and 4.5 % for 2004.

A field sampling was carried out to assess the structure of different types of vegetation and soil characteristics to compare the soil variables from the surrounding areas with livestock and agriculture use.

Soil samples in each sample plot were taken, as well as were analysed in the laboratory, where several variables were identified such as: organic carbon, salinity, pH and organic matter for each one. Significant differences were detected in soil properties between forests and scrub and nearby areas of agriculture and grasslands. The pine forest presented a higher content of organic matter (27 %), neutral pH and very low salinity (11 %), in contrast with the Mezquital areas that had a low content of organic matter (4 %), high salinity and sodium (21 % And 38 %) respectively, low organic carbon content (4 %) and an alkaline pH.

**Keywords:** Desertification, ecosystems degradation, erosion processes, soil degradation. land use changes

## Effectiveness of Commercial Bio-Fertilisers for Improved Phosphorus Acquisition: Use of Rapid Screening Tests

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Phosphorus (P) is a limiting nutrient for crops in most tropical soils, though often present abundantly, yet in forms scarcely plant accessible. P-fertilisation may enrich the soil with P, but also cause ecological damage.

Even more worrying is that rock phosphates, mined for fertiliser production, are likely to be exploited within few decades, while the pressure to raise global food production implies an increasing P-fertiliser demand. Thus, interest is growing to use soil and fertiliser P more efficiently. Coherently, various “bio-fertilisers” for a high P-acquisition are increasingly offered worldwide. Many bio-fertilisers contain phosphate-solubilising bacteria like *Bacillus* and *Pseudomonas* spp. for an improved chemical P-availability or phytohormone active algae extracts to stimulate root development for a better spatial P-acquisition. However, insufficient quality standards, inconsistent performance and weak knowledge limit their successful application. Therefore, simple methods to assess their principal effectiveness are required.

In this study a set of rapid bio-tests with *Cucumis sativus* L. and *Triticum aestivum* L. as indicator plants will be implemented to characterise the principal effectiveness of three commercial bio-fertilisers based on *Bacillus amyloliquefaciens* strain FZB42 (RhizoVital®, ABiTEP, Berlin, Germany), *Pseudomonas proradix* (Proradix®, Sourcon-Padena, Tübingen, Germany) or liquid extract from brown algae (Kelpak®, Kelp Products, Simon’s Town, South Africa). To assess the influence on germination rate and root elongation, seeds will be sown in rolls of filter paper soaked with suspensions containing  $1 \times 10^9$  colony-forming units  $l^{-1}$  of the bacterial inoculants respectively 10 ml  $l^{-1}$  Kelpak®.

The effect on specific root length [ $m\ g^{-1}$ ], root hair length, formation of lateral roots and leaf expansion will be studied in hydroponics supplied with the bio-fertilisers at same concentrations. Qualitative *in-vitro* tests, using agar-media clouded by precipitated calcium, iron or aluminum phosphates, will indicate the P-solubilisation ability of the bacterial strains. The achieved data will be discussed regarding the principal effectiveness of the different used bio-fertilisers to improve the P-nutritional status of crops. The rapid bio-tests will allow a better pre-selection of promising bio-fertiliser preparations for following more expensive pot and field trials.

**Keywords:** Bio-fertiliser, phosphorus-solubilizing bacteria, algae extracts, phytohormones

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## ***Musa* in Shaded Perennial Crops - Response to Light Interception**

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Research to improve the productivity of bananas and plantains (*Musa*) has emphasised monocropping. Millions of small farm households produce this crop associated with perennial crops and trees for consumption and market, but encounter few technologies targeted to their production constraints. Occasional research on the effect of shade on banana productivity has shown that shade reduction up to 20 % has few negative impacts. Shade may reduce wind damage and leaf disease pressure, offset water and nutrient stress and contribute to a more diverse soil food web. Greater light reduction extends the crop cycle and may reduce bunch size, especially under increased plant densities.

A recent project at CATIE in Costa Rica, supported by Bioversity International, dealt with plant growth and disease pressure on banana in different shade conditions, as well as the improvement of light in agroforestry systems in relation to banana production. Disease development of Black Sigatoka on *Musa* 'Gros Michel' was significantly delayed in shade with fewer infected leaves. However, leaf emergence rate was significantly faster in higher radiation.

Light measurements with hemispherical camera in six coffee agroforestry systems with *Erythrina poeppigiana* (Poró), *Terminalia amazonia* (Roble Coral), and *Abarema idiopoda* (Cashá) did not show differences in radiation due to the plant species, but in canopy pruning and plant density. An upper storey less than 100 trees ha<sup>-1</sup> can be recommended for the improvement of banana in shaded conditions.

Further research should focus on the practical improvement of banana in shade. Leaf area index of the upper storey and photosynthetic active radiation (PAR) could be possible indicators for plant densities in agroforestry systems.

Screening of light sensitivity of different cultivar groups of bananas and plantains and within cultivar variability should be done to determine if certain cultivars are more adapted to partial shade conditions. Furthermore, the local farmers' knowledge of banana production in agroforestry systems is not yet adequately exploited.

**Keywords:** Agroforestry, light interception, *Musa*, radiation, shade

## Use and Socio-Economic Value of Wild Edible Plants by the Turumbu in the Tshopo District, DR Congo

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The Turumbu (ca. 10,000 individuals) live in the Isangi territory, District Tshopo, near Kisangani, DR Congo. Part of their territory is occupied by the Yangambi forest reserve. During the last decades of war and civil strife with difficult access to the city of Kisangani, the Turumbu were obliged to secure their livelihoods from the tropical rainforest.

Ethnobotanical research was carried out in July–August 2006 in 1 village (Yalungu, 92 km west from Kisangani) and August 2007 in 2 villages (Yaoseko at 30 km and Yasekwe at 64 km west from Kisangani). All not cultivated plants used for consumption (fruits, leaves, tubers, roots, bark, etc.) were inventoried. Plants were collected in a reference herbarium and information about uses recorded. To determine their socio-economic value, household interviews were held in 30 households randomly chosen from each village. In addition, a market study was started (September 2007–August 2008) in Kisangani to investigate price fluctuations and quantities of Wild Edible Plants (WEPs) sold.

In total, 71 WEP species in 38 families and 60 genera, were collected in the all 3 villages. 25 WEPs were known in 3 villages, 12 WEPs in 2 villages and 34 only in 1 village. In addition, 15 ethnospecies in 6 families (6 genera) were only identified onto genuslevel; 1 ethnospecies onto family level and 9 ethnospecies could not be identified.

On average, households regularly consume 32 WEPs. Selling WEPs is good for 14.7 % of the cash income of rural households. Fourteen species can also be found on the different Kisangani markets. Most WEPs constitute an important food source in difficult periods (e.g. *Dioscorea* spp.), some others are becoming more and more a culinary delicacy (e.g. *Megaphrynium macrostachyum*) or an interesting source of income (e.g. *Gnetum africanum*). A selection of plants will be made for further study and domestication with local farmer groups for income diversification and better food security.

**Keywords:** Domestication, DR Congo, ethnobotany, wild edible plants

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## Using Local Indicators to Evaluate Sustainability of Farming Systems in Leyte, Philippines

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Since even scientists cannot agree on a definition of sustainability, it is important to involve the local stakeholders when trying to identify sustainability indicators and to incorporate their perception of sustainability.

In Leyte, Philippines, criteria (indicators) for evaluating sustainability of farming systems were identified with local stakeholders. Group discussions were carried out with farmers while other stakeholders – representatives from the university, local and international NGOs and the local government unit – were interviewed individually. These locally identified criteria were compiled with externally identified ones and 30 farmers and 18 other stakeholders ranked the complete list individually. For primary data, a survey was carried out with farmers. In the area of Baybay 71 farmers were included in the survey and results from this area are presented here.

Three groups of small-scale farmers around Baybay were included in analysis: farmers practicing the so called “Rainforestation Farming” (RF) – an agroforestry system using indigenous timber trees – on individual plots (n=25), farmers planting exotic timber trees (n=14) on their land, and a comparison group of farmers without any timber trees (n=32).

Different criteria were ranked high by the different stakeholders. Soil quality, use of soil conservation measures and biodiversity were ranked high by other stakeholders, farmers valued security of tenure and membership in organisations highly. Mostly, for criteria which were ranked high by stakeholders, significant differences between the groups of farmers were detected.

Comparing farmers groups, RF farmers and other tree farmers were better off than farmers without timber trees. RF farmers had significantly more land available, were mostly landowners, better educated and reported having higher soil quality than other farmers ( $p < 0.05$ ). But from the set of indicators it is yet difficult to say if tree farmers are better off because they plant trees or if they plant trees because they are better off.

**Keywords:** Agroforestry, farming systems, local indicators, Philippines, rainforestation farming, sustainability indicators

## The Influence of Agricultural Practices on Occurrence of Weed Species and Soil Properties in the Peruvian Amazon

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*Inga edulis* Mart. is popular with agroforesters for its rapid growth, tolerance of acid soils and high production of leafy biomass to control weeds and erosion. The objective of this research was to determine if it is possible to reduce growth of weed species (e.g. *Imperata brasiliensis*) through the cultivation of *Inga edulis*. The impact of agricultural practices on weed occurrence was also analyzed. The treatment was established on experimental plot 19 km from Pucallpa in the year 2006. Four fallow systems were evaluated during the study: (1) natural fallow; (2) planted fallow with cassava; (3) planted fallow with inga (*Inga edulis*); (4) inga + cudzu (*Pueraria phaseoloides*), replicated four times in a completely randomised block design in 12 m × 12 m subplots. On each subplot were collected three biomass samples (1m<sup>2</sup>) of weed species. Most spread species were determined and number of individuals were counted. First results shows, that utilisation of inga could be promising for reducing of *Imperata*, but on the other hand occurrence of other weed species (e.g. *Baccharis* sp.) are increasing. Soil samples were also collected. The first collection was done in the beginning of the trial and then after each harvest of cassava (approx. after 9 months). First mixed samples were collected from each quarter of the plot. Next collection was collected from each subplot. This data are used for estimation of impact of agricultural practices on soil properties and content of basic elements. For detailed results will be necessary continue with this study at least more two years. These results will be evaluated and then will be usable for next agroforestry utilisation of *Inga edulis* in this region.

**Keywords:** *Imperata brasiliensis*, *Inga edulis*, Peruvian Amazon, weed control

## Enhancing Climate Change Adaptation through Agroforestry: Claims, Concerns and Issues of Local Stakeholders in Tanzania

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Climate change impacts will expose up to 250 million people to water stress over the next decade according to the 2007 IPCC (Intergovernmental Panel on Climate Change) report. Increasing demand for food and other agricultural goods will exacerbate the pressure on agricultural lands. Farmers in north-eastern and central Tanzania, principally relying on small-scale rain-fed mixed crop livestock systems, are likely to be most severely impacted.

There is consensus that fostering the adaptive capacity of rural communities through adopting appropriate techniques and adapting their livelihoods will increase the resilience of agro-landscapes and improve capabilities to cope with future climate stress. Substantial relief is expected from the introduction of agroforestry systems which have proven to tone down extreme climate by improving micro climate and reducing evapotranspiration.

For successfully, i.e. sustainably, mainstreaming adaptation strategies it is key to respond to the stakeholders' needs and their own sets of perceptions, values and skills. Thus, participatory approaches in developing comprehensive adaptation strategies are expected to considerably improve their acceptance among stakeholders. The project on "Climate change impact assessment and adaptation options in vulnerable agro-landscapes in East-Africa" aims at developing stakeholder based scenarios of potential future agro-landscapes by bringing together very diverse domains of knowledge and interest.

We present first insights from a survey of semi-structured interviews held with farmers in north-eastern Tanzania. The focus is on outlining the underlying claims, concerns and issues that shape local stakeholders' perception of land use and its values. Stakeholder-based scenarios will be made compatible in an iterative process of a range of rapid appraisal approaches with model-based scenarios.

**Keywords:** Agroforestry, climate change adaptation, farming system, participatory methods

## Environmental Valuation in SW-China: Experiences from a Survey Study in Xishuangbanna

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The contingent valuation method (CVM) for the assessment of the social value of environmental benefits accruing from public projects has gained increasing popularity in countries in transition from planned to market economies like e.g. China. However, it must be scrutinized whether this method is transferable from the socio-economic context of industrialised market economies where it was originally developed to transition economies.

Since the CVM relies on household interviews and, therefore, on personal statements of the household members, it is susceptible to a multitude of biases resulting from problems of perception and correct understanding as well as from other psychological or even socio-cultural factors. This is especially true in a society like China that has little experience with the formation of prices in free markets. This study scrutinizes the possibilities of applying the CVM in such a transition economy by conducting an economic valuation of land-use changes in the Nabanhe National Nature Reserve in tropical Xishuangbanna, SW-China. In a CVM survey, residents of the nearby city of Jinghong were asked their willingness to pay for a governmental program to convert rubber plantations back into forests.

In particular, this survey explores the survey population's knowledge and awareness of environmental changes taking place in the nature reserve about 30 km away and to what extent they feel possible consequences of rubber plantation there on their lives in town. In this context, the question arises whether Chinese people dare at all to criticise government measures like the extension of rubber plantation. Further, we analyse if people in China are willing to sacrifice personal market consumption opportunities for environmental improvements and, consequently, are willing to pay for the proposed rubber conversion program. Thus, it is essential to find out to what extent Chinese people rely on government for environmental improvement and how much they are willing to take personal responsibility for the state of the environment and, as a result, contribute to these improvements themselves. In summary, this study scrutinizes whether Chinese people who have so far not gained much experience with market economy are able to express their utility in monetary terms.

**Keywords:** China, contingent valuation, rubber

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## ***Acacia senegal* (Gum Arabic Tree): Present Role and Need for Future Conservation in Sudan**

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Sudan is the largest African country (2.5 million km<sup>2</sup>) situated in the northeast corner of Africa, (latitude °4' 23 North, longitude °22' 38 East). Sudan shares common borders with nine African countries. Sudan has a tropical climate. From the north to the south, the climatically determined vegetation zones are: desert, semi-desert rainfall woodland savannah on clay soil, low rainfall woodland savannah on sand, high rainfall woodland savannah, special forests and the montane forests.

Insects and pathogens are integral components of forest ecosystems and normally are present at a relatively low density, causing little damage and having negligible impact on tree growth and vigour. From time to time, however, some species may quickly reach damaging densities, spatial distribution may increase and the outbreak may persist for a variable time before subsiding. Such large populations may have adverse effects on many aspects of forests, such as tree growth, survival, yield and quality of wood and non-wood forest products, and soil and water conservation. Pest outbreaks are costly to control and may cause considerable damage, compromise national economies, local livelihoods and food security. *A. senegal* tree is drought resistant, dominates the vegetation cover and exists in the wild as well as on cultivated land. It grows mainly on sandy hills, but also well on cotton soil. Gum arabic produces revenues for the farming communities of gum belt, and contributes significantly to Sudan exports. Besides gum Arabic production *A. senegal* is a multifunctional tree, which has been used for desertification control, reestablishment of a vegetative cover in degraded areas, sand dune fixation and wind erosion control.

The tree faced many problems including pests and diseases. It is e.g. vulnerable to the attack of termites, locusts (*Anacridium melanorhodon*), grasshoppers, longhorned beetles and borers, as well as goats and camels. Fires kill off seedlings and damage the trees. A good deal of damage is caused through cutting off large branches. Moreover, *A. senegal* is also attacked by fungi.

The study focus on pest control strategies, agroforestry systems, crop rotation and tree management, as important instruments to contribute to the conservation of the tree

**Keywords:** *Acacia senegal*, biodiversity conservation, pests, Sudan, tropical forest

## **Socio-Economic and Ecological Assessment of Forest Products Harvesting in Central Aceh and Bener Meriah District Nanggroe Aceh Darussalam – Indonesia**

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This study was carried out to assess the socio-economic and ecological impacts of forest products harvesting in Central Aceh, Indonesia. The assessment included: *Pinus merkusii* and other non-timber forest products (NTFP). The study focussed on the utilisation of *P. merkusii*, economic analysis of existing timber harvesting operations and comparison with Indonesian reduced impact logging guidelines. Also the contribution of NTFP to the livelihoods of the local people in the area, their vulnerability to harvesting, and availability trends were studied.

Data were obtained by using semi-structured questionnaires for open interviews with farmers and concessionaires in the study area. Data analysis was done by employing gross margin analyses, and descriptive and differential statistics.

The results showed that reduced impact logging guidelines are not yet implemented in this region. Forest concessionaires in the study area had an average profit of Rp 197 m<sup>-3</sup> from logging activities. Logging also contributed to the welfare of local people in terms of job opportunities and the implementation of agro-forestry programs. The harvest of NTFPs is an additional activity, contributing about 25 % to the income of the local people in this area. The proportion of NTFP harvesters is low and species are mainly sold to collectors in Central Aceh and Bireun. The intensity of NTFP harvesting is affected by road conditions and market locations.

**Keywords:** Ecological survey, harvesting, NTFP, *Pinus merkusii*, social-economic assesment, logging



## Comparative Evaluation of Labour Use and Profitability of Renewable Soil Fertility Replenishment Technologies in Southern Africa

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The degradation of soil fertility in Sub-Saharan Africa is a major threat to food production in Africa. The problem is caused by increases in human population that have led to a reduction in per-capita land availability and a breakdown of the traditional fallow system as well as the low or non-use of fertilisers due to high costs. A number of practices based on nutrient recycling principles have been developed to assist smallholder farmers improve their soils. Information on the labour use requirements and profitability of these practices has been lacking. Based on field research conducted in eastern Zambia, this study estimated the labour inputs and the financial profitability of different soil fertility management practices (SFM). Results show that when aggregated over a five-year cycle, the labour inputs used in agroforestry fields were lower than that in fertilised maize fields that were cultivated continuously but higher than in non-fertilised fields. Both the total quantity and timing of labour requirements during the farming season in other crop fields managed by farm households are important to farmers. With Net Present Value (NPV) ranging between \$233 and \$309 per ha, agroforestry-based practices are more profitable than de facto farmers' practice (continuous maize production without fertiliser) which yielded an NPV of \$130 ha<sup>-1</sup>. However, agroforestry practices were less profitable than (subsidised) fertiliser which yielded NPV of \$499 ha<sup>-1</sup> and non-subsidised mineral fertiliser which had NPV of \$349 ha<sup>-1</sup>. The return to labour per person day was \$3.16 in subsidised fertilised fields, \$2.56 in non-subsidised fertilised maize, between \$2.55 and \$1.90 for agroforestry and \$1.10 in unfertilised maize fields. These returns compared with a daily agricultural wage rate of \$0.60 in the study area. Quantity and temporal distribution of labour requirements are important for technology evaluation. Price of maize grain, labour wage rate and cost of fertiliser exerted greatest influence on the financial profitability (and hence potential adoptability) of land management practices. Agroforestry has the potential to contribute to soil fertility replenishment and improved livelihoods of smallholder farmers if they are properly targeted to geographic and social niches and, disseminated in conducive policy environment.

**Keywords:** Agroforestry, benefit cost analysis, nutrient cycling, project analysis

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## Global Importance of NTFPs: A Perspective over Time on Trade, Conservation and Socio-Economy

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Almost every paper dealing with Non Timber Forest Products (NTFPs) emphasises their importance. But real value and importance are not assessed properly at a global scale. There are several reasons which hinder the proper evaluation and monitoring of the value of NTFPs in global context. The information bases is obscured by a highly diverse resource and mutually exclusive or multiple indifferent NTFP Bideüses. Often information bases about local consumption and domestic commerce is poor. Additionally, foreign commerce statistics give only a biased view on values and importance. Value adding processes using NTFP resources may not be distinguishable within the trade data. Furthermore, their value is seldom sufficiently reflected over time with respect to their ecological functions and social uses. Additionally, effects of global market pressure battled over local markets may further imbalance importance and price of NTFPs.

This paper will underline the need of a global strategy to integrate a general NTFP production and management approach into conventional forest management systems. Therefore, the global significance of NTFPs and management perspectives are highlighted with respects to trade, conservation and enterprise development. For the sustainable management of NTFPs and global conservation issues, the careful assessment of trade, production and the adaption of a new NTFP importance index have to be included. Such an index tool will have a direct impact on future forest management decisions stratified from global level down to local situations. The improvement can be pictured through the support of decision makers aiming to sustain their forest planning and implementation approach in a balanced economic and social manner. At the end, it can be used as a tool for safeguarding NTFP resource base at global level as well as on subsistence level addressing some of the millennium development goals (MDGs).

This study is based on international trade data and significant case studies of selected NTFPs from different regions of the world. Additionally FAO/CG centres databases and national communication reports are used and complemented by expert interviews and discussions.

**Keywords:** Importance index, MDG, NTFP, resource assessment, sustainability

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## **Socio-Economic Conditions of Biodiversity Conservation at the Phnom Kulen National Park Region, Central Cambodia**

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Cambodia is part of the Indo-Burma biodiversity ‘hotspot’. Although deforestation rates rank among the highest globally, extremely little is known about regional conditions for biodiversity conservation. We conducted an explorative study on rural resource use and socio-economic conditions of biodiversity protection in four settlements near Phnom Kulen National Park (PKNP) located 45 km north of Siem Reap (n=149 rural households; 08 to 12/2006). Low levels of conservation infrastructure as well as extensive fields of anti-person mines hinder collection of scientific conservation data.

After years of industrial-scale logging and intensifying shifting cultivation, continuous forest cover is restricted to PKNP. Land use changes following the Khmer Rouge regime and subsequent political turmoil are best described as an open access colonisation of a forest frontier driven by population growth, immigration, and missing land rights. Colonisation proceeded along the main access road from Siem Reap reaching and trespassing PKNP. The entire study area is characterised by smallholder shifting cultivation with short rotation periods, and permanent wet rice production at low intensity. Land availability and average farm size is bigger farther away from town, i.e. closer to PKNP. Here, forest resources (timber, NTFP) frequently contribute to household income. Closer to town, wage labour becomes more important as an income source. We do not find a clear correlation between the use of forest resources as a livelihood strategy and material well-being. This suggests that the investigated smallholders use forest resources to sustain or complement their (low) income levels, or use them as insurance against the risk of agricultural crop failures.

Hunting and consumption of wildlife as well as the use of wildlife for traditional medicine plays only a small role for total household consumption and household income. Availability ratings by local residents indicate low availability of most populations of larger wild animals (exception: wild pigs). The situation has worsened over recent years. Low availability even in PKNP suggests that past over-hunting may have preceded habitat loss. Although levels of wildlife utilisation are low, remaining hunting pressures may still be too high.

**Keywords:** Biodiversity conservation, Cambodia, hunting, income, national parks, shifting cultivation, socio-economics, traditional medicine, wildlife

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# Cultural and socioeconomic aspects of forest management

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## Conflicts over Land and Forest Induced by Reforestation Project in Lao Cai Province of Viet Nam

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In parallel with land devolution the government of Viet Nam has launched reforestation programs aiming to increase the forest cover and to improve the living conditions of local population. In this context, conflicts between state forest institutions and local people over land and forest have been entailed. It is assumed that this situation depends on the lack of understanding of land and forest use of local people and their involvement in the development processes.

This research aims at harmonising local land and forest use and customary tenure with governmental reforestation programme and legal framework. The current use of land and forest of the ethnic minority group of Hmong is diagnosed. The procedure and outcome of reforestation projects are analysed. Furthermore, the study examines the conflicts over land and forest associated with the reforestation, and provides a scenario for harmonising local land use and tenure with legal framework and state forest programs. The “Human Ecosystem Model” is adapted as the conceptual framework of the research. A combination of qualitative and quantitative methods, such as Rapid Rural Appraisal, Land Use Inventory, Forest Inventory and Household Survey, is employed for data collection in three study villages.

The results uncover the systems of land and forest use and customary tenure of Hmong people. Main uses of land and forest are to meet basic needs of local population such as food, shelter, fuel, etc. Little surplus production is commercialised. The reforestation project has followed top-down approach not taking into account the local reality. It has brought about no tangible benefit to the villagers in terms of cash income, forest products, and rights over land and forest. Conflicts between state forest institutions and Hmong villagers over land and forest which are critical for the villagers' livelihood have been found in all villages under study. Resulting data of the empirical research are integrated in the Human Ecosystem Model that in turn provides a platform for a scenario to harmonise local pattern of land and forest use and land tenure with governmental reforestation programs and relevant legal framework.

**Keywords:** Customary tenure, Hmong, human ecosystem model, land/forest use, natural resources conflict

## Contribution of Community Forestry in Reducing Rural Poverty in Nepal

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Nepal is one of the pioneer countries in the world for modern kind of community forestry (CF). CF has proved successful in recovering the degraded forest lands and fulfilling the public demands. Since it has completed its first generation aimed mainly for restoration of once heavily degraded forests, has now shifted its target to achieve sustainable development, rural livelihoods and good governance as the so called second generation issues.

The roles of CF into the reduction of rural poverty has yet to be fully analysed, however the preliminary results in many cases seemed quite encouraging with some exceptional externalities.

Nepal has the 5.5 mio ha (39.4 %) of natural forest out of which 61 % (3.5 mio ha) can be handed over to community as the community forests for the protection, management and utilisation of forests. Presently, about 1.65 million households or 35 % of the population of Nepal is involved in CF management program. To date 14,337 community forest user groups have been formed of which 778 are composed of women only as the committee members. A total of 1,219,111 ha of national forest has been handed over to community. This highly prioritised participatory programme has been widely acclaimed as a successful forest management approach. It has resulted in rural farmers gaining increased access to forest resources, together with the improvements in biodiversity and landscape values.

The CF has been providing almost all the production factors to the community. The CF Programmes could be suitable mode that provides land, labour, capital and enterprises factors and opportunities. In the society like Nepal, where problems of unemployment and under employment is rampant, CF in many places supplies land for timber and non timber production, capital to establish entrepreneurship, the NTFP cultivation, and establishment of cooperatives and so on.

Furthermore, varieties of forest products are collected, used or sold by User Groups and generate fund that is spent mainly on forest and community development activities. It has been estimated that CFs had earned about NRs. 747 million (at user price) and NRs.1.8 billion (at market price) from different sources in a single year 2003.

**Keywords:** Community forestry, forest user group, Nepal, poverty reduction

## **Assessing the Social Impacts of the Natural Forest Protection Program in Local Forest-Dependent Communities in Mountainous Regions in Western China: Case Studies in Gansu Province and Chongqing Provincial Municipality**

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Social Impact Assessment (SIA) has been employed as a development support instrument in various sectors. The objective is to analyze, monitor and manage the social consequences of planned policy implementations, especially in relation to consequences for local population. In forestry SIA has great potential to go a step ahead in sustainable forest management (SFM), taking into account the rural development objectives and local needs. The SIA can be applied before and after the project and programme implementation.

After recent policy change in China, the Natural Forest Protection Program (NFPP) is being implemented in a top down process by central government from 1998 until 2010. Large parts of the Chinese forests are put under conservation with severe restriction for their economic use. The social consequences for local forest-dependent communities are so far unknown.

Objectives of the research are (1) to understand how the NFPP affects the local communities and households in two case study areas; (2) to analyse their current strategies to cope with these impacts; and (3) to identify optimal strategies for a harmonisation between forest management options as NFPP and rural development and local livelihood improvement. The research intends to be valuable to apply SIA practices in SFM in different regional contexts; is seen as relevant for future development in China.

The theoretical fundaments for indicator selection are “Functionalism” and “Human Ecosystem” approaches. Existing case studies from sectors of mining, fishery, and dam construction served to identify the relevant indicators suited to conceptualise social impacts in the local context.

The derived operational framework contains four categories of social impacts and twelve measurable quantitative and qualitative indicators. The empirical field survey serves in a first step to validate the indicators fit to the real world problems in local communities. Social science methods as Questionnaire Survey, Semi-structured interview, Key informant interview, Target Group Discussion and field observation are employed for data collection; SPSS statistic software is used for data processing and analysis.

In 4 villages a total 80 households are being surveyed and interviewed during field survey. In the contribution a first data analysis is presented.

**Keywords:** Forestry policy, human ecosystem approach, natural forestry protection program, social impact assessment, sustainable forest management

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## **Bouncing Back: Rubber and its Capacity in the Restoration of Rural Livelihood in Post-Tsunami Aceh, Indonesia**

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When the 2004 tsunami hit the Indonesian province of Aceh, 170,000 people were killed and infrastructure in the coastline was severely damaged. The natural disaster further aggravated the economic downturn of a province which already had suffered from a decades lasting political conflict. By now, efforts in reconstruction have shown signs of relief, mainly in the construction and mining sector. Before and after the tsunami rubber production is economically important for Acehnese smallholder farmers. Yet, the rubber sector is known for poor quality of the raw product, lack of local processing capacity and market inefficiencies. This study examines the development of income levels and poverty rates in five coastal and inland villages between 2004 and 2007; it also identifies the role of rubber for rehabilitation of rural livelihoods in Aceh.

Detailed household survey data were analysed with descriptive statistical methods and employing the Foster-Greer-Thorbecke-class of poverty indicators. Complementary interviews with key persons in the rubber marketing chain were carried out to identify constraining factors for market participation of smallholder farmers and to quantify costs and margins of traders. Finally the impact of establishing local processing infrastructure on rubber farm-gate prices was quantified; resulting effects on income levels and poverty rates were simulated.

The analyses reveal that land and livestock assets were lost during the tsunami leading to decreasing farm incomes and a doubling of poverty rates in the coastal area. The disaster may also have indirectly battered the hinterland where incomes stagnated, offsetting positive economic effects of the peace agreement, which became possible only after the tsunami.

Alternatively, on-site rubber processing would reduce transport costs for rubber. The resulting five percent increase of rubber farm-gate prices would – assuming competitive markets – translate into eleven percent lower poverty rates in the study villages. However, market inefficiencies may limit the gains for smallholder farmers suffering from low bargaining power. Due to informational deficits, market interlocking and the absence of a quality grading system for rubber, intermediaries in the marketing chain may benefit most, exacting rents. Given market inefficiencies and institutional constraints in the rubber sector some scope exists for policy intervention.

**Keywords:** Aceh, agro-processing, income, poverty comparison, rubber, rural development, tsunami

## **Influence of Culture on Forest Perception and Use among the Okiek in Kenya**

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The Okiek, a traditional hunter and gatherer community in Kenya, have inhabited the highland forests of the country for a long time. Their traditional forest use that has supported their livelihood is hunting and gathering. The Okiek had to stop their hunting activities due to changing political frame conditions, and instead added small farming and livestock keeping to their livelihood activities during the last decades. Yet, honey collection is one of the traditional practices that still possess major socio-economic importance today and simultaneously represent an important symbol of Okiek cultural identity. For example, celebrating the flowering period of certain tree species in different altitudes of the forest still constitutes a vivid tradition that is related to the promise of a plentiful honey harvest and availability of honey-wine, used in most traditional ceremonies. The importance that is assigned to honey production also prohibits the inappropriate use of fire in the forest.

Taking particular reference to the practice of honey gathering, this paper aims to examine how traditional values and attitudes among the Okiek determine their forest use and perception. The adaptive hierarchical structure that displays the order of abstract, long lasting values and guiding principles as well as the real behaviour serves as the theoretical framework of the research.

Participatory observation and qualitative interviews among the Okiek were conducted in 2007. The recorded interviews were transcribed and have been analysed using the software MaxQda2. An intensive secondary literature study, mainly of anthropological literature, has been performed.

The results reveal that values and perceptions are traditionally rooted. They are closely connected to traditional belief systems and an undisturbed social structure. The paper shows which underlying cultural values exist for each step of the honey production. Furthermore the results demonstrate how traditional elements of forest use are integrated in current land use systems and how these elements contribute to sustainable and livelihood oriented land use systems.

**Keywords:** Traditional forest use, Kenya, hunter and gatherer

## Advancement of Forest Certification in Malaysia - The MTCC-Hamburg Project

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The Malaysian Timber Certification Council (MTCC) follows a phased approach in line with guidelines of the International Tropical Timber Organisation (ITTO). MTCC is a non-profit organisation established to operate a voluntary national timber certification scheme in Malaysia. The forest management standard in use, the Malaysian Criteria & Indicators 2002 is based on the principles and criteria of the Forest Stewardship Council (FSC).

Based on former discussions between MTCC and the Free and Hanseatic City of Hamburg (FHH) and the results of round table stakeholder consultations in Hamburg a two year project was launched in mid 2006. The Institute for World Forestry and the Section World Forestry provided scientific backstopping in terms of technical project management for the implementation in Malaysia. A project coordinator was seconded to MTCC for the period of 18 months. German and Malaysian forestry and certification specialists formed a joint project team that worked independently in cooperation with MTCC and other relevant organisations in Malaysia. Project activities included the determination of the degree of performance between the standard MC&I(2002) and the requirements of FHH with regard to public procurement of wood products in terms of a gap analysis. Assessment of the standard MC&I(2002) in terms of the applicability of the verifier level aimed at identification of potential refinement of the standard. Next to internal working packages, five external specialists were contracted to support the project activities. Dr. Bernd Hahn-Schilling (GER), Dr. Alexander Hinrichs (GER) and Dr. Melvin Gumal (MAL) worked on specific aspects within the technical requirements of the FHH guidelines. Dr. Andrea Tuttle (USA) assessed the institutional arrangement in line with the requirements for certification schemes. Mrs. Tor Moi See (MAL) conducted a verifier review.

Interim results were presented to the Malaysian stakeholders during a mid-term workshop in June 2007 and final results during regional workshops in February 2008 in Sabah, Sarawak as well as at the Peninsula Malaysia. A final workshop to disseminate the results to German stakeholders was held in Hamburg in April 2008. Publication of results is envisaged for late 2008.

The project was jointly funded by MTCC, FHH, German Technical Cooperation (GTZ) and German Timber Trade Federation (GD Holz).

**Keywords:** National certification initiatives, Malaysian timber certification council, public procurement, sustainable forest management



# Ecology and genetics of tropical forests

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## Temporal and Spatial Variation in Soil Seed Banks in Elain Natural Forest Reserve, North Kordofan, Sudan

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This study was conducted in Elain Natural Forest Reserve, 26 km Southeast of Elobeid town, capital of North Kordofan State, Sudan. It was carried out in May and December 2004 to estimate soil seed banks in four soil depths (5, 10, 15 and 20 cm) under two densities of trees (88.9 and 150.3 trees per ha). Vegetations (trees, shrubs and natural regenerations) were sampled and number of stems and species composition per sample plot were obtained. Visible seeds were estimated for each soil depth at each tree density. Collected soil samples were exposed to germination under nursery conditions and the germinated seeds were identified and counted. The obtained data were analysed using descriptive statistics and means comparison. Possible co-relations between tree seed density and number of stems per sample plot (0.1 ha) were worked out. Though seven tree species were reported and five naturally regenerated, in the study area, seeds of *Acacia mellifera* were the only detected seeds in the bank. Tree seeds density ranged from 828.6 to 1052.6 seeds m<sup>-2</sup> representing 59.7 to 73.9 % in the top 5 cm soil depth, whereas the highest germinated seeds (trees, shrubs and herbaceous) were 3540.5 seeds m<sup>-2</sup> of which only 10.0 % were tree seeds. The results of the study showed that tree seeds available up to 10 cm soil depth and decreasing with increasing in depth, while herbaceous seeds are vary and available up to 20 cm depth. These findings may be of great values for the upcoming studies in the context of soil seed banks and their impacts on plant biodiversity.

**Keywords:** *Acacia mellifera*, forest reserve, biodiversity, soil seed bank

## Needle Morphological Variation within and among a Population of *Pinus merkusii* in Central Aceh, Indonesia

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*Pinus merkusii*, also called Sumatran Pine, is one of the truly tropical pines in the world, is a native to South East Asia which is extensively distributed in Thailand, Laos, Cambodia, Viet Nam, Sumatra (Indonesia) and the Philippines. It has a large altitudinal range from a few meters above sea level to over 1800 m. It is one of the major plantation species in South East Asia and is favoured for both timber and pulpwood production.

*P. merkusii* is a medium large size tree, reaching 25–45, with a trunk diameter up to 1 m pyramidal to conical crown on young age, and flatter and spreading on old age. The needles are very slender, rigid, straight 15–25 cm long and less than 1 mm thick, green to yellow colour and are found in a pair of two. The two needles in a same fascicle are almost similar in size with just 1 mm different with each other. The needles are persistent for 2 years and its dried leaves weigh around 60–90 milligram per fascicle. The length and shapes of needles, stomatal density etc are dependent on the local environment, CO<sub>2</sub> concentration, the availability of water and light intensity hence the study on needle morphological variation within and among population of *P. merkusii* in central Aceh has been conducted in November, 2007 with the main objective of identifying the needle morphological variability. The length of needles and fascicle, shape of the needle and stomata density are taken as the major traits to identify the variability. Altogether 1820 needles from 90 trees from 6 populations were collected and analysed for morphological traits. Out of these, 60 needles from 6 populations were microscopically studied for stomata density. Furthermore, 10 needles (all are 2 months natural dried) from each population were weighed and length measured for the analysis of needle length - weight relationship. Statistica 6.0 programme has been used for the statistical analysis and interpretation of data.

The lengths and shape of needles are found significantly different according to population whereas the stomata density is found insignificant.

**Keywords:** Needle, *Pinus merkusii*, population, sites, stomata, stomata density

## Synergistic Effects of *Rhizobium* sp., *Thelephora* sp. and Arbuscular Mycorrhiza Inoculation in Improving Seedling Growth of *Paraserianthes falcataria* (L.) Nielsen

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*Paraserianthes falcataria* (L.) Nielsen, in Indonesia called “Sengon” is a leguminous tree species widely grown for timber and used in reboisation programme in Indonesia. It is a valuable multipurpose tree for the humid tropics. One of the fastest growing of all tree species, it is used for pulp and other wood products, fuelwood, ornamental plantings and shade for coffee, tea, cacao and cattle and has good effect in the protection of soil by erosion. However, the quality of seedlings that produced by the farmers is still low. The application of beneficial microorganism is an interesting alternative to improve the seedling growth and might be an alternative or supplement to chemical fertilisers and fungicides. In this study, the synergistic effect of indigenous *Rhizobium* sp., *Thelephora* sp. and arbuscular mycorrhiza (AM) inoculation on improving seedling growth of *P. falcataria* plants was investigated in a greenhouse experiment. Single *Paraserianthes* seeds were cultivated in pots each of which containing 2 kg sterile soils/sand mixture (3:1) with and without *Rhizobium* sp. (1 g nodule per 10 ml with concentration of application 20 ml per pot), *Thelephora* sp. (1 g fruit body per 10 ml with concentration of application 20 ml per pot), *Glomus* sp. (250 g infected soil per pot) or none of both as control. 50 N, 50 P, 100 K, 50 Mg kg<sup>-1</sup> soils were fertilised.

Soil inoculation with the selected *Rhizobium* sp., *Thelephora* sp. and *Glomus* sp. strain significantly improved the seedling growth of *Paraserianthes*. Seedling height and diameter stem of *Paraserianthes* was positively affected by both microorganism. The seedling biomass production of *Paraserianthes* was positively affected by both inoculums and was even higher in the combination of both inoculations compare to single application and untreated control. Moreover, roots of *Paraserianthes* were not only healthier but also showed a significantly higher percentage of AM infection in combination treatment of both inoculums, indicating the sinergism between both microorganisms. The level of AM-propagules in the soils were not generally low but rather indirectly as consequence of poor root development. The results suggest that both microorganisms are suitable as bioeffector agents that may ameliorate plant growth and health

**Keywords:** *Glomus* sp., leguminous tree, *Paraserianthes falcataria*, *Rhizobium* sp., *Thelephora* sp., arbuscular mycorrhiza

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## **Dentrometrical Characterisation of a Common Plant Species (*Anogeissus leiocarpa* (DC.) Guill. & Perr.) in Pendjari Biosphere Reserve and it's Surrounding Land (Benin)**

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*Anogeissus leiocarpa* is a dominant plant species of woodlands on non-flooded soils. This species is a more used fire wood in peripheral of the Pendjari Biosphere Reserve (PBR). The present study examines the dynamic of the species' population using the size class distribution in Pendjari Biosphere Reserve comparatively to surrounding areas.

Globally, 15 and 10 plots sized 30 m × 30 m were respectively established in PBR and its landuse area. Plots were established in landuse areas' riparian forest and the Reserve' mosaic forest–savannah. Dentrometrical parameters such as diameters of individuals which dbh ≥ 10 (d), basal areas, heights, size classes distribution of diameters and heights, densities of individuals which dbh < 10 cm and dbh ≥ 10 cm were calculated. Both zones were compared using the t-Student test (for diameters, heights and basal areas) and the Man-Whitney test (for densities). The size class distributions of diameters were analysed using median dbh and Skewness' coefficient. Statistical analyses were performed using Minitab 13.2.

No significant change appeared in the small size class diameters. The big diameter classes (30–60 cm) showed important numbers of individuals in the landuse areas. Moreover the landuse showed higher Median dbh (14.09 versus 11.70 cm in the reserve) with the lower Skewness coefficient ( $\beta_1=0.48$  versus 0.73 in the reserve). These results highlighted a positive asymmetry distribution by size class diameter in both zones. Big diameters individuals are more important in landuse area than in Reserve. *A. leiocarpa* population is younger in the Reserve than in landuse area where its habitats were reduced to the riparian forests. The class “8–12 m” showed the high frequency of individuals for both zones. These differed significantly for some dendrometrical parameters such as: **(i)** individuals' diameters ( $d = 17.82$  vs  $22.39$  cm) with the lower values in protected area; **(ii)** density of individuals with dbh < 10 cm (respectively  $D1=230.30$  vs  $104.76$  stem ha<sup>-1</sup>) and; **(iii)** density of individuals with dbh ≥ 10 cm (respectively  $D2=274.74$  vs  $176.19$  stem ha<sup>-1</sup>) with higher values in protected area. Basal areas and heights were identical. Our results indicated that *A. leiocarpa* would be threatened in the peripheral while apparently healthy in the Reserve.

**Keywords:** *Anogeissus leiocarpa*, Benin, dentrometrical parameter, size class distribution

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## Identification of Tree Growth Limiting Soil Parameters in the Savannah Regions of Northern Brazil

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Since 1999, savannah areas located in northern Brazil, Federal State of Roraima, have been afforested with *Acacia mangium* Willd with the objective of timber production on marginal sites. Thereby the added value of this economically underdeveloped region is increased and new jobs are created.

*A. mangium* is generally well adapted to acid and nutrient poor tropical soils. Nevertheless growth differences can be observed within the Brazilian plantation sites. Depending on their growth performances, three different yield classes have been defined. The aim of the current study was to investigate, by means of analysis of soil and foliar nutrition levels, whether these growth differences can be referred to nutrient deficiencies or imbalances. Results of these investigations were compared with data from nearby natural forest stands. Furthermore the impact of *A. mangium* plantations on physical and chemical soil parameters in the course of time was studied.

In terms of soil and leaf nutrient contents variance analysis reveals no significant differences between the yield classes. However, natural forest stands show significant higher contents of organic matter ( $>20 \text{ mg dm}^{-3}$ ) than the plantation areas ( $13\text{--}17 \text{ mg dm}^{-3}$ ). Overall, most nutrient stocks both in soils and leafs are on a very low level according to several literature studies. Especially N, P, K, Ca, Mg and S contents range in the deficit level. In contrast Fe, Mn and B can be found on optimum levels or even above.

Furthermore pH values of plantation soils decrease after afforestation. Accumulation of organic matter does not occur in the expected dimensions therefore no enrichment of organic matter was observed with increasing plantation age. Slightly negative correlations between tree growth performances and soil nutrient contents were found.

The results reveal that inadequate growth performances cannot be explained by lack of nutrients. Nevertheless, periodic refilling of the soil nutrient stocks probably provides beneficial effects regarding tree growth.

In future, potential afforestation sites should be selected more carefully, especially regarding the water availability during the dry season since this seems to be the most important factor influencing tree growth.

**Keywords:** *Acacia mangium*, Brazil, savannah-afforestation, soil and foliar analysis, tree growth limitation

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## **Climate Change, Landscape Dynamics, Land Use and Natural Resources in the Atlantic Forest of Rio de Janeiro**

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This research project addressed the objectives to develop an assessment framework for understanding the causes and processes of landscape change, taking into account relevant aspects of global change, in particular future climate conditions. The second objective is to assess the ecological and socio-ecologically viable concepts to establish forest connectivity in dynamic rural landscapes in the Atlantic Forest of Rio de Janeiro. Assessment of economic and ecological impacts of land-use and land-use change to define appropriate land-use systems related to landscape context and environmental changes, and finally, to design planning tools for decision making for natural and agricultural resources management and conservation under multiple objectives. The main outputs of the project are the understanding of natural and socio-economic systems behaviour in short-term and long-term, focusing on the interactions between water quality and availability, agricultural production and environmental resilience. Understanding causes and processes of landscape change, and the effects of the climate change on the natural and agricultural systems. The second output is an ecological and socio-ecologically viable concepts to establish forest connectivity in dynamic rural landscapes in the Atlantic Forest of Rio de Janeiro. Economic and ecological evaluation of land-use systems (agriculture, economic forestry and husbandry) within their specific landscape context and adaptation of those systems to the local environment. Comparative assessment of primary forest and secondary forests to classify the forest systems, and finally, define information requirements of implementing institutions in regional planning and conservation in relation to climate change and landscape dynamics. Design tools for the elaboration of sustainable development strategies for the Mata Atlântica region taking into account relevant aspects of global change on private level (farm level) and on public level (natural park administration, and municipality administration).

**Keywords:** Atlantic forest, climate change, land use, landscape dynamics

## Evaluating Community Forest Management in Sustainability Perspective

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Even with the highest priority for Community Forestry (CF) in Nepal, the sustainable management of the forest has remained as unsolved issue in common property resource management. With the twin objectives of evaluating the sustainability and analysing the current CF management system to suggest a model of yield regulation for maximum economic and ecological benefit, the research work was carried out in two different types of community forests of Chitwan district in inner Terai region of Nepal. Forest inventory with systematic sampling design with post stratification and social surveys were carried out to provide biophysical and social information for the analysis.

While CF outside buffer zone has a big potential of forest product utilisation as of its high stocking ( $176.7 \text{ m}^3 \text{ ha}^{-1}$ ), the CF in riverine flood plain of Buffer zone has the potential of fulfilling the multifarious objectives ranging from forest products to habitat conservation for many wildlife species to promote ecotourism.

On the basis of biophysical conditions of forests and socio-economic needs of users, the objectives of maximum wood production and soil conservation for community forest outside buffer zone; and objectives of maximum biomass production and habitat management are proposed to reset for community forests outside and inside buffer zones respectively in order to achieve the goal of sustainability and maximum benefit. Even-aged management system adopting Breymann method of yield regulation with different possible mode of regeneration is proposed as the best management option for Baghmara Community Forest in protected area buffer zone. Stem number guide curve method in Uneven-aged management system with selection cutting has been prescribed for yield regulation of CF outside buffer zone. With the application of prescribed yield regulation technique users in outside buffer zone CF can get the wood volume at the rate of 9 folds of present timber harvest and CF in buffer zone can sustain ecotourism industry in long run by maintaining viable wildlife population in their forest.

**Keywords:** Community forest, sustainability, yield regulation

## **Vegetative Propagation Study Using IAA on some of Sudanese Forest Trees in Kordofan, Sudan**

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Vegetative propagation provides an alternative source of planting stock for a wide range of useful indigenous species. The research was carried in Kordofan state, which is characterised by sparsely vegetated as a result of the low amount of rainfall, deforestation and desertification. The study investigates the effects of different concentrations of growth hormone indole acetic acid (IAA) on five indigenous trees (*Acacia senegal*, *Acacia seyal* var. *seyal*, *Grewia tenax*, *Acacia tortilis* and *Boswellia payrifera*). The work was carried out by completely randomised block design with three treatments, two concentration of the IAA (1000 ppm, 1500 ppm) and the control (without hormone). Each treatment was applied to 45 cuttings divided in three replicates. Cuttings were taken from selected adult trees with length of 15 cm in early morning and planted in pure sandy soils in well-drained pots and put in a normal room temperature in the nursery. The data was analysed with analysis of variance. The results showed that the IAA growth hormone generally accelerated and enhanced the budding and rooting of the cuttings, but the effect of the IAA is different among the tree species. The overall effect of propagation hormone (IAA) on final budding was significant ( $p < 0.05$ , ANOVA), the highest length values being recorded in *Grewia tenax* (9.6 cm in 1500 ppm IAA) and *Acacia senegal* (4.2 cm in control). Cuttings of *Boswellia payrifera* and *Acacia tortilis* gave roots with the second concentration of IAA (1500 ppm) and the control treatments. The study concluded that, using of IAA for these forest trees gave successful propagation, and can be a source of uniform plants of known genotype and for the provision of genetic information. As a result of this study, the following recommendations may be made for using IAA in forest trees propagation under different concentrations, tree ages and environmental conditions.

**Keywords:** IAA, Kordofan, Sudanese forest trees, vegetative propagation

## Dynamics of Traditional Ecological Knowledge, Local Use and Conservation of Native Trees and Shrubs in the Bolivian Andes

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Native trees and shrubs are essential components of rural landscapes in the semi-arid inner-Andean valleys of Bolivia. They can be found as hedges and bushes in various agro-ecosystems such as terrace walls, slopes, field boundaries and fallow land. Their distribution and floristic composition are the result of dynamic spatial and temporal interactions between local farmers and the environment. Local uses of natural resources and biodiversity reflect the constantly evolving Andean culture, which can be generally characterised as an intertwining of the human, natural, and spiritual worlds.

The aim of the present ethnobotanical study was to analyse the dynamics of traditional ecological knowledge, to ascertain local farmers' perceptions and uses of native woody species in Andean communities and to associate the results with local conservation activities for the trees and shrubs concerned. Our case study was carried out within two communities of the Tunari National Park (Dept. Cochabamba) in Bolivia. For data collection, research methods from social science (semi-structured interviews, participative observation, participatory mapping) as well as vegetation surveys were combined. Local actors included women and men of all ages as well as families from different social categories and altitudinal levels of permanent residence. Our study indicates that, due to a multitude of socio-economic pressures (*e.g.* migration of young people) as well as changes in use of biodiversity (*e.g.* replacement of native by exotic introduced species), the traditional ecological knowledge base of native trees and shrubs and their respective uses has become diminished over time. In many cases it has led to a decline in people's awareness of native species and as a consequence their practical, emotional and spiritual relationships with them have been lost. However, results also show that applied traditional ecological knowledge has led to local conservation strategies, which have succeeded in protecting those tree and shrub species which are most widely regarded for their multifunctional, constant and exclusive uses (*e.g.* *Schinus molle*, *Prosopis laevigata*, *Baccharis dracunculifolia*). The presentation will discuss the question if and how applied traditional ecological knowledge positively contributes to local initiatives of sustainable use and conservation of biodiversity in rural areas.

**Keywords:** Andean culture, biodiversity conservation, Bolivia, ethnobotany, multifunctional use, perception, rural landscape, shrubs, traditional ecological knowledge, trees

# Ecology of Mexican forests

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## Canopy Openness and LAI Estimates in Mixed Pine-Oak Forest with Different Management System in Northeast Mexico using Hemispherical Photography

MARCO AURELIO GONZALEZ TAGLE, WIBKE HIMMELSBACH, JAVIER JIMÉNEZ PÉREZ

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Structural variation in mixed pine oak forest canopies influences light availability and distribution. In temperate mixed forest, natural and man-made small scale disturbances produce canopy openings that are an important source of heterogeneity in forest understory light regimes, and play a critical role in determining patterns of tree regeneration. The canopy structure in mixed pine-oak forest was characterised using hemispherical photography technique. The experimental study was carried out in two stands: one stand without thinning (SM) and other with thinning (mainly used for firewood). The objective of this study was to determine how canopy openness (CO) is affected by selection cutting, and how the CO influences the woody regeneration. The parameters used to characterise the forest canopy were the canopy openness (CO) and the leaf area index (LAI). We took nine hemispherical photography per plot, at 1.3 m above-ground. Forest structure was measured in three compartments (A) 500 m<sup>2</sup> for tree species  $\geq 10$  cm, (B) 100 m<sup>2</sup> for individuals with  $\text{dbh} \leq 10$  cm and  $\text{dbh} \geq 3$  cm and (C) for all woody species  $\text{dbh} \leq 3$  cm. The results on forest structure showed that the species richness for the compartment A do not shown significant differences between the stand SM ( $3 \pm 1.2$ ) and the stand CM ( $3 \pm 1.2$ ). Moreover, no significant differences were found on compartment B, but significant differences were found on compartment C. A higher species richness were found on stands SM ( $9.4 \pm 2.6$ ) in comparison with the stand CM ( $3.8 \pm 1.3$ ). The canopy openness (CO) values varied between 22 %-35 % on both stands. On the other hand, the LAI on the stands (SM) varied from 1.1 m<sup>2</sup> m<sup>-2</sup> to 1.7 m<sup>2</sup> m<sup>-2</sup>, while on the stands (CM) the LAI values ranged from 0.9 m<sup>2</sup> m<sup>-2</sup> to 1.9 m<sup>2</sup> m<sup>-2</sup> for the month of February 2007. Finally, the results obtained confirmed the usefulness of hemispherical photographs in forest ecology and direct future research in mixed pine-oak forest in the Sierra Madre Oriental, Mexico.

**Keywords:** Canopy openness, hemispherical photographs, Mexico, mixed pine-oak forest



## Environmental Influences on Forest Structure and Woody Species Diversity after Forest Fires in Mexican Pine-Oak Forest

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Forest fires in pine-oak forest in Mexico's Sierra Madre Oriental have had a remarkable relevance since the extraordinary fire season in 1998, due to their direct contribution to deforestation, changes in forest structure, species composition, and recently to their impact to the increment of carbon dioxide in the atmosphere. Nevertheless, few studies have investigated post-fire stand dynamics or natural regeneration. The influence of environment, fire year and stand location on natural regeneration was studied in 23 post-fire stands in the Mixed pine-oak forest of Nuevo Leon state.

Our goal was to describe the present forest structure and woody plant species composition along a fire chronosequence in pine-oak forest in the SMO to (1) increase the understanding of successional patterns in mixed pine-oak forest in this region, and (2) to relate successional patterns to environmental variability. Besides using time-since-fire as a control variable, other parameters may also have an impact on forest succession and woody plant species composition, thus we included analyses of site aspect, elevation, slope and potential solar radiation. Multivariate analyses showed that local environmental factors, including fire year, continue to structure species composition. Environmental factors explained 45 % of the species variance. *Arbutus xalepensis*, *Ceanothus coeruleus*, were clearly associated with stands with lower slopes and younger post fire stands while *Quercus canbyi*, *Quercus laeta*, *Quercus polymorpha*, and *Quercus rysophylla* were associated with steeper slopes and higher incomes of potential solar radiation. Older post fire stands, appear to be associated with lower elevations stands dominated by *Pinus pseudostrobus*, *Juniperus flaccida*, *Quercus laceyi*, and *Cercis canadensis*. *Quercus virginiana*, *Prunus serotina*, and *Juglans mollis*, were associated with stands that had experienced the most recent fires of all. The woody species composition and abundance in post-fire stands appeared to be determinate by a complex of environmental factors, including fire. Different species were clearly favoured in stands with different topographic and different fire histories. Fire history varied with elevation, implying that topography and fire may exert mutual influences. Thus, while current forest fires in the Sierra Madre allow natural regeneration to continue, Mexican foresters should consider incorporating natural disturbance regimes into their management practices.

**Keywords:** Forest fire, forest structure, Mexico, pine-oak forest, Sierra Madre Oriental

## Water Relations in Native Trees, Northeastern Mexico

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Native trees and shrubs that grow in the semiarid regions of northeastern Mexico are very important feed resources for range ruminants and white-tailed deer. They also provide high quality fuel wood and timber for fencing of range land and construction of domestic goods. Since water stress is the most limiting factor in this region, the present work was focused to investigate the relation and the effect of diurnal and seasonal leaf water potentials ( $\Psi$ ) of native tree species on soil water availability and evaporative demand components. Water potential is the index of water stress. This study was carried out at the Faculty of Forest Sciences of the University of Nuevo Leon (24° 47'N; 99° 32'W; 350 masl) Mexico. The tree species included in this study were: *Cordia boissieri* (Boraginaceae), *Condalia hookeri* (Rhamnaceae), *Diospyros texana* (Ebenaceae) and *Bumelia celastrina* (Sapotaceae). Determinations of  $\Psi$  in the four tree species were made at 10 days intervals between July 10 and November 30, 2007 by using a Scholander pressure bomb.  $\Psi$  was monitored in five different plants per species at 2-h intervals between 06:00 (predawn) and 18:00 h. Air temperature, relative humidity vapour pressure deficit, precipitation and soil water content were registered throughout. Data were subjected to one-way ANOVA and correlation analysis. During the wettest period (Sep-10),  $\Psi$  ranged from -0.72 in *C. boissieri* to -1.30 MPa in *B. celastrina*. Conversely, during the driest period (Nov-30),  $\Psi$  varied from -2.90 (*B. celastrina*) to -6.10 MPa (*D. texana*) revealing high water stress during driest season and *B. celastrina* was more tolerant to water stress. Diurnal  $\Psi$  values were negatively correlated with air temperature and vapour pressure deficit, on the contrary, a positive relationship was found with relative humidity. Gravimetric soil water content and precipitation data were linearly correlated with predawn. The ability of tree species to cope with drought stress depends on the pattern of water uptake, seasonal precipitation and the extent to control water loss through the transpirational flux. Further studies on these and other tree species in the region will help in the efficient management and selection of drought tolerant species

**Keywords:** Drought, native trees, northeastern Mexico, soil water content, water potential, water stress

## Estimation of Carbon Stock from Volume and Biomass Equations in a Cloud Forest Ecosystem in Northeastern, Mexico

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An indicator of climate change is the global warming, produced by the increment of different greenhouse gases concentration in the atmosphere such as the carbon dioxide ( $\text{CO}_2$ ), the methane ( $\text{CH}_4$ ), the oxidise nitrous ( $\text{N}_2\text{O}$ ), the sulfur dioxide ( $\text{SO}_2$ ) and the chlorofluorocarbons (CFC), being the  $\text{CO}_2$  responsible for the greenhouse effect. The use of fossil fuels and the change of soil use are considered as the two main sources of  $\text{CO}_2$  in the atmosphere. The atmospheric  $\text{CO}_2$  is incorporated to the metabolic processes of the plants by the photosynthesis and participates in the composition of all the necessary structures so the tree can be developed like the foliage, branches, crown, roots and the stem. This investigation was developed in the Biosphere Reserve El Cielo, which is located in northeastern Mexico and it is located in the Sierra Madre Oriental, with 19,946 hectares. The main objective of this study was the estimation of carbon stock in the cloud forest ecosystem (*Liquidambar styraciflua*, *Quercus sartorii*, *Q. germana*, *Magnolia schiedanea* and *Podocarpus reichei*). Sample plots were taken randomly ( $1000 \text{ m}^2$ ), in places that did not present disturbance indicator plants and with a high tree species diversity with different diametric categories. With the field data the volume and biomass determination was carried out for different species. To estimate the tree volume the following models were used  $V=a_0*(d) a_1$  (hardwood) and  $V=a_0 + a_1 *d^2 + a_2*h + a_3*d^2*h$  (softwood). To determine the biomass was applied the equation  $b=a_0+(d)$ , and the best carbon equation was  $C=0.69322*d(2.3427)$ , where V is the tree volume, b is the biomass dry weight (kg), C is carbon stock (kg), d is the diameter (1.3 m). This model had the best adjustment in the tree species of the cloud forest ( $r^2=0.95$ ). Subsequently the carbon stock was estimated in the tree stems obtaining  $56.7 \text{ Mg C ha}^{-1}$  for this forest ecosystem. With this procedure we can evaluate the carbon stock in different cloud forest ecosystems in northeastern Mexico.

**Keywords:** Biomass equation, carbon equation, carbon stock, cloud forest ecosystem

## Fitting Species Abundance Models in Tree Strata in a Cloud Forest

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Species-abundance models can be used to detect forest disturbance in ecosystems that had been logged. With the aim of knowing the impact of the selective logging on the distribution of tree species abundance, we analysed the forest disturbance and successional stage of two experimental plots with different historical of management. Four species-abundance models were fitted in the tree strata of two stands with different historical of management in “El Cielo” cloud forest, Tamaulipas, Mexico. Two sampling schemes were tested to evaluate its efficiency in collecting the data needed to fit species-abundance models. The log-normal distribution fitted well the data in the unlogged plot, while for the logged plot none of the abundance models shows a significant fit, however, the species distribution of this plot is developing to a log-normal. The geometric series and the broken stick model did not fit well the abundance data in none of analysed plots. The results indicate that both stands show an intermediate successional grade, between the pionner and climax stages, where the species with middle abundance are the most dominant. The transects were found to be better to collect the data needed to fit species-abundance models in the tree strata of this forest. We found significant evidence that the stand that had been selectively logged is currently in an earlier successional stage compared to the unlogged stand, due to the latter fitted a log-normal distribution, whereas the data for former did not. Contrary to some studies that claim that species-abundance are nor good to detect forest disturbance in sites that had been logged, this study shows that these models can be used appropriately to evaluate whether or not a forest is disturbed.

**Keywords:** Cloud forests, species abundance-models, successional stage

## Social resources

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# Biofuel vs. food and bioenergy crops

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## Economic Viability for Jatropha Production at India's Wastelands: A Scenario Analysis

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India's increasing energy consumption resulting from its economic growth and the expanding transportation sector will contribute to Global Warming. This research investigates the potential of Indian agro fuel, especially Jatropha based fuel production on wastelands. Further we discuss, how the potential of Jatropha can be made accessible for landless and poor farmers as well as how Jatropha fuel could support India's transportation fuel and energy demands more CO<sub>2</sub> neutral.

In this analysis a benchmark price for Jatropha fuel competitiveness to fossil diesel is assessed and translated into a maximum price for Jatropha seeds using a value chain approach. As Jathropha fuel options we compare Jatropha pure plant oil (JPPO) and Jatropha methyl ester (JME) according their production costs. The calculated maximum price for Jatropha seeds is used to link the Jatropha fuel alternatives with the Jathropha seed production scenarios. To measure the economic viability of three different cost scenarios (low cost, baseline and high cost) we apply financial analysis and compare the different net present values.

As our focus is to estimate at which range of crude oil prices and interest rates Jatropha seed production becomes economically viable results show that Jathropha fuel production become competitive to fossil diesel if crude oil prices reach levels above US\$ 75 per barrel (low cost scenario JPPO, interest rate 6 %). Even as JME has higher production cost as JPPO we conclude that both have the potential to serve as renewable energy source, but a higher value for Jatropha farmers could be achieved with JPPO production.

We conclude that, the economic viability of Jatropha fuel can and has to be increased through improved breeding regarding yields and oil content, lowering of production costs, increasing processing efficiency and the development of decentralised JPPO usage as fossil diesel substitute. Further, the findings suggest that the Indian state and federal governments need to provide assistance and clear framework conditions for the future to allow the diffusion of Jatropha fuel production in India.

**Keywords:** Agro fuel, bio fuel, India, *Jatropha curcas*, renewable energy, wasteland

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## Physical, Mechanical and Chemical Properties of *Jatropha curcas*

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Lack of energy resources and increasing energy demand is a worldwide recognised phenomenon. Biofuels are well known as an alternative source of energy, physic nut (*Jatropha curcas*. L) is a drought resistant shrub belonging to the family *Euphorbiaceae* and is an eminent plant for biofuel production. The role of *J. curcas* as a substitute of fossil fuel is remarkable. Cultivated in Central and South America, *J. curcas* was distributed by Portuguese seafarers in Southeast Asia, India and Africa. The plant and its seeds are non edible (toxic) to animal and humans; toxicity of seeds is mainly due to the presence of curcine and deterpine. The post-harvest technology, physical, mechanical and chemical properties of *J. curcas* nuts and kernels were investigated and reported. The physical properties studied embrace: moisture content, 1000-unit mass, geometric mean diameter, sphericity, bulk density, solid density, porosity, surface area, specific surface area, static friction coefficient on various surfaces, angle of repose and suspension line. The chemical properties include oil content in seed and kernel, crude protein in seed and kernel, ash content, free fatty acid, iodine value, acid number, saponification value and gross energy in seed and kernel. The mechanical properties were rupture force, deformation at rupture point, deformation ratio at rupture point, hardness and energy used for rupture (toughness). In the oil industry, different processes must be done before oil extraction occurs: **(a)** dehulling, separating hull from nut, **(b)** deshelling, separating shell from kernel, **(c)** drying and than **(d)** oil extraction. Physical, mechanical and chemical properties of seed and kernel are needed for the design of equipment to handle, transport, process, store and assessing the product quality.

**Keywords:** Biofuel, *Jatropha curcas*, oil extraction, physical properties

## **Energy Management as a Means of Rural Development- Case Studies of Selected Crop Processing Operations in Nigeria**

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Nowadays the predominant paradigm in conventional agriculture establishes that “technology is adequate whenever an increment in input produces an increase in output”. This kind of statement usually results in an oversimplification of agricultural systems and loss of biodiversity in rural space. Energy management and energy balance measurement in agricultural production and processing are some of the important indicators of the authenticity of this paradigm. The primary objective of any energy measurement scheme is to minimise the energy cost components of the production costs, but not at the expense of product quality or higher overall costs. The knowledge of energy consumption in each unit operation of a production system is useful for determining high energy consuming areas. This study summarises the results of energy audits conducted in selected poultry industries, palm-kernel oil mills and cashew nut mills in south western Nigeria. The results of the study revealed that scalding and defeathering are the most energy intensive unit operations in poultry processing in Nigeria, accounting for about 44 % of the total energy consumption. Out of the seven readily defined unit operations in palm-kernel oil production, cracking, roasting, crushing and oil expression are identified as the most highly energy-intensive operations accounting for more than 90 % of the total energy consumption. Only two unit operations (drying and roasting) have been identified as the most highly energy intensive operations in cashew nut processing mills. This represented over 80 % of the total energy consumption in the mills. These studies have established baseline data upon which energy conservation strategies in these industries can be put in place.

**Keywords:** Cashew nut, energy audit, energy management, Nigeria, poultry

## **Biofuels in Latin America: Ownership Models and Social, Environmental and Economic Risks**

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The models of ownership of the technology of biofuels (land and refineries) determine the structure of economic, social and environmental impacts of biofuels for the long term. Policies for the promotion of biofuels in Latin America (LA) shouldn't imitate those implemented in EU or USA, because these regions do not share similar objectives on biofuels, and because of the weakness of the Latin American institutions in charge of environmental protection and social equity. The strategic objectives of LA in biofuels are i) a reliable appropriation of the energy, ii) the real enhancement of the population's economy, iii) the protection of the environment and iv) the sustainability of the business. The dynamics of a model of ownership is ruled by a tendency toward vertical integration. There are at least four ownership models, with diverse types and intensities of social, environmental and economic impacts. The first model fully integrated requires abundant offer of labour and effective power for seizing large extensions of land. Under this model, long-cycle highest profitable crops like palm are preferred. The monoeconomies promoted with large extensions of land with one crop favours monopsony of labour. Long term crops impose a long application of fertilisers and pesticides. This model is present in Malaysia. A partially integrated model emerges in places with high competition for land, scarcity of labour and high social control. The profit has to be more broadly distributed between refineries and many small farmers. The economic dependence of small farmers on the production of the land, makes to prefer short term crops, favouring soil renewal. Small plants for processing vegetal oils for direct consumption of the producer conforms a third model. The low quality of these fuels is a barrier that impedes the commercialisation but also protects against the risk of prices. A fourth model in which many small producers participate in mid-size refineries could be implemented for promoting regional energy security, short-term crops and the ample distribution of benefits. A policy for the promotion of biofuels focused should first consider the model of ownership.

**Keywords:** Biofuels, Latin America, ownership models

## Competition for Agro-Energy Resources in Germany in a New Era of Global Trends and Strategies and its Implications for the Agricultural Sector in the Tropics and Subtropics

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The agro-energy required to meet the demand for bioenergy in Europe and Germany is partly supposed to come from countries in the tropics and subtropics. Hence, the future development of agro-energy demand and production in Europe and Germany will influence the competition for resources in the tropics and subtropics. In Europe the agro-energy sector has benefited from support schemes aiming at increasing the contribution of agro-energy to the total energy supply. Recent developments however indicate that this endeavour is challenged by a new era of global trends and strategies. The market prices for food crops, costs for energy, agro-energy support schemes as well as technical and institutional innovations affect among others decision making in agro-energy production. Changes of these factors influence the competition for resources. Ignoring these effects can result in a misjudgement of the driving forces and the adoption of unsuitable measures to reduce competition for resources.

The impacts of different scenarios on allocation of resources, income and the environment are assessed applying multi-criteria modelling for regions in Germany. The effects on the competition for resources in the tropics and subtropics are deduced qualitatively based on the scenario results for different agro-energy production and demand levels in Germany. The scenarios are derived from the Millennium Ecosystem Assessment including among others changing costs for energy, increasing market prices for food crops, further support for agro-energy production and different technical and institutional innovations.

Resources allocation and feedstock availability for agro-energy production greatly vary depending on regional endowment and farming systems. The results highlight that the competition for resources is highly sensitive towards changes of energy costs. The analysis reinforces that support schemes are the main driver for the development of the agro-energy sector. Nevertheless, oil price increases undermine the existing support schemes and efforts to promote agro-energy production. The study indicates that the institutional setting has a great influence on the development of the agro-energy sector. The results suggest that the impact of the agro-energy sector development in Europe on the competition for resources in the tropics and subtropics is determined by the setting of global, national and regional institutions.

**Keywords:** Bioenergy, competition, institutions, MEA, multi-criteria modelling, resources, scenario simulation

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## Examining Germination Rates of Seeds of Physic Nut (*Jatropha curcas* L.) from Philippines and Viet Nam

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Due to an increasing demand for energy and lacking energetic resources, biofuels are worldwide recognised as an alternative source of energy. Physic nut (*Jatropha curcas* L.) is a perennial shrub of the tropics and subtropics, which produces seeds containing approximately 30 % of oil. It is drought resistant, grows on poor soils, and is able to increase soil fertility in a long run. Due to its properties, physic nut is promoted by many researchers, NGOs, private entrepreneurs and even governments as a possible solution to combat environmental degradation and shortage in energy supplies at the same time.

Huge plantations in many parts of the world have been established and more are planned for the future. However, propagation up to now is mainly done vegetatively by cuttings, which involves the related problems, such as reduced vigour, transport of diseases, and a shallow rooting system of the propagated plants. When seeds are used for propagation, mainly wild collections are used, with unclear yield potential. In India generally three seeds are sown in one planting whole, to insure germination of at least one seed. One goal of today's research is producing higher yielding cultivars of physic nut. Due to the enormous cost related to breeding of perennial plants, promising planting material of physic nut will have a high price in the future market. Therefore examining of useful propagation methods, selection of propagation material and pre-treatments of seeds for reaching desired germination rates is of high importance.

In the presented experiments seeds from Leyte Island (Philippines) and Son La province (Viet Nam) were tested. Two factors were tested: "Storage time" of seeds and "degree of ripeness" of fruits. Storing the seeds for 20 days after harvest led to an increase in germination rate from 1 % to 92 % (Philippines) and 8 % to 73 % (Viet Nam). The older the fruits the seeds were obtained of, the lower the germination rate.

Success of different pre-treatments was tested additionally on the seeds from Philippines. Plants of seeds that had been soaked in water over night before planting showed the highest survival rate.

**Keywords:** Biofuels, germination, *Jatropha curcas*

## Is *Jatropha* Oil Attractive for Smallholder Farmers in the Philippines? - A Case Study

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As the consumption of fossil fuel is in strong contrast to their limited resources and the effects of greenhouse gases become obvious, the worldwide demand for alternatives increases. Numerous research activities are under way, to make biofuels, such as oil from the *Jatropha* plant (*Jatropha curcas* L.), a substitute for diesel fuel.

This article aims at verifying whether *Jatropha* cultivation can be profitable and compete against existing cash crops such as coconut in the Philippines.

As a first step of the economical analysis, the production cost of *Jatropha* oil is determined, based on primary data collected in the vicinity of the Visayas State University, Philippines. As in this region the major competing cash crop is copra, the Net Present Value (NPV), the Internal Rate of Return (IRR), and the Benefit-Cost-Ratio (BCR) for *Jatropha* and copra is calculated in a second step.

The findings are, that the base scenario's production cost for *Jatropha* oil is 35.62 PHP per kg, which is lower than the current price for diesel fuel of 39.40 PHP per l. The *Jatropha* plantation's NPV is positive, however, its difference to the NPV of copra is so minor, that already small changes in the parameters make *Jatropha* cultivation economically less attractive than the copra production already established. Therefore the non monetary benefits smallholder farmers can expect from *Jatropha*, are important to consider. In contrast to the copra market, which is monopolised by big oil mills and focuses on the international market, *Jatropha* oil production lends itself to decentralised processing and local markets. The oil produced by farmers could fuel their numerous diesel engines, thereby creating a local market and positive multiplier effects for employment and local economic growth.

The article concludes that *Jatropha* cultivation, the expelling and the marketing of the oil is very suitable for benefiting the local economy and smallholder farmers. In principle, they can control the entire value chain of this product as it can be marketed in rural areas without the need of middlemen. With raising fossil fuel prices this product offers an increasing income opportunity for smallholder farmers in the Philippine.

**Keywords:** Copra, decentralised processing, income opportunity, *Jatropha curcas* oil price, Philippines, smallholder farmers

## Jatropha Seed Shells as Energy Source

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The seed shells of *Jatropha curcas* are a promising fuel for combustion technology. Thermal energy can be used for various purposes, e.g. for drying of *Jatropha* fruits or for transesterification of *Jatropha* oil to produce biodiesel. Gross energy of *Jatropha* shells is about 18–19 MJ kg<sup>-1</sup> and therefore comparable to rice husk and wood, which are still known as major energy source for dryers in rural areas of tropical and subtropical countries.

Shells from the de-shelling process are a bulky material which is comparable to rice husk. They consist of 50.9 % carbon, 39.5 % oxygen, 5.8 % hydrogen and 0.8 % nitrogen. Volatile matter and fixed carbon with values of 61 % and 29 % are comparable to rice husk. In general, combustion technologies for such fuels are readily available. However, for small scale combustion units, the technology and its operation have to be adapted accurately in order to reach a complete and clean combustion. In addition, the operation of the furnaces influences strongly efficiency and emission of toxic exhaust gas components. Furthermore, chemical composition of *Jatropha* shell and fusibility of fuel ash are influencing combustion behaviour. However, the fuel characteristics for *Jatropha curcas* seed shells are not yet available.

Therefore, the objective of this study is to investigate physical and chemical properties of *Jatropha* seed shells and to develop a combustion technology to be used by small scale farmers. Analysis of the combustion parameters of *Jatropha* seed shells and the analysis of combustion technologies is needed as a requisite for a systematic design process.

**Keywords:** Combustion, energy, *Jatropha curcas*, seed shell

## Energy Potentials of Some Selected Agricultural Wastes as Local Fuel Materials in Nigeria

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Agricultural wastes are potentially huge source of energy-giving materials. They are as of plant-derived materials that can be used for energy. These include wood, herbageous plants, crop and forest residues, animal wastes, etc. In Nigeria, large quantities of these wastes are produced annually and vastly under-utilised. The practice is usually to burn these residues or leave them to decompose. However studies have shown that these residues could be processed into liquid fuels or combusted/gasified to produce electricity and heat. The main benefits of the use of biomass as energy source are rural development, increase in farm income, market diversification, reduction of agricultural commodity surpluses and derived support payments, enhancement of international competitiveness, revitalisation of retarded rural economies, reduction of negative environmental impacts. Ten agricultural wastes in Nigeria were subjected to ultimate and proximate analyses to determine their energy contents using the method of association of official analytical chemists. The samples are: groundnut shell, yam peels, coconut shell, mango peels, palm oil mill effluents, corn cob, cherry, orange peels, melon shell and black walnut hull. Results of analyses showed that the mean higher heating values of the waste samples are 16 505 kJ kg<sup>-1</sup>, 19 597 kJ kg<sup>-1</sup>, 20 647 kJ kg<sup>-1</sup>, 15 891 kJ kg<sup>-1</sup>, 17 303 kJ kg<sup>-1</sup>, 19 458 kJ kg<sup>-1</sup>, 28 203 kJ kg<sup>-1</sup>, 28 203 kJ kg<sup>-1</sup>, 19 299 kJ kg<sup>-1</sup>, 21 392 kJ kg<sup>-1</sup>, and 21 143 kJ kg<sup>-1</sup> for groundnut, shell, yam peels, coconut shell, mango peels, palm oil mill effluent, corn cob, cherry, orange peels, melon shell and black walnut hull respectively. All the waste samples considered have heat values greater than some well known biomass-fuels and fall within the limit for the production of steam in electricity generation. As a result of this, it is envisaged that industries that use their waste biomass for energy would simultaneously solve a waste disposal problem and save money on their energy needs.

**Keywords:** Agricultural wastes, heating value, Nigeria, ultimate analysis



## Potentials and Constraints of Biofuel Production in Ethiopia

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The last few years have witnessed both a dramatic increase in the price of oil and an increase in the production of biofuels. Recent trends also show that interest in biofuels is expanding towards developing countries where production costs are relatively inexpensive and gives possibility for biofuel to contend with fossil fuel prices. Biofuel has several advantages over fossil fuels especially in landlocked countries like Ethiopia. However, the growing concern in Ethiopia and elsewhere is that an increase in feedstock cultivation will reduce resources available for agricultural production that jeopardises food security to the growing human and livestock population. Five of the 20 feedstock producing companies currently operating in Ethiopia are considered for this analysis. The purpose of the present study was to determine the current and future biofuel production potential and possible challenges in Ethiopia. The analysis focused mainly on nationally and internationally available statistical information.

Results show that, among the promoted feedstocks, Castor bean and *Jatropha curcas* are best suited to the growing conditions of the country. A 25 % cultivation of the contracted land for *Jatropha* would cover the entire blend requirement and provide a surplus of 419.5 and 321 million litres biodiesel based on the B10 and B20 respectively. If half of the area is cultivated, it could significantly displace fossil fuel consumption in the country. Castor, with relatively small land coverage in the country and lower oil yield, even 50 % cultivation can have a maximum production potential of 55.79 million liters which covers 54 and 27 % of the total requirement based on B10 and B20 scenario respectively. If the total castor concession is cultivated, the maximum achievable yield would be 111.57 million liters which could cover 54 % and 108 % of the B20 and B10 case respectively. The projection towards 2020 showed that, if half of the overall leased areas for both crops are cultivated, a surplus of 485.4 and 308.9 million litres can be achieved.

Furthermore, the paper provides baseline data for planners and policy makers on the probable problems of continuous leasing on sustainability of pastoral livelihood and food security.

**Keywords:** Biodiesel, biofuel, castor, Ethiopia, *Jatropha curcas*, potential, scenario



# The multidimensionality of participatory development

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## From Transfer to Co-production of Knowledge - New Challenges for Research and Extension

STEPHAN RIST

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The classical innovation-diffusion model basically conceptualises the spread of innovation as a rather formalised social process that is supposed to follow a 'bell curve'-like adoption; it is supposed to be initiated by innovators which are followed by early adopters, early and late majority take-overs who are leaving behind the 'laggards' (Rogers, 1993). This rather mechanistic understanding is supposed to be initiated by research - which plays a role of innovator - who passes the solutions over to extension services that bring them to the farmers.

In other words, the innovation-diffusion model assumes that there is a clear task division between the actors: Scientists who 'create' new knowledge and technologies that have to be 'transferred' by extension workers to farmers who are supposed to 'adopt' them. Furthermore, the innovation-diffusion model assumes that academic theory precedes practical action. Knowledge is conceived of as being created independently of its use and application, and thus, theory and practice are separated from one another. There is a growing body of scientific works about the general roles of sciences that show that the above summarised 'transfer model' has significant shortcomings, especially when innovations are bound to high degrees of complexity, uncertainty about their outcomes and impacts, or when the views and valuations of the technological innovations are disputed in a wider societal context.

As a consequence, approaches which understand innovations as the outcome of process of co-production of knowledge, based on social learning processes between farmers, scientists, extensions, policy makers and other actors involved are becoming more important.

An overview of basic features of the concept the approach of knowledge co-production and social learning processes lays the ground for presenting the new challenges that research and extension are facing when they are contextualized in these more comprehensive approach for a more comprehensive understanding of knowledge production in the context of rural development.

**Keywords:** Innovation-diffusion model, rural development, social learning

## Modalities of Farmer-led Research with Multipurpose Forages

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The agricultural R & D community still struggles to find a set of coherent technologies and approaches to help households in fragile environments with high risks and poor infrastructure to withstand setbacks and make use of opportunities as a result of changing circumstances. A promising technology is multipurpose forages providing income, food, fodder, shade and soil fertility. They can improve the environmental and socio-economic sustainability of smallholder production systems. A novel approach researching farmer-led experiments with multipurpose forages was evaluated in the hillsides of Honduras, where 200 farmers in 12 communities defined their research objectives and conducted experiments with different forage species. The experiments were farmer-designed and monitored and evaluated jointly by farmers and researchers. Around half of the participating farmers were women.

The variety of forages together with the chosen approach inspired farmers to different research modalities. Of the 169 implemented experiments, the farmers opted to carry out 50 % by individual farmers on individual fields, 25 % on a semi-collective basis in which at least part of the work – planting, weeding – is done as a group. Another 25 % chose a collective approach where all activities were carried out together on fields allocated to the group. The share of individual trials increased with each subsequent research period – increased experience seemed to lead to more individuality. Farmers at higher altitudes tended to conduct experiments more collectively than at lower altitudes. Collective experiments were more likely to be formal than individual ones and showed higher scores, as did female managed experiments. Farmers obtained knowledge and experience with research processes and new forages, which were primarily regarded as a promising opportunity to increase food security. Contacts with research and development organisations as well as interactions with fellow-farmers and other communities were regarded as highly beneficial. Empowerment and self-esteem of women increased. Fringe benefits appeared to be an important incentive to participate in trials. Farmers turned out to be able to assess forage based technologies when given the possibility to experiment freely. In most cases it was sufficient to provide adequate information and to ensure a systematic follow-up.

**Keywords:** Farmer participatory research, food security, Honduras, multipurpose forages, research modalities

## Participatory Action Research on Marketing Fresh Litchi with Ethnic Minority Farmers in the Thai Highlands

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Smallholders of Hmong ethnic minority are growing litchi in mountainous areas in the north of Thailand. As a marginalised group, their bargaining power and market access are limited, being forced to accept the farm-gate price offered by exploitative middlemen. In recent years, growers have got low prices for their fresh litchi fruits to the point that some have cut down their orchards to plant other cash crops instead, such as vegetables. Yet, it is recognised that on sloping lands, fruit orchards are beneficial in minimising soil erosion. Concerns over sustainable land use and rural development have prompted a group of academics from Hohenheim University, Germany, and Chiang Mai University, Thailand, to collaborate and invite farmers to initiate talks with a large supermarket chain that aims to buy directly from growers, thus bypassing the middlemen and guaranteeing higher prices.

The prospect of higher financial benefits has incited 25 farmers to comply with Good Agricultural Practices (GAP) guidelines and to reduce the use of hazardous agrochemicals. They have organised themselves as a litchi grower group and expressed readiness to adapt their cultivation methods to the buyer standards. Drawing on qualitative research methods, such as semi-structured interviews and participant observation of negotiations between academics, farmers and company representatives, our research provides a basis for deriving a coherent framework to sequence innovation adoption in a joint marketing venture. The paper presents the decision-making processes between relevant actors, assesses their influences and identifies key determinants in developing market plans between a large business partner and a small marginalised farmers' group.

**Keywords:** Innovation processes, market development, participatory action research, qualitative research

## **Situation and Problem Analysis in the Naban Watershed: From History to Recent Development**

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In Yunnan province, China, rapid rubber-driven rural development is coupled with a dramatic decline of biodiversity. Within the framework of the “LILAC: living landscapes China” project consortium – the authors are researching the case of the Naban River Watershed. They are looking for relevant options for the introduction, adaptation and diffusion of innovations which may help to conserve the status-quo of biodiversity. The project aims at organisational development, i.e., ways to influence local institutions and structures as well as processes of generation, dissemination and use of knowledge including extension and education activities.

Systemic interventions of this kind require profound insights into the historical as well as the present situation, the problems of various actors and their causal interaction. Based on an analysis of land-use problems, the factors and framework conditions for the adoption and dissemination of innovations within the local and the formal knowledge system are being assessed.

Starting in January 2007, an in-depth situational analysis was conducted in five villages of the Naban He Nature Reserve combining (amongst other PRA tools) extensive observations and narrative life-histories with a stratified, semi-standardised household survey.

The presentation will show the complexity of problems and identify priorities as well as consequences for organisational development. The initial euphoria soon went after preliminary results were analysed, showing a wide field of conflict: between the reserve administration and the farmers but also within the farmers’ groups. Development is strongly linked to rubber, tea and hybrid rice with strong economic forces towards enlarging rubber plantations. Access to these resources is unevenly distributed between villages and ethnic groups. The land tenure system is complicated and often intransparent. Experiences with new crops such as beans, water melons, grapefruit, capsicum are wide-spread but often negative. The potential lies in innovations which may improve the existing plantation system and conserve or even rehabilitate biodiversity.

**Keywords:** Adoption, biodiversity, China, innovations, knowledge systems, organisational development, PRA, situational analysis, triangulation

## Rural Livelihood Strategies, Poverty Alleviation and Sustainable Resource Use in Cambodia: Is Community-Based Ecotourism Applicable?

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Cambodia has been looking for appropriate integrated conservation and development approaches in rural areas, where natural resources are increasingly shrinking from heavy exploitation of resource-dependent communities. Community-based ecotourism (CBET) is promoted as a tool to secure conservation and promote development of rural society, sparking through local communities to the Cambodian state. It has emerged from neo-liberal and neo-populist principles of government and civil society organisations with strong support from international development programs. These stakeholders consider CBET initiative as one of the most ideal driving forces for many projects in national parks, protected areas and biosphere reserves. This initiative is being implemented under two schemes: community-based natural resource management (CBNRM) and integrated conservation and development projects (ICDPs). Yet, there has been no study in Cambodia on how to use it as a sustainable means to stimulate economic activities of local communities whose livelihoods are condemned as destructive and illegal, to reduce poverty, while providing strong incentives for sustainable resource conservation.

Based on theoretical and empirical bases, this study aims to analyse the effectiveness and applicability of developing ecotourism as a tool to address a dual need - integrated conservation and community development - in the core areas of the Tonle Sap Biosphere Reserve (TSBR) in Cambodia. Mixed methods were employed for data collection from a range of all stakeholders and beneficiaries. The analysis involves several methods, namely content analysis, framework matrix, statistical analysis and Ecotourism Opportunity Spectrum (ECOS) model. The findings reveal local livelihood options, environmental governance, the contexts of internality and externality, and the interaction between livelihood security and natural resource management and conservation in TSBR core areas. In addition, the potential, limitation and pitfalls of ecotourism development for contributing to livelihood improvement and diversification as well as to sustainable consumption of natural resources in these areas are critically discussed in this paper. Finally, it recommends six guiding principles for all concerned stakeholders of ecotourism and three major phases of a holistic framework for sustainable conservation and development in these TSBR core areas.

**Keywords:** Community-based ecotourism, integrated conservation and development, livelihood strategies, Tonle Sap Biosphere Reserve

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# Land use and biodiversity conservation

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## Birds of Coffee Lands

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Shade coffee plantations may have similar or higher bird diversity than natural forest. However, coffee and forest differed in species composition. Shade coffee may be beneficial for generalist bird species, but poor for forest specialists. I studied the diversity and feeding ecology of birds in the valley of the Magdalena River (Cordillera Oriental, Colombia). The landscape is dominated by shade coffee plantations, but mixed crops, pastures, gardens, guadua bamboo forests and secondary forest are also present. I caught the birds with mist nets. In addition, observations along transects between 1998 and 2006 were recorded. I registered 110 bird species from 21 families. The families with larger numbers of species are Fringillidae, Thraupidae and Tyrannidae. Pastures and mixed crops are dominated by seedeaters, insectivores and omnivores. The zones with shade coffee and guadua bamboo forests have a high diversity of nectarivores, frugivores and migratory species. The secondary forest, guadua bamboo forests and gardens are important for nectarivore birds of the understory. Hermit hummingbirds follow routes along these habitats to foraging in the inflorescences of Heliconiaceae, Costaceae, Musaceae and Zingiberaceae. Other hummingbirds (mainly non hermits) defend and maintain feeding territories from other nectarivores, including nectar robbers such as the Bananaquit.

Shade coffee contributes to maintain the local biodiversity in agricultural regions by providing habitat for some forest bird species, acting as buffer areas for forest patches and limiting the expected loss of species due to deforestation. Given the large area devoted to coffee cultivation in the Neotropics, more studies are needed to understand and monitor the effects of these plantations on ecological and evolutionary processes at different scales.

**Keywords:** Bird diversity, neotropics, shade coffee plantations

## **Plant Biodiversity Use in SW China: Preliminary Results of Ethnobotanical Research**

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There is a continuing demand for products from wild species, mainly by people living in rural areas to support their daily life and subsistence. Approximately 1–5 % of global food is harvested from natural forest. More than one billion people now live within the world's biodiversity "hot spots". often, these people have a traditional life style that evolved over a long time to cope with specific environments. Traditional land use enabled people to live simply but without destroying their environment - a role model of sustainable land use. In many places, modernisation and implementation of new development policies promotes intensive higher yield agricultural systems resulting in an alteration of the traditional life style. The Nabanhe National Nature Reserve (NNNR) is experiencing such changes. The reserve is located in Xishuangbanna Dai Autonomous Prefecture, along the western banks of Lancang River, South-west China. The reserve harbours eight vegetation types with high floristic diversity. Five different ethnic minorities also live in this area. An ethnobotanical survey was conducted during the dry season in 2007/2008. We used semi-structured interviews to collect data on wild food and medical plants. Interviews were supplemented by field walks. In addition, plant samples were collected for identification. During field work, 94 utilised plant species representing 45 families were identified. Among these wild species 48 are used as food and 49 species are used for medicine. Principal families holding medical plants include Asteraceae (6 spp.), Araceae, Verbenaceae, Lamiaceae, Melastomataceae (each with 3 spp.). For food plants Piperaceae (6 spp.), Apiaceae (5 spp.) and Solanaceae (3 spp.) contributed the highest number of species. The results show that a variety of plants from different families are used by local people in the area. Detailed information about the miscellaneous use of these plant species will be presented.

**Keywords:** Biodiversity use, China, ethnobotany

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## **Plant Diversity Hot Spots along the Eastern Escarpment of the Rift Valley of Northern Ethiopia: Key to Conservation Priority**

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Northern Ethiopia is characterised by rugged and mountainous landscapes. It once was well covered with dense forest. Considering current land use conflicts, it is not feasible to implement broad range conservation strategies at the landscape level. The aim of this study was to identify the diversity rich zone in a landscape where biodiversity conservation may take priority. We measured the plant diversity in two sites using twenty eight quadrats (50m\*50 m). Quadrats were located along altitudinal gradients ranging from 1000 to 2700 m a.s.l. Both transects were selected to pass through Dessea forest which is one of the national forest conservation priorities habitat types. For both transducts vascular plant species richness increased steadily with increasing altitude up to 2000 m and declined thereafter. The minimum species richness was 4 species per plot at the lower altitude, the maximum was 45 species per plot obtained between 1900 and 2100 m a.s.l. Hence, the altitudinal zones in the range of 1900-2100 m can be considered as biodiversity hot spot corridor that require biodiversity conservation priority. Conserving such species rich zones may serve as an important habitat and corridor for birds and wild life. Being a source of seed, conserving such diverse corridors will also facilitate the vegetation restoration activities that are widely undertaken in the degraded zones of northern Ethiopia. The diversity of vascular plants along altitudinal gradients, the different plant communities and their structural composition, including some key stone species, were analysed and will be further discussed.

**Keywords:** Altitudinal gradient, dessea forest, Ethiopia, plant diversity, species richness

## **A Sensitive Question : Biodiversity Conservation with the Local Population: a Case Study in Central Menabe, Madagascar**

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In Madagascar – a biodiversity hotspot of international importance – the villagers depend on the forest for energy, construction materials, foodstuff and medical plants. In addition, conversion of forest provides much needed land for agriculture. Most of the currently proposed management systems for the conservation of forests do not take into consideration villagers' needs. Indeed degradation and deforestation have continuously occurred in places where demand for land and forest products is high.

To protect the biodiversity, the Malagasy government wants to increase the area under protection from 1.7 mio ha to 6 mio ha. In this context it is vital to know how to balance the needs of villagers with the importance of biodiversity conservation. If current management practices continue, who will be winner of the competition between conservation issues and the local population's requirements for forest resources?

The research presented concentrates on the balance between forest-based livelihoods and biodiversity preservation by focusing on the main tree species used by the local households. An inventory of the tree resources was carried out for a total of 120 plots shared between 4 types of forest landscape. The aim has been to come to a specific understanding of stakeholder requirements and strategies in order to identify the needs of villagers with regard to tree resources and their ability to manage the forest resources. Data for the survey were obtained by means of 202 questionnaires made in 7 villages, 11 interviews with actors who use wood in their everyday activities, 12 interviews with members of forest managing associations in 5 villages, 6 interviews with societies that transform wood into furniture and 3 interviews with NGO's about conservation or development.

**Keywords:** Forest biodiversity, forest management, forest products, human-forest interface, Madagascar, land use balance

## **Data, Information and Monitoring – Their Role in Conservation and Management of Natural Resources**

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Sustainability is the guiding principle when it comes to managing natural renewable resources. Sustainability can only be enacted and monitored when sufficient data and information is available that allows targeted planning and focussed impact assessment. In principle, we assume that a good information base is a prerequisite for good decisions; that better information leads to better decisions; and that lack of quality information puts good decisions at risk.

The systematic gathering of baseline data as an input to mid-term planning has a long history in the field of forestry: forest inventories date back to the 18<sup>th</sup> century (about the time when the term “sustainability” was coined by the forest and mining engineer Carl von Carlowitz). Forest inventories have taken a dynamic development during the past century and today they are flexible and versatile tools that adapt to many different situations and target objects; they allow to generate information that is being demanded and used far beyond the traditional forestry sector.

Monitoring for the evaluation of biodiversity and conservation has also been conducted on a regular basis, in particular after the UNCED 1992 in the context of the Convention on Biological Diversity (CBD). The data sources, variable sets, estimation techniques and modelling approaches used in biodiversity monitoring and in forest inventory are very similar and it appears worth while to evaluate their commonalities.

In this paper, the role of data and information in decision processes regarding the sustainable management of ecosystems and of renewable natural resources is discussed. Typical techniques and application issues are presented and discussed, and some future research and application challenges are identified.

**Keywords:** Ecological survey, natural resources, biodiversity evaluation, Convention on biological diversity

## Bushehr Province (N.E. Persian Gulf) as an Important Reservoir for Plant Biodiversity in Iran

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Bushehr Province is a biodiversity hotspot in N.E. Persian Gulf. There are some protected regions in Bushehr that can be considered as *in-situ* conservation sites for plant biodiversity. Desert weather and different habitat zones in Bushehr province (mountainous areas in the eastern parts, coastal area and wetlands in the western part) provide many ecological niches for high spectrum of ornamental, medicinal and otherwise valued plant. Some important examples are *Phoenix dactylifera* (food), *Prosopis cineraria* (protective and ecological), *Prosopis koelzinia* (protective and ecological), *Avicennia marina* (ornamental, protective and ecological), *Ficus bengalensis* (ornamental, protective and ecological), *Amygdalus scoparia* (ornamental and food), *Pistacia khinjuk* (medical-industrial), *Tecomella undulata* (ornamental and protective), *Suaeda fruticosa* (ecological and food), *Ziziphus spina-christii* (food and ornamental), *Ducrosia anethifolia* (medical), *Salvia aegyptiaca* (medical), *Galadiolus italicus* (ornamental), *Bellevalia saviezii* (ornamental), *Ornithogalum persicum* (ornamental), *Aloe vera* (ornamental and medical), *Ricinus communis* (ornamental and medical), *Capparis mucronifolia* (food), *Plantago psyllium* (medical), *Calligonum comosum* (ornamental and ecological), *Alhagi manifera* (medicinal). Connectedness between two ecosystems (mountain and desert) created a natural genetic reservoir in the N.E. Persian Gulf. Khark wild life refuge (island), Kharku Natural Monument (island), Nakhilo-Dayer national Park (island-inland), Heleh protected area and international wetland, Nayband marine national park, Khaeez mountainous reservoir (ecotone ecosystem) Razm Abad and Chah Talkh forest reservoirs represent high value plant habitats and conservation sites. Our ethnobotanical and systematic studies can be used for the determination of new genetic resources in supporting sustainable development. *Ex-situ* conservation of some vulnerable taxa (gene banks) can be used for gene conservation and for enhancing the nutritional and future economic security of farmers in the South of Iran.

**Keywords:** Biodiversity, Bushehr, Iran, ethnobotany

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## Genetic Diversity of the Tropical Legume Genus *Stylosanthes* in Venezuela: An ongoing Project

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*Stylosanthes* is a predominantly neotropical genus of legumes considered as most important for purposes other than grain production (*e.g.* feed, soil cover). Some species have been of particular importance in some regions of sub-Saharan Africa, tropical Asia, and Australia. In Venezuela, however, adoption of *Stylosanthes* species has been relatively low or nil. This is partly due to lack of commercial seed and to the fact that only small efforts have been undertaken to evaluate diversity at the local level. In previous research, a combined taxonomic and biogeographic study based on Venezuelan herbarium specimens and germplasm accessions was conducted. Based on morphological characters, 11 *Stylosanthes* species were identified, and their natural distribution was documented. Nevertheless, there were a number of differences among the populations that were not discernible using morphological analysis, only; a complementary technique is required to assess such differences.

The main objective of the research presented here is to measure intra-specific diversity of Venezuelan *Stylosanthes* species in order to assess whether variations among populations have a genetic basis. To ensure that the diversity evaluated is truly natural, the research concentrates on the variability that occurs in the wild, *i.e.* not considering germplasm conserved *ex situ*. In view of the need to make a compromise between solidity of data and economic feasibility of the collecting activities involved, for each of the 11 species three populations from contrasting environments, covering a large geographic range, were sampled in the dry seasons of 2007 and 2008 (seed and herbarium specimen). The collected seed will be used for molecular analysis of genetic diversity, applying the Simple Sequence Repeats marker (SSRs) technique, the collected herbarium specimens will be used for morphological studies.

As a result, we expect not only to have a better tool for delimiting the species within the genus, based on both, SSR and morphological analyses. In addition, we will have an indication whether the morphological differences among populations have a genetic basis. These results together with the ones we will obtain from further morpho-agronomic evaluations, may lead us to identify particularly promising populations.

**Keywords:** Molecular analysis, morphological analysis, SSRs markers, taxonomy

## Effects of Low-Temperatures and Marking on Survival of the Adult Codling Moth *Cydia pomonella* (Lepidoptera; Tortricidae)

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Synchronizing the laboratory rearing with the appropriate climatological conditions is one of the rear-release-recapture studies dilemmas. Regarding this issue, we evaluated the effect of low temperature on adult codling moths as well as marking on its survival in the laboratory. In order to keep adult codling moths in the appropriate condition before releasing, the effects of low temperature and individual marking were tested on 12–24 h old adults after rearing the codling moth on the artificial diet based on the Ivaldi-Sender formulation with a little modification. In the first experiment which was designed in Factorial format as  $3^3$  and in CRB base, Blocks included male, female and male-female and factors contained lethargic temperatures, marked and unmarked adults. Adults were kept 3 and 5 minutes in  $-20^{\circ}\text{C}$  to make them motionless and lethargic and then marked individually with felt tip pens. Treatments were transferred to incubators in optimum condition (photoperiod of 16:8 h, L:D,  $24^{\circ}\text{C}$  and  $65\pm 5\%$  R.H.) in the cylinders and fed by autoclaved water in soaked cotton. Survival rate evaluated daily for 13 days. In the second experiment, 12–24 h old adults were kept in  $4^{\circ}\text{C}$  during the whole adult life and fed with 10 % sucrose. The survival rate evaluated with two days interval for 27 days. Data were analysed by GLM procedure, SAS. Significances of data were computed in alpha 0.05 %. The results in the first experiment pointed that the differences between the Blocks were not significant, additionally the female had the lowest survival mean. Meanwhile differences in factors were significant. Hence, both of the low-temperatures duration significantly influences adult longevity as well as the marking. Differences between the sexes in the second experiment was obviously significant, moreover the females were more survivor than males.

**Keywords:** Codling moth, marking, moth rearing, survival rate

## Geographical Distribution of the Species *Schoenocaulon officinale* in Venezuela

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*Schoenocaulon officinale* (Schltld. & Cham.) A. Gray ex Benth. (Liliaceae), known under the common name ‘sabadilla’, seems to originate from Mexico and was spread southward by Native American Indians. The species contains alkaloids of the veratrum group and since ancient times, has been used as a natural insecticide. It also has medicinal properties which have been used to treat circulatory and hypertensive disorders. *S. officinale* has been reported to occur in Venezuela; however, little is known about the geographical distribution of the plant which is a prerequisite to undertake wild seed collection.

The objective of the study presented here was to assess the distribution of the species in Venezuela in order to evaluate the feasibility of undertaking wild seed collection. An ecogeographical survey was conducted to identify ecological areas where the species grows, and based on this information; two sites were selected to estimate the species’ population density under natural conditions.

As a result of this survey, it is shown that 1) *S. officinale* grows in four states, *i.e.* Aragua, Distrito Capital, Miranda, and Trujillo, 2) the species is not native to the country but it was probably introduced, and 3) the sampled areas have a mean population’s density of approximately 8.75 plants m<sup>-2</sup>; which represents a minimum potential seed harvesting amount of 83.63 kg ha<sup>-1</sup>. With these results, it can be concluded that wild seed collection of *S. officinale* in Venezuela is feasible. To achieve this goal, strategic cooperation with Venezuelan institutions should be taken into consideration in order to ease the access to the plant genetic resources.

**Keywords:** Insecticide, Liliaceae, medicine, natural distribution, veratrum, wild collection

## Classification and Predictive Vegetation Mapping of Rangelands at the Jabal al Akhdar Mountain, Northern Oman

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Little is known about the distribution and the ecology of plant species as well as the response of the vegetation to environmental conditions in the mountains of northern Oman. Data on the distribution of vegetation are vital for the conservation and the development of sustainable management strategies for rangelands. The aim of this study was to investigate the vegetation patterns of open woodlands along an altitudinal and a grazing gradient on the Jabal al Akhdar and to predict the distribution of vegetation across the rangelands based on the relationship between the spatial distribution of vegetation and environmental variables.

Predictive vegetation modelling requires digital maps of the environmental variables, as well as spatial information on the vegetation attribute of interest. Species composition and vegetation structure were investigated for 62 samples (20 × 30 m) using a nested plot design. The environmental data were either obtained from existing digital datasets or derived from a Digital Elevation Model. Five different vegetation groups were distinguished on the basis of a two-way cluster analysis and an indicator species analysis. Canonical Variate Analysis was used to determine which linear combinations of explanatory variables discriminated best between those groups. An automatic forward selection and associated partial Monte Carlo permutation tests (999 permutations) were performed to test the discriminatory power of the explanatory variables [altitude (m a.s.l.), aspect (°), grazing intensity (from 0 = no grazing to 3 = high intensity), geology (limestone, siltstone, greywacke and basalt), topographic location (wadi or plateau site) and the distance to the settlement (m)]. The topographic location on wadi sites ("wadi",  $F = 21.83$ ;  $p = 0.001$ ), altitude ( $F = 17.26$ ;  $p = 0.001$ ) and grazing intensity ( $F = 14.88$ ;  $p = 0.001$ ) were found to be the most important variables distinguishing between clusters. A modelling approach based on discriminant analysis and logistic multiple regression in combination with a geographic information system was applied to predict the spatial distribution of vegetation types within the study area.

**Keywords:** Canonical variate analysis, cluster analysis, Hajar Mountains, open woodlands, vegetation mapping

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## Vulnerability of Wetlands

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Vulnerability, resilience and adaptation are often used in connection with economics and human risk analysis. These terms are less commonly applied to ecosystems and in this work have been put in relation to wetland ecosystems. Existing definitions and classifications of wetlands are reviewed with respect to their use and concept of vulnerability, resilience and adaptation. The problems that can arise during agricultural use of these very resilient, semi aquatic ecosystems are discussed.

Wetlands fulfil many functions that are important to society. Among these functions are filtration and storage of water, nutrient and sediment retention, biodiversity conservation and flood protection. Through human use wetlands are altered and possibly degraded. This degradation will affect the wetlands ability to fulfil certain functions. The intensity and extent of the use and the ability of adaptation of wetlands are crucial for the degree of change in the functions of each specific wetland.

In this literature review the factors affecting the stability of a wetland are stated and defined. The interaction of factors from the environmental, socio-economic and policy sector are assessed. Wetlands are categorised according to their location (climatic zone), hydrology, and soil type. The agricultural management techniques applied to the wetlands are classified under natural (indigenous), drained (rice-wheat) and wet / irrigated (rice-rice). Yield and productivity declines resulting from possible changes in soil properties are statistically analysed in relation to the wetland categories. Scenarios are derived and being discussed as to how the functionality of a wetland is likely to change under specific management intervention strategies.

**Keywords:** Adaptation, ecological functions, resilience, yield decline

## On the Problem to ‘transfer’ Benefits estimated from Stated Preferences of OECD Citizens for the Valuation of Local Biodiversity Conservation Measures

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Recent estimates of the economic value of ecosystem conservation imply that conservation of primary ecosystems is up to 100 times as beneficial than ecosystem conversion to agriculture or silviculture. A substantial share of these benefits stem from indirect use and non-use values stated by OECD citizens. These ‘willingness-to-pay’ (WTP) figures are then applied to conservation areas in developing countries.

The southern Ecuadorian Andes, *e.g.*, the area of the Biosphere Reserve Podocarpus-El Cónдор (BRPC), are a hotspot of biodiversity. The remaining primary forests are threatened by smallholder encroachment in the northern part of BRPC. Here, forested land is converted to pasture to raise cattle. At a net profit of about 100 USD yr<sup>-1</sup> ha<sup>-1</sup>, cattle farming is the most profitable smallholder land-use option. Selective logging (10 USD yr<sup>-1</sup> ha<sup>-1</sup>) or alder plantations (90 USD yr<sup>-1</sup> ha<sup>-1</sup>) are economically not attractive without external financial support. Does international non-use WTP for the conservation of biological diversity suffice to compensate farmers for lost profits from the non-conversion of BRPC forests?

Menzel (2003) estimated an average WTP of 108 € yr<sup>-1</sup> for German citizens for avoiding the projected loss of a half of 50.000 endangered species in developing countries. Assuming that this figure represents the maximum WTP for additional international biodiversity conservation by each of the 290 million OECD households, roughly 31.6 billion € yr<sup>-1</sup> could be generated. The total area of remaining primary vegetation in the 25 global biodiversity hotspots amounts to 2.123 million km<sup>2</sup> resulting in a WTP for additional conservation of 150 € ha<sup>-1</sup> yr<sup>-1</sup>. At current €/USD exchange rates, this appears sufficient to compensate losses from any agricultural or silvicultural development restrictions.

Among other issues in the application of stated preference studies, the ‘benefit transfer’ necessary to apply international WTP estimates to local conservation problems poses multiple conceptual challenges. Strictly speaking, none of the currently available WTP studies can directly be applied to the BRPC case as the Ecuadorian Andes (or their species) are not explicitly addressed in any of the studies. To improve the situation, new systematically surveyed data are necessary that allow for a flexible spatial reference across multiple scales.

**Keywords:** Benefit transfer, biodiversity conservation, economic valuation, willingness-to-pay, Zamora

# Rural development

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## **The Sedentarisation Process of the Bahima in Uganda: An Emic View**

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The traditional lifestyle of nomadic pastoralists – freely moving with their herds – is under threat worldwide and rapidly disappearing due to many reasons. These include human population growth and the associated pressure that it has on grazing land as well as political and economic pressure. More and more cattle keepers have adopted a sedentary lifestyle and are practising mixed crop-livestock farming and deriving livelihoods from other non-pastoral activities. This is also the case for the Bahima pastoralists of Uganda who are keeping the Longhorned Ankole cattle. The sedentarisation of the Bahima pastoralists in Western Uganda started in the 1940s and is still going on. In this study former nomadic cattle keepers, who have settled with their families, were interviewed in order to document the decision to settle and the subsequent changes in the lifestyle of these people. All interviewees expressed their satisfaction with their sedentary life. Interestingly, pastoralists do not – contrary to the popular, romantic belief in many western countries – enjoy moving so much. Conflicts with other families, loss of people and animals because of diseases or predators and scarcity of water were mentioned as major problems. Traditionally, the Bahima had no home base where they returned to. Depending on feed and water availability, they stayed up to three months in one place.

The idea of sedentarisation started being spread in the first half of the 20<sup>th</sup> century. The majority of the interviewees settled between 1950s and 1970s. Most respondents said it was the decision of the household head to settle and the wife agreed. Others explained that it was a collective decision between husband and wife. Land scarcity, access to education, better availability of water and the possibility of crop production were given as factors for settlement. The decisions were influenced by Christian missionaries, the government and friends.

**Keywords:** Bahima, nomadic life, pastoralist, sedentarisation, Uganda



## **Wildlife Value, Trophy Hunting and Rural Development: With Illustrations from Tanzania**

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This article examines the value of trophy hunting as special form of wildlife tourism, its role and importance as a source of economic growth and rural development, and how its potential could be further developed. The geographical focus lies on Tanzania where wildlife tourism is already well organised and seen as potential contribution to growth. Also, the management approach of ‘Community-Based Conservation’ (CBC) in surrounding areas of reserves and parks stresses the need to incorporate rural communities. Aim is to provide benefits to communities to strength conservation, rural development and poverty alleviation under economic use of wildlife. As reference point, mainly data and findings from the Conservation Program of the Selous Game Reserve (SGR) but also from other countries’ national parks are reverting. The analysis is embedded within the concept of ‘Total Economic Value’ and methods of descriptive statistics, literature review and discussions are applied.

It will be shown that trophy hunting as a direct use value is high-valued through demand and preferences of tourists. In 2003, trophy hunting value of the SGR was approximately US\$ 3.6 million and the single hunters’ willingness-to-pay for a trip was US\$ 6,700. A decomposition analysis reveals the importance of buffalos as high-valued species and tourist fees’ contribution to the entire value.

Under special condition of CBC, the effects for rural development as indirect use value reveal a diametric picture of positive, negative and missing results. Whereas direct benefits like household incomes and job creation are low, managed harvests as ‘by-product’ and indirect benefits like channeling of revenues into projects are more successful.

However, for future incentives, it will be discussed that possibilities and impulses for rural development starting from trophy hunting are caught in a dilemma. Trade-offs between development and conservation as well as other difficulties exist. Exemplarily, trophy hunting creates limited working opportunities while job creation can act against poaching. Contrary, support of agricultural and infrastructural improvements through channeled revenues can work against conservation goals and threat the resource wildlife as basis of trophy hunting. Finally, some recommendations are derived.

**Keywords:** Rural development, Tanzania, valuation, wildlife, willingness-to-pay

## Payment for Environmental Services (PES): A Driver for Promoting Sustainable Land Use and Environmental Stewardship among Smallholder Farmers in Sub-Saharan Africa

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One of the greatest challenges of conventional production technologies used in the agricultural sector in many developing countries is that they are a major user of water resources and they contribute significantly to greenhouse gas emissions. Despite these challenges, there exists some agricultural production systems that are based on natural resource management principles that offer opportunities for producing food while simultaneously mitigating climate change, build up the soil biological capital resource and contribute to the sustainability of land use systems. In most cases however, field level adoption of these technologies by smallholder farmers has generally been limited due in part to non supportive policy and institutional context, among other reasons. The low adoption is particularly more pronounced in low income countries where seasonal food deficits occur, as priorities are placed on food security much more than on the conservation of natural resources and on environmental quality. This paper draws on natural resource economics framework, and uses externality theory to establish that individual farmer's (private) investment in agri-environment technologies will always fall below the social optimum level of adoption of these technologies. To bridge the gap, other approaches beyond "sermons" (moral persuasions) and "police actions" (regulations) are needed. This paper argues for the institutionalisation of Payment for Ecosystem Services (PES) mechanisms as an additional approach to promoting agri-environment technologies.

Taking particular cognizance of the context of Sub-Saharan African countries, we identified options for addressing institutional and policy constraints and facilitate the adoption of agri-environment technologies to unlock its potential to satisfy both food production and global environmental goods. The options include the following: appraisal of regional and national policies to evaluate the extent to which they promote or constrain field level uptake of land use practices; conditional and targeted incentives for agri-environmental land use practices; cushioning financial vulnerability and bridging the time lag between investment and accrual of benefits; investment in information and capacity building of farmers and national extension systems to encourage farming communities to adopt agri-environment technologies; new institutional forms of science policy linkages to bridge the gap between technology developers and policy makers.

**Keywords:** Science-policy linkages, adoption, agri-environment, environmental services, payment for environmental services, Zambia, willingness-to-pay

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## Assessing Multifunctional Land Use and Sustainable Development in Rural Regions of Developing Countries

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Sustainable land use is a key issue to improve food security, control land degradation and reduce poverty, especially in developing and transition countries. Global changes and growing demands on resources have resulted in dynamic changes of land. Hence policy- and decision makers have increasing demand for ex ante assessment tools to support decision making processes in a sustainable way. The EU-funded projects LUPIS ([www.lupis.eu](http://www.lupis.eu)) and SENSOR TTC ([www.sensor-ip.org](http://www.sensor-ip.org)) develop methods and tools for assessing policy impacts on land use and sustainable development in a selected number of case study regions in Africa, Asia and Latin America. The concept of Land use functions (LUF) is developed for sustainability impact assessment (SIA) to assess in an integrative way the economic, environmental and social impacts that land use changes have on sustainable development. Based on the Driver-Pressure-State-Impact-Response (DPSIR) framework the analytical chain is developed to structure case study regions and to identify cause-effect relations between policies, land use changes and regional sustainability issues. Sustainable development is then interpreted implying the LUFs framework to allow policy makers, scientists and stakeholders identifying at a glance those functions of the land which are fostered or hindered under various scenarios of land use changes, and makes it possible to explore the trade-offs between them. Initially this concept has been developed for European regions and is now being tested in a selected number of case studies in Asia and Latin America to identify strengths and weaknesses of this approach, and also to provide a primer for sustainability impact assessment in developing countries. Therefore a heterogeneous set of land use related problems is assessed to test the transferability of the LUF approach: land degradation in China, side effects of infrastructure projects and land conversion in Brazil and agrarian crisis leading to farmer suicide in India. Participatory approaches are used to define relevant key land use functions and to identify regional sustainability issues in the respective regions. The LUF framework as presented here comprises guidelines on how to implement LUFs and perform a sustainability assessment in developing countries.

**Keywords:** Decision support tools, integrated assessment, land use change, land use functions, land use policies, multifunctionality, sustainable development

## **Cattle Cooperatives in Cuba: How Will Policy Changes Affect their Members?**

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Cuba is apparently heading to a period of changes in the way it handles its economy. In the agricultural sector, the country is reorganising the Agricultural Ministry and its local offices and enterprises, in order to give more freedom to production entities. Two of the sectors that are intended to benefit the most from these changes are the cooperative sector and individual smallholders, as markets are opened up for the first and new land is allocated to the second. In light of these changes and the scarce published information on the rural sector of Cuba, a study with 30 cattle cooperatives and their members was carried out in the eastern part of the country. The study included a survey of household welfare of cooperative members, combined with an analysis of aspects such as production, economic success and resource use at cooperative level. Qualitative and quantitative methods were combined in order to get a picture of the production problems at cooperative level, and the impact that their economic success has on the poverty levels of their members. The possible impacts that the changes in policy could have on this sector are analysed as well. It was found that households in general spend more than half of their income on food, and food availability, diversity and quality were their most pressing needs. Other aspects that negatively affect the perception of life quality for the interviewed households are related to the dwellings and access to hard currency. Contrary to expected, there was little relationship between the economic success of the cooperative and the welfare of the members, suggesting that policy changes geared towards agricultural productivity would not necessarily have an important impact on the households.

**Keywords:** Cooperatives, Cuba, economic reforms, rural poverty

# Rural development and food security

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## **Andean Agricultural Biodiversity, Socio-Economic Factors and their Impact on Dietary Diversity and Nutritional Status: Case Study in Puno, Peru**

URSULA CHAVEZ ZANDER<sup>1</sup>, ANGEL MUJICA SANCHEZ<sup>2</sup>, MICHAEL KRAWINKEL<sup>1</sup>

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Despite the high food plant biodiversity of the whole Andean region of Latin America and its nutritional potential to improve human nutrition, the rural population in Peru is still suffering malnutrition.

To achieve Millennium Development Goal I sustainable strategies should be developed. Food Diversification can be a sustainable approach.

Crop production in Puno, situated at 3,580 m a.s.l., includes a great variety of potato, quinoa (*C. quinoa* Willd.), cañihua (*Chenopodium pallidicaule* Aellen), tarwi (*Lupinus mutabilis* Sweet) and many other species. Unfortunately some of these are neglected despite their high nutritional potential (high quality protein, iron, calcium, provitamin A etc) in the present time.

Several local communities, however, still keep traditional knowledge and farming practices contributing to their food security.

Decrease of traditional knowledge, lack of nutrition education and adoption of urban consumption patterns of high energy but low nutrient density foods influence utilisation of traditional species and impair a healthy balanced diet.

Aim of the study was to assess the impact of traditional andean crops on local food security. Socio-economic factors were also considered.

Four Aymara rural communities at different ecological regions in the South of Puno at the Lake of Titicaca were selected. They live and show different degrees of agrodiversity at different altitude: at 3850 m, 3947 m and 4100 m a.s.l.

Semi-structured interviews and a semi-quantitative 24 h-recall were conducted with women between 15–49 years of age. Their nutritional status was measured with anthropometric indicators (height and weight for calculation of BMI), hemoglobin levels and collection of dried blood samples for quantification of retinol binding protein (for Vit A status) and transferrin receptor (for iron status).

The survey and measurements were carried out in three periods: rainy, post-harvest and farming season.

Results of this study will highlight the need of strategies for diffusion of information about a healthy and balanced diet for vulnerable groups (women, children, sick and

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elder people) in the higher Andean area. It is expected that the nutritional value of traditional species can be demonstrated as well as the need to supporting programmes linking traditional agriculture and nutrition security.

**Keywords:** Andean crops, dietary diversity, human nutrition, Peru

## **Analysis of the Effect of Land Tenure on Technical Efficiency in Smallholder Crop Production in Kenya**

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Agriculture is the backbone of the Kenyan economy contributing 26 % to GDP and 70 % to employment. Majority of the farmers in Kenya are smallholder farmers possessing less than 3 acres of land. The agricultural sector in Kenya has been facing several challenges among them declining yields. While the decline in yields could be associated with several other factors, it could also be as a result of the effect of insecure land tenure systems which are little understood. This study examines the technical efficiency of alternative land tenure systems among smallholder farmers and identifying the determinants of inefficiency with the objective of exploring land tenure policies that would enhance efficiency in production. The study is based on the understanding that land tenure alone will not be enough to indicate the levels of efficiency of individual farms, other socio economic factors such as gender, education and farm size would also be expected to be important determinants of efficiency. A stochastic frontier approach in a Cobb Douglas form was used to estimate technical efficiency and to identify other factors (other than land tenure) that would affect efficiency. The study is conducted in 22 districts in Kenya and this allows comparison within different land tenures systems that exist among smallholder farmers. Preliminary analysis indicates that households with title deeds status have higher technical efficiency. The education status of the household head is correlated to technical efficiency. The study recommends that land registration process in Kenya should be undertaken in all regions of the country to allow farmers make investments that will lead to increased technical efficiency.

The study showed that parcels with a land title have a higher efficiency level. Other factors such as education status of the head of the household, access to fertilisers, and group participation were also found to significantly influence the technical efficiency of the farm. The study recommends that the process of land registration should be extended to other regions of the country but at the same time other factors such as access to inputs and improvement of education status should be addressed.

**Keywords:** Kenya, land tenure, smallholder, stochastic frontier, technical efficiency



## **Making National Reforms Work by Building on Pan African Exchange - The Africa Forum Contributing to the Land Reform Process in Namibia**

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Commitment to pro-poor rural growth is a vital factor to ensure sustainable development in African countries. The Africa Forum, which was established in 1997, brings together representatives from government, the private sector, NGOs, civil society, regional economic communities and donors, in order to provide a platform for discussion to lay the foundation for a more specific sector analysis of the drivers affecting pro-poor rural growth. During the annual Africa Forum meetings, African decision makers exchange experiences on policy and programmes in agriculture and rural development. Findings of these ‘peer-learning’ discussions represent a valued contribution to the international debate on programmes in agriculture and rural development. As a result of last year’s Africa Forum held in Accra, Ghana, three priority issues driving pro-poor rural growth could be identified for Namibia: harmonising and aligning donor support, good governance and infrastructure development. In Namibia the existing Land Reform Action Plan serves as the guiding programme and the discussions at the Africa Forum revolved around how to support its implementation. A Country Team with representatives from the different ministries involved in Land Reform as well as representatives from the farmer unions and NGOs was established. It is committed to address the priority issues identified during the Africa Forum, as part of the process towards land reform in commercial and communal areas; and in support of pro-poor rural growth.

In Southern Africa, where about 70 % of the population is dependent on agriculture, the access to land represents an issue of livelihood. Using the example of land reform in Namibia, this presentation will focus on how the priority issues identified during the Africa Forum are put into practice and which policies have been developed, in order to ensure that the land reform will lead to pro-poor rural growth.

**Keywords:** Africa forum, land reform, Namibia, programme based approach

## Farming in Transition – Evidence and Experience from Hebei Province, PR of China

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After the introduction of the household responsibility system in 1981, agriculture in China experienced a strong increase in productivity. However, farm sizes remained stagnant or even declined. Income inequality did not only rise between urban and rural areas but also within rural areas. These are not the only obstacles on the way to sustainability in agricultural production.

A rising share of farms is managed by older people and the current migration policy does not allow rural residents to permanently exit agriculture and rural areas. Moreover, input levels for mineral fertiliser in Hebei province were found to be very high and by this environmentally unsustainable.

This paper focuses on the relationship between institutional changes, due to the ongoing transition, and farmer's decision to work on or off the farm. Multinomial regression analysis of data from official Chinese sources and results from qualitative surveys on village, household and individual level are used in the study. Descriptive analysis of Research Center for Rural Economy (RCRE) panel data provides the result, that the proportion of full-time farm households in the sample is declining over time and off-farm income is gaining in importance. Province level statistical data show that the share of the primary sector as source of GDP is declining in Hebei as it is the case in other provinces of China. Interviews with farmers reveal, that mistrust against fertiliser sellers or neighbouring villages lead to an inefficient overuse of fertiliser. Also this is named as reason for not making use of the possibility to rent land or exchange plots.

The answers of village heads during interviews in Quzhou county shed light on the importance of improvements necessary in the agricultural institutions and extension services to provide farmers with better information for using inputs efficiently. Therefore the focus of future research will be on this topic. Additionally the findings presented indicate, that a shift away from part-time to full-time farming could be a possibility to reach the goal to raise the living standard of the rural population by developing rural areas to become urban ones and to raise efficiency levels in China's agricultural sector.

**Keywords:** Agricultural extension service, migration, North China Plain, panel data, part-time farming, rural development

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## **Productivity of Private Farms: The Case Study of Tashkent Region, Uzbekistan**

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The agrarian sector of national economy of Uzbekistan is going through difficult process of fundamental changes. The main issue of this process is transition into new model of economic development, connected with more effective use of market instruments and mechanism of their regulation. In the process of transition new economical and organisational frames for agricultural producers are formed.

By the new legislative conditions since 1990 three different types of farms were established: agricultural cooperatives, private farms and household farms. Counter-productive policies such as intervention on input and output markets, misapplication of the bankruptcy law, lack of land market and ineffective finance system have affected the reform process. The productivity of the “strategic” crops: cotton and wheat declined. Most agricultural cooperatives in the period 2001–2003 were pronounced bankrupt. In 2003 the government changed direction of reforms in order to restructure the agricultural cooperatives. The agricultural land was given to rent through competition to private farms.

This paper examines changes in agriculture productivity in 15 districts of the Tashkent region, Uzbekistan over the period 2000–2005. An input-oriented Malmquist Productivity Index (MPI) is used. The results of the study show that the average MPI amounts to 0,889, that is the TFP (total factor productivity) declined almost 11 % on average per year. Portioning of productivity changes into technical change and technical efficiency revealed that impact of structural change in 2003 on TFP and the study shows that the time period between 2002 and 2004 is characterised by technical regress followed by technical progress. The improvement should be ascribed to mechanical or organisational technical progress.

**Keywords:** productivity index, restructuring, total factor productivity, transition economy, Uzbekistan

## **Territorial Sustainable Development in Aranjuez-Sardinal, Central Pacific Region of Costa Rica**

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The little effectiveness of the prevailing economic development model and its consequences in the persistence of the rural poverty, have motivated the rise of innovative and more holistic approaches. During the last years a new methodology is taking place: Territorial Sustainable Rural Development (Desarrollo Rural Territorial Sostenible: ETDR). The ETDR is essentially an integrated process of rural territories, agents (stakeholders), markets and public political intervention. The approach searches the integration of the rural territories to its interior (endogenous development potential factors) and with the national economy and defines its spectrum of action in four dimensions: 1- the natural base of the resources in the territory and the environment, 2- the local development economy, 3- the social relations, and 4- the institutions as final expression of the interaction of its inhabitants, and delimits them to a geographical space.

The zone of study, the watershed of the rivers Aranjuez and Sardinal in the Pacific Central Region of Costa Rica presents a tropical rainy climate, means annual temperatures vary with altitude. The farm production is centred on small and medium producers of coffee on organic, sustainable and conventional farms. These farms produce also milk and vegetables: chili (*Capsicum* spp.), green bean, tomato, cabbage.

The objective of the project is to improve the institutional and the civil society capacities (farmers and farmers' organisation) in the territory, through the creation of new mechanisms of organisations, the promotion of collective action and the empowerment of local communal and economic initiatives.

Preliminary results of this process are: 1- Map of actors in the territory; 2- Map of investments; 3- Institutional equipment conformed; 4- Local committee formed; 5- Strategic areas for the elaboration of the definitive plan of development: gender, tenancy of the properties (land tenure), infrastructure, knowledge management. These topics are essentially the bases of the "Local Economic Development", and indicate that the proposed strategy of ETDR is the appropriate one

**Keywords:** Economic development, rural development, sustainability, watershed

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## Evaluation of the Popular Restaurants Program as a Food and Nutrition Security Action in Brazil

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The topic Food and Nutrition Security has been strongly discussed in Brazil, leading the country to develop a policy and the implementation of social programs in order to achieve the food security of all population. Within these actions is the “Popular Restaurants Program” which aims to offer meals with very low cost (US\$ 1,69) to people experiencing food insecurity situation. Aiming at evaluate if the programme was in accordance to its objective, a cross section study was conducted at two units (restaurants) so-called “Centro” and “Taquaralto” in Palmas City, Tocantins, Brazil. Socioeconomic, health, antropometric (weight and height) and dietetic data of users were collected from 600 individuals (300 at each unit). In addition, the willingness to pay (WTP) for the improvement of foodservice was also analysed by the Contingent Valuation Method and econometric models were formulated, to face WTP value with socioeconomic variables (income, education, gender, age and frequency of use). The monthly income per capita showed wide variability between users of both units (US\$ 00.00 - US\$ 1775.14 to Centro and US\$ 00.00 - US\$ 1183.00 to Taquaralto). Approximately 30 % of sample was considered overweight and low intake of fruits and vegetables was also observed. WTP to Centro unit was US\$ 70 004 (monthly/agregate value) or US\$1.74 month<sup>-1</sup> person<sup>-1</sup> and to Taquaralto was US\$ 17 829 (monthly/agregate value), or US\$ 0.44 month<sup>-1</sup> person<sup>-1</sup>. The higher value attributed to Centro can be partially explained by the expressive number of people willing to pay more to the improvement of the foodservice program. Results suggest that, as a food and nutrition security program, it would have a focus to the whole service which includes user’s health and profile, and not only to the food distribution. Also it is hoped that this work could help public managers in order to contribute to the improvement of programme actions.

**Keywords:** Food security, nutrition security, popular restaurant, willingness-to-pay

## **The Profitability of Livestock Donation in the Tsunami Affected Aceh Besar District in Indonesia**

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The Tsunami on December 26, 2004 devastated the livestock sector in Aceh, Indonesia. Many families lost their animals, the primary or secondary source of income. Thereafter, numerous programs were established by different organizations, one activity being livestock distribution to replace the loss. Most of the livestock given to farmers were chicken, goats and cattle, whereby goats and cattle were popular. Donors and farmers assumed that these animals improve farmers' livelihoods and did not consider the marked differences in values and management requirements, both from an animal husbandry and from an economic point of view. Therefore this study aimed at analyzing the management requirements and economic profitability in donated goats and cattle. The data were collected in four villages using in-depth structured interviews with 10 cattle and 10 goat farmers per village. The data was subjected to gross margin (GM) analysis and simple statistical analysis. The average GM (in million Rupiah) was 4.8 in cattle and 1.3 in goat. The t-test showed that there was a significant difference in GM between cattle and goat farmers ( $p < 0.05$ ). Moreover, cattle were also used for fieldwork in many households. In cattle farmers, the consumption of own products accounted for 12.5 % of total beef consumption, while the consumption of goat meat in goat keeping households was only based for 2.5 % on own goat products. Furthermore, 25 of the goat keeping households but only 14 of the cattle keeping households reported diseases in their animals ( $p < 0.05$ ). It is concluded that in the Tsunami affected area, the monetary and non-monetary benefits of cattle donations were more interesting for the farmers than those of goat donations.

**Keywords:** Donations, profitability, gross margin, tsunami

# The role of forests in conserving natural resources

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## **Eating from the Same Pie: Co-Existence in the Face of Resource Competition in Pastoral Areas of Ethiopia**

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Driven by synergetic factor combinations of resource scarcity leading to an increase in the pressure of production on resources, changing opportunities created by markets, outside policy intervention, loss of adaptive capacity, and changes in social organisation and attitudes, the Karrayu pastoralists are in a state of gradual transformation in their livelihood system. Like many pastoral areas of the country, the Karrayu pastoral and agro-pastoral land has been a hub for resource competition since the land can be used for different purposes by different interest groups. The conservation scheme by the Awash National Park, the state-driven commercial farms and the mushrooming of small-scale cultivators are the main contenders for the ever shrinking pasture land of the Karrayu pastoralists. Under these compelling or changing circumstances, the Karrayu pastoralists started to carry out farm activities on a joint basis with other partners. In the process, an informal land market has emerged in which land is temporarily or permanently transferred between households within the pastoral group or outside it through sales or mortgages. There are indications that there will be an increasing conversion of the pasture land into arable land, given the present high demand for cultivable land. These are manifested from the commercial farm and the small cultivators side as well. Particularly, the state farm has a plan to boost its sugarcane production in response to the growing demand for sugar. These changes signify the fact that land is assuming a commodity value as a means of production and exchanges which attribute it did not possess prior to the advent of cultivation. In the final analysis, all the different arrangements by the Karrayu communities are adopted to maintain the continuity of the pastoral practice while simultaneously searching for an alternative to cope with adversities.

**Keywords:** Adaptation, resource use co-existence, new arrangements, transformation

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## From Natural Resource to Pro-Poor Ecosystem Service Management in the Amazon: How to Make the Right Choices?

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The Amazon is the largest among the few tropical ecosystems in the world, where growing human needs for land and development still widely coincide with abundant natural resources and local as well as globally important ecosystem services. Poverty in the Amazon is not as extreme and widespread as in the world's more densely populated rural areas. Yet, rural livelihoods strategies depend much more on what nature has long been providing at relatively low cost. Increasing evidence about environmental impacts of climate change and deforestation indicate that this might not be so forever. If the benefits of the services provided by the Amazon ecosystem are to be sustained for future generations, new and more effective approaches to ecosystem management are needed.

Here we evaluate whether and how an ecosystem services perspective towards natural resource management can offer new responses to upcoming challenges of minimising tradeoffs between development objectives, such as rural welfare and environmental sustainability in the Amazon context.

Policymakers have choices regarding management options (MO) for achieving specific development objectives, but little guidance regarding how to choose between alternatives in different settings, or how their choices should be influenced changes in settings. The fundamental evaluation criteria for choosing between alternative management options should be their expected cost-effectiveness, effects on the poor, and effects on non-targeted ecosystem services. Yet, the serious application of one or more of these criteria in policy decision-making processes is rather the exception of the rule in the tropical world.

Ecosystem service characteristics, e.g. dynamics and uncertainty, are important determinants of these MO evaluation criteria, as are their establishment and operational costs and related information needs. Political, institutional, and economic settings (and changes in them) are equally important determinants of MO performance. Based on these notions the paper critically reviews traditional and innovative environmental management options and highlights what is known in the Amazon region about ecosystem services characteristics, management settings, and the performance of MO. It ends with a discussion of knowledge gaps and how these could best be addressed within the current national and regional research and development agendas.

**Keywords:** Environment, forest management, poverty, alleviation, ecosystem services, Amazon, environmental protection

## **Agroecology – Movement for Rural Development, Scientific Discipline or Just an Agricultural Practice?**

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The term ‘agroecology’ is used more than ever today with varied meaning ranging from scientific discipline, agricultural practice, or social movement. The objective of this presentation will be thus to clarify these different meanings. Towards this aim, the historical development of agroecology was analysed, with selected examples from USA, Brazil, France and Germany, in an attempt to study and discuss the evolution of the different meanings from the four contrasted examples.

The term agroecology can be traced back to the 1930s. The period up to the 1960s can be called the scientific ‘old age’ of agroecology. Scales and dimensions of scientific research in agroecology changed over the past 80 years from the plot or field scale to the farm or agroecosystem scale. Presently two main approaches persist: one maintaining the agroecosystems scale approach, the other leaving a concrete spatial scale around the farming system, and entering the dimensions of the food system. The latter approach tries to link natural and environmental sciences and agronomy with sociology and economy. Based on this highly interdisciplinary basis, agroecology might be able to significantly contribute to applied research topics, in particular in tropical and subtropical agroecosystems.

Different environmental movements started in the 1960s, often developed in opposition to industrialisation processes of agriculture. Some of them evolved towards agroecological movements in the 1990s, often with the major objective of rural development. Agroecology as an agricultural practice emerged in the 1980s, and was thereafter often intertwined with agroecological movements.

In general, various interpretations of agroecology exist with different weights and specifications throughout the world. In France, agroecology is better known as a practice, and to certain extent as a movement, whereas the scientific discipline is occupied by the discipline agronomy. In Germany, agroecology has a long tradition as a scientific discipline, but the agroecology in the sense of a movement or a practice is more or less inexistent. In the USA and in Brazil we find all three types of utilisation of agroecology with a certain predominance of agroecology as a science in the USA and a stronger movement and/or agricultural practice in Brazil.

**Keywords:** Agroecosystem, Brazil, France, Germany, rural development, scientific discipline, sustainable agriculture, USA

## **The Rural Poverty-Environmental Relationship in the Brazilian Amazon Region: The Case of Tocantins State**

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This study analyses the relationship between rural poverty and environmental degradation, aiming to validate or to refute the poverty-environment hypothesis, which belongs to the mainstream of sustainable development theory. This poverty-environment hypothesis – or poverty-trap thesis - asserts that poverty is a major cause of environmental degradation, forming a vicious circle or a poverty trap situation. In this way, any policy that reduces or alleviates poverty has, necessarily, positive impacts on environmental preservation. In this context, the present study analyses this relationship in the rural areas in the city of Palmas – Tocantins State, located in the Brazilian Amazon Region, also so-called Legal Brazilian Amazon.

A database was formed based on 45 interviews with small farmers - during the year of 2007 -, including several environmental and socioeconomic indicators. Non-linear regression (probit) models were estimated, with dummy variables as dependents, expressing the environmental degradation, and the socioeconomic indicators as independent variables, expressing the different rural poverty situations. The impacts of access to markets, information, credit and technical assistance on environmental degradation were also estimated in the model.

The results point towards a refutation of the hypothesis that rural poverty and environmental degradation is directly correlated, forming a vicious circle or a poverty trap situation. Moreover, the study is unprecedented in the Brazilian Amazon Region and the results showed that this relationship is ambiguous and therefore policies that aim to alleviate the rural poverty do not have, necessarily, positive impacts on environmental preservation. For this reason, the results will be send to the regional decision makers and Policy makers, aiming to subsidise new specific “win-win” policies, which alleviate the local rural poverty and at the same time contribute to the conservation of the natural resources and the environment in the city of Palmas, Tocantins State, Brazilian Amazon Region.

**Keywords:** Brazilian Amazon Region, environmental degradation, rural poverty, vicious circle hypothesis

## **Change in Natural Resources vs. Socio-Economic Development – Identification of Bottlenecks for Exploiting Future Agricultural Potentials in the Jordan Valley**

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Competition for natural resources in the Jordan Valley takes place between the riparian countries and societies as well as within the concerned countries. Reasons for the latter are the expansion of urban areas and the demand for the preservation of nature. Research results from a team of German, Israeli, Jordanian and Palestinian socio-economists indicate that Climate Change will most likely increase agricultural potentials in the area at least in the coming three decades due to the greenhouse effect. The subsequent step in this model-based analyses on the development of agricultural potentials, farming systems and enterprises were parametrisation procedures according to scenarios developed by a group of experts from the concerned countries under the umbrella of the project GLOWA Jordan River. Results indicate that assumptions about political, demographic and economic changes have a far greater impact on agricultural potentials than anticipated changes in the status of climate, water, land and ecosystems. A deadlock in the peace process combined with a slow economic growth would, as expected, engender a most unfavourable development of agricultural incomes in Israel and Jordan in the long run, but would first lead to a strong increase in value creation from agriculture until about 2010 for want of alternative resource use. Palestinian farmers would benefit even beyond that decade, even if their profit margin would just be sufficient for balancing the growing needs of their families. Progress in the peace process or, alternatively, strong economic growth would penalize Palestinian farmers due to the competition for land and water without adequate compensation from employment opportunities, while their Israeli and Jordanian colleagues would enjoy significant increases in profits at least until 2030. Progress in the peace process and simultaneous economic growth would stabilise farm incomes

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of Palestinian farmers after a slight decrease until 2010 and lead to a modest but constant increase of farm incomes in Israel and Jordan. However, indications are that improvements in the current institutional and infrastructural set up for agriculture in all countries may have the capacity to absorb substantial parts of negative impacts under all scenarios.

**Keywords:** Israel, Jordan, jordan Valley, land, Middle East, Palestine, rural development, scenario analysis, socio-economics, water

## Incentives in Contingent Valuation Studies

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This paper analyses possibilities to improve contingent valuation surveys which are used to assess the social value of public goods like e.g. environmental changes. The contingent valuation method (CVM) is a survey based technique which assesses an environmental project by asking a representative sample of citizens their willingness to contribute to that project.

An important requirement for obtaining reliable results in CVM surveys is for respondents to answer honestly to the willingness to pay question. Depending on the payment mechanism respondents often have an incentive to strategically over- or understate their preferences for the public good, thereby systematically biasing CVM results. It is, therefore, essential to design payment mechanisms where it is in the respondent's best interest to answer truthfully according to his preferences. In this study we test the incentive structure of a number of alternative payment mechanisms. In particular we test the Clarke mechanism, which is known to be incentive compatible in theory. Although this mechanism is highly appreciated in theory it has never been implemented in empirical work in the context of the CVM. First, this study analyses theoretical incentive structures of mechanisms conventionally employed in CVM. Second, the Clarke mechanism is adapted to fit the CVM context to create the incentives to make people answer truthfully to the willingness to pay question. The different payment mechanisms are then applied in an empirical survey to compare the theoretical predictions with empirical results.

The public good to be valued was a flood prevention project in the Northern Thai city of Chiang Mai. In this project flood protection is to be achieved by technical measures in the city as well as by reforestation and soil conservation measures in agricultural areas in the upstream watershed. The survey including a total of 1500 face-to-face interviews has been conducted in Chiang Mai in the beginning of 2008. The results of this study will help making CVM surveys a more reliable tool for the valuation of environmental changes.

**Keywords:** Contingent valuation, environmental valuation, incentives, mechanism design, voting

## **Participatory Forest Management and the Creation of Alternative Income Opportunities in Rural Areas in East Africa - A Case Study of the Bale Mountains, Ethiopia, and the Transferability to Kakamega Forest, Kenya**

JULIANE HEINRICH, DOMINIK CREMER-SCHULTE, INGA DÜVEL, PATRICK KÖRNER, STEPHAN NEUBACHER, KATHARINA KABOTH, ALEXANDER REICHERT, FRANZISKA SIELKER, SABINE NOACK, THOMAS HÄNERT  
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The proposed contribution of an advanced students' project of the Faculty of Spatial Planning at the University of Technology Dortmund will present the social, economical and ecological impacts of the Integrated Forest Management Project (IFMP) in Adaba-Dodola, Ethiopia. This project was initiated in 1995 by the Gesellschaft für Technische Zusammenarbeit (GTZ) in the Bale Mountains in the Oromia Region of Ethiopia. The inducement for the IFMP was the heavy degradation of the remaining natural forests in this area due to uncontrolled anthropogenic use. The overall goal of the IFMP was to protect the remaining forests from further destruction and to develop, use and manage them sustainably. To reach this goal and respond to the problems adequately the GTZ decided to develop a community-based approach which was named the WAJIB approach (local language abbreviation for forest dwellers association). The idea of WAJIB is that the forest dwellers get exclusive rights to use the forest which allow them to earn their livelihood with forest products. In return the WAJIB associations have to guarantee the maintenance of the tree cover. Supplementary measures of the IFMP included the implementation of non-wood-based income generating activities from which the most recognised one is the eco-tourism project in Adaba-Dodola.

The presentation will explain the outcomes of a three-week excursion and the further analysis and conceptional work and will respond to the following questions:

- o What were the effects of the IFMP on the forest and its biodiversity and on the inhabitants of the Bale Mountains Region?
- o How can the forest management in the Bale Mountains be improved in future?

The work is also based on the relation to the BIOTA (Biodiversity Monitoring Transect Analysis) sub-project E14, which is conducted at the Faculty of Spatial Planning and which studies alternative livelihoods with regard to forest and biodiversity conservation in Kakamega Forest, western Kenya. The contribution will comprise if certain aspects of the IFMP are transferable to this region and its natural rain forest. The advanced students' project work started in October 2007 and will end in July 2008 with a final report.

**Keywords:** Alternative income, BIOTA, Ethiopia, participatory forest management

## Developmental Returns from Investing in International Agricultural Research

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To truly reflect development values evaluation of Agricultural Research for Development (ARD) may need to go beyond evaluation of research performance in terms of the products and services delivered, towards assessing the development outcomes in terms of social and environmental sustainability, at various levels including public goods such as biosphere functions and outcomes for poor people in terms of poverty alleviation, food security, and natural resources use and conservation. Successful agricultural innovation and sustainable rural development depend on social, political, economic and institutional processes as much as technological ones. Technology is therefore but one aspect among many factors influencing to what extent the course of development follows sustainable pathways. Preferably, therefore, evaluation of ARD can be designed and carried out within a holistic development studies framework. Analysing dissemination of research products and calculating rates of monetary returns may remain important; but ultimately impact assessments and evaluations may wish to examine how research products and services are used and how their use affects peoples lives, their societies and environments. This entails therefore a shift away from directly measurable (often market based) impacts; towards capturing the complexity and non linear nature of agricultural innovation and sustainable development. While ARD has been documented as being largely beneficial even in narrow monetary terms we argue that impact assessments has been carried out largely within economic paradigms that are limited in capturing elements such as natural capital and environmental services.

**Keywords:** Development returns, impact indicators, institutional change, Overseas Development Assistance

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# Farmers' perceptions, participation and adoption

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## **Farmers' Perception, Profitability and Factors Influencing the Adoption of Improved Maize Varieties in the Guinea Savannahs of Nigeria**

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The study links farmers' perception, profitability and a Tobit analysis to examine the adoption related to a new technology, improved maize varieties (IMV) developed by International Institute for Tropical Agriculture (IITA), Institute of Agricultural Research (IAR) and National Agricultural Research and Extension Service (NARES) and recently released in the savannah zones of Nigeria. The paper analyses farmers' perception, profitability of IMV and factors influencing the adoption of IMV in the savannahs of Borno State, Nigeria. A multistage sampling design was used to select 232 maize farmers, subsequently interviewed by means of structured questionnaire. Descriptive statistics, budgetary technique and a Tobit model were used as analytical tools. Farmers' perception shows that early maturity and high grain yields of IMV were the positive perceptions that influenced 66.4 % adoption among the respondent farmers. The gross margin results indicated that IMV was highly profitable with a mean gross margin of N65,289 (€384) per hectare as against local maize variety with a mean gross margin of N34,691 (€204) per hectare. The Tobit model result shows that statistically significant ( $p = 0.05$ ) factors that influence the adoption of IMV, with the expected signs include: farm size, extension contact, access to credit, fertiliser, farming experience and household size. Policy that enhances farmers' access to credit will facilitate adoption through increased access to seeds of IMV and purchase of complementary fertiliser input will enhance the intensity and the rate of adoption. Also, policy, which provides adequately trained and equipped extension workers for disseminating technology information, has the potential to increase the intensity and rate of adoption of the improved maize technology.

**Keywords:** Farmers' perception, gross margin, improved varieties, key words: adoption, maize, Nigeria, profitability, Tobit model

## Farmers' Perceptions of Attributes of Agricultural Technologies and their Impact on Adoption: A Case Study of Nakuru District, Kenya

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Farmers' perceptions of attributes of technologies as a factor influencing adoption of technologies is often neglected in diffusion studies even as the challenge of low, slow and incomplete adoption of new and improved technologies for rural development continues. Since farmers make rational decisions, technologies must possess certain attributes that appeal to them, fulfil their varied needs and are consistent with available household resources. Perceptions of farmers towards new and improved agricultural technologies were assessed based on the attributes of relative-advantage, compatibility, complexity, trialability and observability. Data were collected in a field survey using structured questionnaires administered to 190 randomly selected members of farmers' groups in Nakuru District, Kenya. These farmers' groups were affiliated with the demand-driven Agricultural Technology Information and Response Initiative (ATIRI) of the Kenya Agricultural Research Institute (KARI). Data analysis procedures included descriptive statistics, factor analysis and logistic regression. Descriptive analysis of the aforementioned technology attributes yielded means above 2.6 on the scale of 1=unimportant, 2=important, 3=very important for all attributes. Over 70 % of farmers considered each attribute as 'very important' in influencing their adoption decisions. The factor analysis explained 65.2 % of the total variance and extracted five factors. Factor 1 with 15.8 % of total variance explained, gave observability as the most important attribute of technologies. Factor 2 with 14.3 % of total variance explained, was most related to trialability. Factor 3 with 12.7 % of total variance explained, was consistent with compatibility. Factor 4 with 11.2 % of total variance explained, was associated with complexity. Factor 5 with 11.8 % of total variance explained, denoted relative advantage. The computed chi-square for the regression model ( $\chi^2=11.803$ ;  $p < 0.05$ ) suggests that the model parameters jointly are significantly different from zero for the effect of perceptions of technology attributes on adoption. Specifically however, significant results were realised for observability ( $p < 0.05$ ) and trialability ( $p < 0.1$ ). Therefore, agricultural research and development activities must focus on technologies whose results are visible to other farmers, can be tried on the installment plan, are consistent with existing values, past experiences, and needs of potential adopters, can be learnt and used with ease, and are perceived as better than existing ideas.

**Keywords:** Adoption, ATIRI, attributes of technologies, farmers' perceptions, Kenya

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## Extension Services in the Bie Province, Angola – Assessment and Perspectives

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The Bie Province is traditionally an agricultural region. More than 85 % of population is involved in either direct agricultural or related activities. Agriculture is recognised as the main sector of peoples' living. The long-lasting civil war significantly influenced all spheres of daily life at all levels. As a matter of fact, agricultural production stopped. Farmers were forced to join army troops and majority of arable land was mined. Even though the climate is generally favourable for crop cultivation the soils tend to be of low fertility. Agriculture in the Bié Province is still dependent on the external assistance, especially in terms of knowledge and skills of sustainable technologies and agricultural input supply. Most of the constraints limiting an immediate better performance of agricultural production lie in farmers' lack of knowledge and skills. The traditional information transfer has been interrupted and network of extension services became extinct. Nowadays, several initiatives of NGO as well as governmental sector are carried out within rural extension to provide such an important technical support to farmers. However, the renovation process of extension services has progressed very slowly in comparison with the urgent needs of farmers. Our survey focused on the current performance and potentials of rural extension as perceived by extension agents and farmers. Recognition of changes in agricultural development in the last five years, identification of main constraints and outlining of possible solutions were the principles of our research. The results will serve as implications for competency modelling and development of curriculum of in-service training designed for extension agents in the Bie Province.

**Keywords:** Angola, extension services, in-service-training

## **A Reference to Rural Livelihood in Cameroon: A Case Study from South West-Cameroon**

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Rural livelihood and development have become a very important topic of discussion in today's social sciences and economic development. In Cameroon the government has elaborated a whole paper for rural development and poverty alleviation baptised under the umbrella name Poverty Reduction Strategic Paper proposed by the World Bank and IMF. Also the restructuring of the former Ministry of Agriculture to Ministry of Agriculture and Rural Development shows how the Cameroon government is committed in improving rural livelihood.

My thesis research is to make a reference of rural livelihood in Cameroon; as diversified as the African continent itself has a lot of differences as you move round the various geopolitical regions of the country. That is to say, differences exist in local dialect, traditional beliefs, farming practices, natural resource endowment, topography and climate which will later be elaborated in the thesis proceedings. The South West province will be my case study because of its richness' in natural resources and also good soil and climatic conditions suitable for agriculture. It is here that most of the main plantations are located and also where the country's lone oil refinery is found. It is quiet amazing that most of the rural people in this province just like in other parts of the country are malnourished or go to bed with an empty stomach; lack basic education infrastructures; lack health facilities; good farm to market roads and other social facilities for people to live a comfortable life.

This research will bring out the different methods in which rural people survive in Cameroon. It's not only on poverty and farming but rather looking at rural livelihood as a whole. Though agricultural is the backbone of development as was the case with the developed countries; it's also important to state that off-farm employment and specialisation will stimulate rural development.

**Keywords:** Agricultural development, diversification and rural development, livelihood, poverty alleviation

## Subjective and Objective Factors for Farmers' Adoption of Soil Conservation Strategies

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Smallholder farmers in our research area, Meegahakivula, Sri Lanka, are facing decreasing yields due to soil degradation primarily caused by unsustainable production practices. Farmers' strategies to increase production and hence income in short term leads to shrinking long term productivity. Our project is part of an interdisciplinary attempt with agronomists and specialists from remote sensing. We want to gain insights on the sustainability of the production practices, implemented by a private development programme which promotes *Gliricidia* cultivation. *Gliricidia*, a legume tree, is believed to improve soil fertility and soil structure by increasing nitrogen and organic matter content. Besides the incorporation of *Gliricidia*, various incentives as free seeds, extension, etc. are offered to the households.

As socioeconomic project component, we seek to understand why farmers participate in the development program. The design of the study considers the characteristics of the programme where incentives are only provided if farmers cultivate following the required production practices. This calls for a discrete analysis of the motivation for participation and a study on objective factors for *Gliricidia* adoption.

In a first step based on farmer's subjective utility the motivation for participation will be assessed. The assessment of farmer's aims for future development helps to understand the subjectively perceived effects of the programme on household's development. Second, a logit-model is used to find objective factors affecting *Gliricidia* adoption. For both analyses the sample of 119 households, including both programme participants and non-participants, is divided into two sub-samples. The first sub-sample is interviewed during dry season, while the other at the end of rainy season. The hypothesis is that the utility for participating in the programme as well as farmer's assessment of their situation is different depending on the condition of the influencing environment, while the objective factors for adoption should not differ between the two time points.

The analyses are accompanied by a one-year survey, where information on economic activities as well as consumption figures is assessed on monthly basis. The survey provides data to model, in a second step, effects of possible strategies regarding factors affecting adoption in addition to farmers' stated aims and utility.

**Keywords:** Programme participation, soil conservation decision, Sri Lanka

## What is the Role of Farmers Training on Cotton Production in Pakistan, China and India?

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This paper presents the results of a comparative analysis of the impact of farmer training in Farmer Field School (FFS) in cotton production three major cotton producing countries, namely China, India and Pakistan.

From 2000 to 2004, Food and Agricultural Organisation of United Nations (FAO) was supporting the Farmer Field School (FFS) project on the Integrated Pest Management (IPM) training farmers under “FAO-EU IPM Programme for Cotton in Asia”. The major purpose of the programme is detoxifying, existing pest control strategies, and replacing them with more sustainable, environmentally friendly cotton production technologies. In addition, the programme also develops, implements, and evaluates sustainable farmer education program.

This research uses panel data collected from trained and untrained cotton farmers in these three countries. Trained farmers under the concept of the FFS group have developed new skills, due to the intensive training. A “difference in difference” model was developed to measure the impact of training participation on farmer knowledge. Other dependent variables were decision making capacity, pesticide use, yield, gross margin as well as environmental effects. Here the environmental impact quotient (EIQ) has been used as dependent variables in the model.

Results show that the FFS training in cotton can generate benefits for farmers under different socio-economic and policy conditions. It was found that generally the programme significantly reduces the growth rate in pesticide use. Furthermore it can be assumed that externalities are being reduced based on the results of the EIQ analysis. Country differences were found, e.g. the productivity effects are higher in countries with lower yields such as for example in Pakistan. The results suggest that investment in farmer education can be efficient if the target population is well chosen and quality can be assured.

**Keywords:** Cotton, farmer field school, impact assessment, IPM



## **Participatory Risk Assessment: A New Tool for Improving Smallholder Market Access and Consumer Health**

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Rapid urbanisation, globalisation and intensification of livestock production in developing countries are causing dramatic changes in food production, supply and consumption with the potential of generating unprecedented opportunities for poor farmers, processors and traders.

Most poor people buy and sell in informal markets which have escaped safety and quality regulation. Studies on livestock products in these markets typically find high levels of pathogens and other hazards such as toxins or drug residues. These not only impose a heavy burden of avoidable sickness and death, but constrain producer access to higher value markets where standards prevail.

Managing food safety in informal markets is challenging: regulation by definition has failed, while lack of knowledge and lack of resources constrain the ability of producers, traders and consumers to self-initiate better food safety. Risk-based approaches that focus on the harm caused by hazards and use a pathway approach in order to identify the best means of preventing harm are likely to be more effective at ensuring food safety than traditional methods relying on inspection and punishment.

This paper reviews risk-based approaches for better management of food-borne diseases in developing countries, with an emphasis on local markets and emerging diseases. Methodologies developed by the Codex Alimentarius Commission (CAC) are reviewed. The benefits of risk-based approaches as well as the challenges of adapting them are discussed: we argue that the limited application is partly due to lack of expertise and partly due to difficulties in applying risk assessment to diverse, non-linear, shifting, and data-scarce systems in which formal and informal (or traditional) food supply systems co-exist and overlap; views of various stakeholders on food safety objectives diverge; there is low willingness or ability to pay among consumers for improved food quality, and low enforcement capacity.

Using examples from ongoing case-studies involving emerging food borne diseases in East Africa, we suggest that incorporating participatory methodologies can meet the need for adapted risk analysis appropriate to the developing country context.

**Keywords:** Food security, participatory methodologies, risk assessment

## **An Assessment of Livelihood Transitions Triggered through Conservation Agriculture in Different Vulnerable Productions Systems in Central Mozambique**

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Poor people worldwide are blamed for unsustainable use of natural resources, especially in agrarian communities. In Mozambique about 80 % of the population comprises subsistence farmers living in rural areas largely depending on natural resources and very often their activities lead to soil erosion, deforestation, siltation of rivers and pollution. Seventy percent of the population lives on less than US\$1 per day. Drastic weather changes confront many farmers leading to sudden harvest losses and this is a common problem in vulnerable production systems. As consequences, an increasing number of farmers have become food insecure. Agricultural scientists and the Government of Mozambique have suggested conservation agriculture as an alternative system to replace rotational cultivation, fallow periods and other “resource mining” systems. It is argued that conservation agriculture has a huge potential to improve livelihoods in this country. Although the concept of conservation agriculture has been introduced by public and civil society organisations, the adoption by farmers is slow and its impact on livelihoods is yet to be realised. Against this background, a livelihood transition study is being conducted to explore livelihood pathways triggered through conservation agriculture in different vulnerable production systems in Mozambique. The key question is whether conservation agriculture contributes to asset accumulation and more sustainable livelihoods in future. The sustainable livelihoods framework model focusing on the social, human, natural, financial and physical capitals existing among farmers will be applied in this study. Rather than focusing on the problems and what needs to be done for the farmers, this approach seeks to establish both the explored and unexplored development potentials that exist among farmers. Data collection technique will include individual interviews, focus group discussions, qualitative interviews, community mapping, photography, livelihoods and institutional support assessments in Manica and Sofala provinces. This approach enhances support and empowerment through involvement of the community members at every stage of the research process including the dissemination of research findings. Results from this research will help policy makers in designing appropriate agricultural policies that could help unlock the livelihoods potential of conservation agriculture in central Mozambique. This paper presents insights gained from the first research phase.

**Keywords:** Conservation agriculture, livelihood contributions, livelihood transitions, livelihoods, poverty, vulnerable production systems

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## Adoption of Sustainable Land Use Practices in Africa: Opportunities and Challenges

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Due to the breakdown of the traditional farming systems resulting from shortening of traditional fallow periods and use of marginal lands in southern African region, one of the greatest challenges is to identify appropriate agricultural approaches that help to increase food production for the increasing human population at a minimum cost to the natural resource base. A number of sustainable land use systems (SLUS) have been developed or promoted in the region in response to this challenge. The systems developed include conservation agriculture, integrated soil fertility management technologies and “fertiliser tree” systems. The biophysical feasibility of these land use systems has been well established and their benefits from economic, ecological and environmental perspectives have been well documented. While a few cases of success stories have been recorded in some locations, farmer adoption of these sustainable land use systems has generally lagged behind biophysical and technological achievements that have been attained in such systems thereby reducing their potential impacts. In this paper, we synthesized key SLUS that have been developed or promoted in southern Africa, assessed their level of uptake by farmers, and identified major drivers and constraints that affect wider diffusion and adoption of the systems. The analysis revealed that technological characteristics of SLUS are important but not exclusive condition for sustained widespread adoption of the systems in smallholder farming communities in the region. Cases of success stories were recorded where the SLUS have been targeted to appropriate farming communities and disseminated within appropriate supportive policies. The widespread adoption of SLUS is nonetheless constrained by several challenges that were grouped into four broad categories: household-specific constraints (*e.g.* age, resource endowment), institutional and policy constraints (property rights, agricultural policies), geographic and spatial factors (access to market), and information factors (awareness, training). Specific actions needed to address these challenges are formulated as the way forward.

**Keywords:** Adoption, agroforestry, conservation agriculture, organic agriculture, southern Africa, sustainable agriculture



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