

# Deutscher Tropentag 2002

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

## **Challenges to Organic Farming and Sustainable Land Use in the Tropics and Subtropics**

### Book of Abstracts

compiled and edited by  
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The authors of the articles are solely responsible for the content of their contribution.

# Preface

Dear guest,

this is to welcome you in Witzenhausen, Faculty of Ecological Agricultural Sciences, University Kassel. During DTT 2002 I wish you outstanding scientific speeches and posters, fascinating and motivating discussions, meeting old and making new friends, enjoying warm hospitality and —weather permitting— the scenic landscape around Witzenhausen.

The subject of the conference tries to reflect the specific ecological approach of the agricultural faculty in Witzenhausen, which has an over hundred years tradition in tropical agricultural education. We would like to stimulate discussions on what is ecological, organic or sustainable agriculture, especially in the tropics and subtropics and how research can contribute to extend environment friendly production of sufficient high quality food, not forgetting economic and social aspects.

This book contains the great majority of abstracts of oral and poster presentations of DTT 2002, including the keynotes of invited speakers, who are internationally reputed and estimated representatives of their scientific subject. Full papers —as far as available— will be published in the internet (<http://papers2002.tropentag.de>).

I wish you all a successful and enjoyable event, safe return to your home and I hope to meet all of you again in 2003 in Göttingen, only 35 km from here.

I will not forget to thank all the highly motivated and cooperative people, who contributed in planning and organization of the conference, especially also the extended local organizing committee. Last but not least it is indispensable to thank the generous sponsors without the support of whom this conference could not have been implemented.

Rüdiger Krause



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# Plenary Speeches

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## **Attacking the Tragedy of Hunger and Desperate Poverty Through Pro-Poor Agricultural Science**

DENNIS GARRITY

*International Centre for Research in Agroforestry (ICRAF), Kenya*

The current tragedy of hunger and desperate poverty in the developing world is solvable. And by setting firm targets for the eventual elimination of these scourges, the world's attention is now focused on making concrete progress on these goals as never before. Progress has already been made. The percentage of the world population that is food insecure has fallen from 37% thirty years ago, to 18% today, even though the global population has nearly doubled during that period of time. But progress has also been very uneven. There were huge declines in food insecure populations in Asia, but the number of food-insecure people in Africa has more than doubled in the past thirty years.

Agricultural research has a crucial role to play in creating and sustaining the escape from food insecurity and poverty. It does this in several ways: By enabling poor farmers to increase their own-farm food production; by providing greater rural employment opportunities and growth in the rural nonfarm economy; by lowering food prices to poor consumers; and by empowering the poor through greater opportunities for collective action. Sustainable productivity increases in small-scale agriculture are critical to benefit rural people caught in vicious poverty traps. Agroecological approaches to better farming that rely on limited cash investments are necessary. These approaches focus on meeting the needs of small-scale farms in the less-favored areas. They link modern science with indigenous knowledge and practices. They maximize the efficiency of local materials. And they thrive on the strong participation of farmers in identifying problems and designing solutions appropriate to their needs and circumstances. Agroecological approaches give poor people more power and influence over the research system, and thus push pro-poor agricultural research ever closer to the customers.

The generation of improved fallow systems, and other tree-based soil fertility technologies, for disadvantaged farmers in southern and eastern Africa, has exemplified these principles. These systems have enabled farm families to double or triple their food crop yields, and to sustain those yields better during frequently-occurring droughts. In addition, diversified tree cultivation systems have been notable drivers of economic development in many countries, particularly in Southeast Asia. Market-driven production of new or under-recognized tree products are a very significant opportunity to increase both assets and income on the land throughout the tropics. One example is smallholder timber production as a farm enterprise: It is increasingly dominating wood production in many countries. The notion that small farmers are not, or cannot



be, competitive producers of a wide range of farm products has been soundly proven to be erroneous. By debunking this myth, the way is open for much greater needed investments in pro-poor agricultural science to support the smallholder sectors of developing countries, and to thereby create rural prosperity and a sound foundation for economic development.

## **Global, Regional and National Fora for Agricultural and Development Oriented Research**

CHRISTIAN BONTE-FRIEDHEIM

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Limited regional and inter country research cooperation in the agricultural sector has existed for many decades. In several developing regions such cooperation had ended with national independence. For many reasons agricultural research had lost some of its efficiency. The general weakness of national agricultural research, especially in fighting hunger, was a very important reason for the development of the system of the Consultative Group for International Agricultural Research (CGIAR). This was built on the early work of the Rockefeller and Ford Foundations, with their successful wheat and maize institute in Mexico and their rice institute in the Philippines. The CG system consists now of 16 institutes. In several geographic regions or sub-regions an increasing exchange of experience and closer cooperation in the agricultural research sector could be noted in the last 30 years. Regional and sub-regional agricultural research fora were created. These fora and also the international agricultural research centres contributed to regional cooperation. For a number of countries such regional and sub-regional fora were quite often a first step to cooperation in the agricultural research sector. Soon some disadvantages became also obvious, as early on only agricultural research of the public sector was involved.

Even earlier some criticism could be noted on the priority setting process in international agricultural research of the CG system, where only very few national research managers from poor countries were participating, representing the demand side. In the winter of 1992 a meeting was arranged in Rome to discuss the future of agricultural research, with many national researchers from different developing regions participating. The idea of a global and more as well as stronger regional and sub regional fora for agricultural research was developed. Several such fora could be established in the same decade. The secretariat is located in FAO in Rome. The last global forum meeting took place in May 2000 in Dresden. (A copy of the Dresden Declaration should be available).

The first meeting of the European Forum took place in The Netherlands, in Wageningen in April 1999. The topic was "Global Agricultural Research for Development: How can Europe Respond? Call for Initiatives". The second European Forum met in Rome in May this year. (A copy of the Rome Declaration should be available).

Since 1999 national fora were also founded in some western European countries, for example in The Netherlands, France, Switzerland and the UK. Five important reasons for the creation of national fora for agricultural or development oriented research were:

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- a) Better cooperation between national researchers;
- b) Greater influence of researchers on the priorities of nationally financed development oriented research;
- c) Greater influence of researchers on the priorities of EU financed development oriented research;
- d) Better cooperation in Europe between different researchers and research institutions;
- e) Easier access to international research funds, and greater participation in international agricultural research.

In December 2001 a second, successful attempt was made to create a German Forum for Development Oriented Research (DFOR). Members of the Forum are scientific associations, NGOs, industrial research firms, foundations as well as implementing agencies for development programs and projects. It is hoped that the first plenary meeting in Bonn in September 2002 will adopt a Resolution, to be distributed widely among parliamentarians and politicians. (A copy of the Bonn Resolution should be available).



# Session 1: Sustainable Plant Production and Biodiversity

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# Subsession 1a: Organic Farming

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## **Organic Coffee, Biodiversity, and Agrochemicals: the Use of Shade Trees for Low-Input Coffee Production in Central America**

REINHOLD G. MUSCHLER

*Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Department of Ecological Agriculture, Costa Rica*

still to be delivered

## **Organic Agriculture in Rural Development — Whose Agenda?**

JOHANNES KOTSCHI

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### **Introduction**

Organic Agriculture (OA) in Developing Countries is dominated by interests, values and norms from the North. This limits its spread, restricts its importance as an innovative concept for self-sustained rural development and, ultimately, inhibits the worldwide growth of markets for organic produce. There are thousands of local initiatives which strive for Organic Agriculture, with no access to the global market and with an urgent need for support. From the northern perspective they are often labelled as “hidden Organic Agriculture” or “Organic by Neglect” and considered as part of the global movement. But there is little awareness of their potentials and needs, which differ significantly from northern settings. The enthusiasm about the increase in organic trade in the North has diverted attention from this problem, with the result that the potential for development of Organic Agriculture in the South is under utilised.

### **Description of Approach**

AGRECOL, a German NGO, has started an initiative under the theme “Organic Agriculture for Rural Development”. The project aims to contribute to the endogenous development of Organic Agriculture and, thus, to increase its importance in revitalising agriculture towards sustainable food security. Local NGO from all over the world have been invited to participate, and an E-group of around 80 members has been established. By E-mail dialogue the group exchanges experiences, analyses shortcomings, and identifies solutions. A part of the group will meet in Bonn/Germany for a workshop in late October. Together with European professionals they will share ideas and initiate appropriate measures in order to overcome identified constraints.

### **Conclusion**

The project is still in its initial phase. Important first results are:

1. Farming Communities are in great need of a threefold know-how development.
  - a) sound advice at farm level is required (production, farm planning, marketing),
  - b) advisors of such communities need professional training to allow qualified extension and deepening of the knowledge base, c) site specific technology development which combines farmer led research with specific OA knowledge from “outside” is essential. But, how can this triangle of know-how development be financed? Export oriented initiatives may get such necessary support from international traders as part of their production contract and financed by

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premium prices. But what can be done to help the many who do not have access to export markets?

2. Standards for production and processing have proven indispensable for Organic Agriculture. They compel producers and food processors to develop environmentally sound technologies, which makes OA a driving force for innovation. Secondly, the strict production guidelines and the related inspection systems have created confidence among consumers in the high quality of organic products and the market is growing rapidly. But what kind of standards are necessary and appropriate? The global economy demands more and more uniform standards, whereas ecology, culture, economy etc. call for diversity and a site-specific development led by farmer communities, who conduct crucial research with their initiative and creativity through trial and error. Does this not require independence from global standards, and is equivalence really an issue where there is no export market?
3. Quality control via inspection and certification is the logical complement to standards. But the usual system — “one producer one external inspection a year” does not meet the needs especially of smallholders who farm less than 1 ha of land. The development of group certification with internal control systems represents an encouraging search for alternatives. But again: the system in all its elaborateness is meant for export production, and requires an enormous effort in training and supervision from outside. Why not look for indigenous ways of quality control, which may be more appropriate and more efficient?
4. Many initiatives claim that their main constraint is access to markets. They are attracted by international contracts with premium prices but most do not have the means to produce for them. Awareness is dawning that domestic markets have to be developed. Organic Food as luxury goods in big supermarkets of Shanghai and Lima does already exist. But how can marketing strategies for smaller urban places and even rural areas be conceived?

Further work of the group will concentrate on the above mentioned aspects.

**Keywords:** Food security, rural development, sustainable agriculture

## **Umstellung von mineralisch-synthetischer auf organische Düngung — Herausforderung für Biobetriebe in den Tropen und Subtropen**

LUKAS KILCHER

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Ein Herzstück des Biolandbaus ist die Förderung der Bodenfruchtbarkeit und die Ernährung der Pflanzen durch das Dreigestirn Fruchtfolge, Bodenmanagement und organische Düngung in Form von Kompost aus betriebseigenen und lokalen Ressourcen. In gemischtwirtschaftlichen Betrieben gemäßiger Klimabereiche ist die Versorgung mit organischen Düngern meist ein untergeordnetes Problem. In den Tropen und Subtropen hingegen ist die Umstellung von mineralisch-synthetischer auf organische Düngung eine große Herausforderung für Biobetriebe. Dafür gibt es verschiedene Gründe:

**Betriebsstrukturen:** Insbesondere im Exportbereich überwiegt der Pflanzenbau. Viehlosen und -schwachen Betrieben fehlen eigene Hofdünger.

**Diversität:** Vor allem größere Betriebe sind spezialisiert auf wenige Betriebszweige. Auch im Biolandbau konzentriert sich das Interesse auf Cash Crops.

**Zerstörte Bodenfruchtbarkeit:** Düngung mit leichtlöslichen Düngern, intensive Bodenbearbeitung und fehlende Bodenbedeckung reduzieren die Bodenfruchtbarkeit (mikrobielles Bodenleben, Pufferkapazität des Bodens etc.) und bilden eine Hypothek für die Umstellung auf bio.

**Kaum Stallhaltung:** In vielen Regionen der Tropen und Subtropen verbringen die Nutztiere die größte Zeit auf der Weide; Stallhaltung ist auf kurze Zeitabschnitte im Tages- und Jahresablauf beschränkt, so daß nur wenig tierische Hofdünger gesammelt werden können.

**Zugang zu organischen Materialien:** pflanzliche und betriebsfremde Kompost-Rohmaterialien (z.B. zugekaufte Hofdünger, Nebenprodukte aus der Lebensmittelverarbeitung) sind oft Mangelware. Mit betriebsfremden Materialien geht der Biobauer ein erhöhtes Risiko für Rückstände ein.

Das FiBL ist in verschiedenen Ländern der Tropen und Subtropen an Versuchen und Pilotprojekten beteiligt, welche eine Optimierung der Düngung unter verschiedenen pedoklimatischen Verhältnissen in biologischen Anbausystemen zum Ziel haben:

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- In Mexico und Chile ist das Ziel, vulkanische Böden gemischtwirtschaftlicher Kleinbetriebe mit einer Kombination von Kompostgaben, Bodenbedeckung und Agroforstsystemen zu revitalisieren.
- In Kuba geht es darum, die Fruchtbarkeit der ferralitischen Böden zu fördern und die Stickstoffzufuhr auf den hochspezialisierten Zitrusplantagen zu gewährleisten. Gute Resultate bringen Komposte aus pflanzlichen Materialien in Kombination mit permanenter Bodenbedeckung durch Leguminosen und Hecken.
- In der Türkei steht die Optimierung der Hofdüngeraufbereitung auf intensiv wirtschaftenden Acker- und Obstbaubetrieben im Vordergrund. In Modellkompostanlagen werden optimale Verfahren entwickelt und von dort in die Praxis gebracht.

Gerade die ferralitischen, sandigen und vulkanischen Böden in den Tropen und Subtropen sind wegen ihrer geringen Wasser- und Nährstoffrückhaltekapazität erst recht auf Zufuhr von organischer Substanz angewiesen. Die Düngungsstrategie des biologischen Landbaus — basierend auf Fruchtfolge, Intercropping, Bodenmanagement und organischer Düngung — bietet geeignete Lösungen für diese heiklen Böden. Anhand von Erfahrungen aus der internationalen Zusammenarbeit des FiBL in Mexico, Chile, Kuba und der Türkei gibt dieser Beitrag einen Überblick über die Herausforderung und zeigt Lösungsansätze.

**Keywords:** Compost, organic farming, tropical agriculture

## **Prospects and Problems of Local Level Organic Vegetable Production in Bangladesh**

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Bangladesh Agriculture is in the process of transformation from subsistence to commercial farming. Meanwhile, Bangladesh has entered the European Market with export of vegetables and other high value crops. This paper deals with two case studies where tomato was cultivated with organic and/or inorganic inputs in winter 2000, in two villages in Bangladesh. Farmers' reaction and market situation were observed. Visited farmers positively assessed the quality of the organic products. Farmers were also satisfied with the price of the daily harvest from the organic plots and the apparent soil structure improvement. However, farmers could not achieve the expected economic benefit from the organic products. Although farmer received an average 9 % higher price than from inorganic plots, the fertilizer cost increased 24.6 % in organic plots. This increased the total cultivation cost by 6.8 %. All plots were treated with Nimbicidin (neem oil) as pest control measure. Highest yield was obtained 75 % organic and 25 % inorganic fertilized plots but there was no significant difference in yield between 100 % organic and 75 % inorganic plots.

A comparative study by small-scale and relatively large-scale production schemes gave a different scenario. Cultivation in 0.33 ha plots resulted in higher transaction cost and reached up to 23 % of the daily crop sale. The cultivated area of 1.2 ha reduced the transaction cost but it reduced the price of the daily crop sale due to a supply that exceeded the local demand. In both cases, farmers were dependent on local market and the local middleman handlers or retailers exploited them even by 60 % of the consumer price. After five months intensive cultivation farmers net benefit was not satisfactory in comparison to other field crops like mustard or lentil.

**Keywords:** Farmers reaction, organic and inorganic fertilizer, organic products, transaction cost

## Experiences with System of Rice Intensification (SRI) in Cambodia

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Rice production in Cambodia, like in many other countries of the region, dominates the agricultural sector. Rice farming provides food, income and employment for about 65 % of the Cambodian population. However, yields of rice production are comparatively lower (1.7 t/ha) than for example in neighboring Thailand and Vietnam. Furthermore, about 80 to 85 % of the national rice production is largely the result of only one rain-fed crop per year. Increasing rice production in Cambodia has been an explicit goal of many development efforts from international and national projects during the last decade. The approaches to increase rice yields focus on the identification and dissemination of improved varieties, recommendation of correct fertilizer application, as well as on Integrated Pest Management (IPM).

Since 2000, an increasing number of Cambodian farmers started to practice the system of rice intensification (SRI), which was originally developed in Madagascar. SRI entails rather unconventional cultivation practices, especially in plant and water management, and therefore does not spread as easy as a new variety. The paper describes the essential elements of SRI, i.e. transplanting immediately after uprooting, careful transplanting, transplanting young seedlings, transplanting one by one, transplanting with wider spacing, improving soil aeration by avoiding continuously saturated soil during the vegetative growth and by early and frequent weeding. The paper further discusses the experiences of 400 Cambodian farmers in adapting SRI during the wet season 2001. Yields ranged from 2 to more than 10 t/ha, depending on how many elements of SRI were applied. The majority of farmers obtained yields from 3 to 6 tons per ha and the overall yields showed an increase from 50 to more than 200 % over the national average. So far these achievements result mainly from small plots sizes, but importantly also with traditional crop varieties and without chemical fertilizers. Similar encouraging experiences with SRI are reported from a number of other countries worldwide, especially in Madagascar and Sri Lanka. Also IRRI is increasingly aware of the potential of SRI for sustainable improvement of rice production for small farmers with limited resources.

**Keywords:** Rice production, sustainable farming

## PC Software for Optimizing of Raw Material Composition for Compost

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The solid wastes of Asia cities are typically composed of 70–80 % organic waste. In Africa or other developing countries we can find almost the same values. Unclear what practical relevance this should have, as in the composting facility one does not know what the inputs were. One of the first tasks in developing a successful composting program is getting the right combination of ingredients. Two parameters are particularly important in this regard: moisture content and the carbon to nitrogen (C/N) ratio.

Moisture is essential to all living organisms, and most microorganisms, lacking mechanisms for moisture retention (like our skin), are particularly sensitive in this regard. Below a moisture content of 35 to 40 %, decomposition rates are greatly reduced; below 30 % they virtually stop. For most compost mixtures, 55 to 60 % is the recommended upper limit for moisture content. Of the many elements required for microbial decomposition, carbon and nitrogen are both the most important and the most commonly limiting. For most materials, a C/N ratio of about 30 to 1 (by weight) will keep these elements in approximate balance, although several other factors can also come into play. For the determination of the right compost mixture a PC software for optimizing of raw material composition for compost can be used, which is described in this paper. Basic evaluation criteria for compost software are the operational parameters C/N ratio and moisture content. The database for this software contains ca 60 fundamental lead organic materials, where we can find some typical raw materials for tropical and subtropical areas. The software is created by programming language Java. Among the main aims of this project are creating the software which will be easy-to-use and a reliable and friendly graphical user interface. All of this can be done by Java.

**Keywords:** Composting, C/N ratio, Java, moisture content, organic waste, software, tropical and subtropical areas



## Effect of Vermiculture and N Fertiliser Application on Yield of Sweet Potato (*Ipomoea batata* L.) Clones

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Cuban agricultural production is strongly affected by the lack of energy which led to a shortage in the availability of chemical products such as mineral nitrogen fertiliser. The average sweet potato yield with 5–7 t/ha is lower compared to about 19 t/ha world-wide. Thus Cuban agricultural research puts great efforts in investigating local substitution products for mineral N fertiliser, such as humus or vermiculture.

In order to investigate the effects of vermiculture (0 and 5 t/ha) and mineral N fertiliser application (0 and 70 kg urea-N/ha) on sweet potato yield and N uptake of four commercial sweet potato cultivars of the same maturity group, a field experiment was conducted at the INVIT experimental station from October 2001 to March 2002. No chemical plant protection was applied. Most important Cuban sweet potato weevil, *tetúan*, was controlled by application of the fungus *Beauveria bassiana*. Planting density was 44,444 plants/ha, plots were irrigated with 25 mm weekly.

N application increased sweet potato yield significantly from 21.4 to 26.0 t/ha. We found no significant interaction between clones and level of N supply, but noticed a significant (Pr: 0.0642) interaction between clones and vermiculture. Vermiculture application, further, had a significant effect on leaf DM. Cultivar 90-510 was significantly higher yielding compared to clone 354, which is predominantly grown in Cuba. From our data it appears that high yield is negatively correlated with leaf weight ratio (LWR) and positively correlated with HI. LWR and HI among clones ranged from 15 to 20 % and 55 to 78 %, respectively.

We conclude that application of mineral N fertiliser can partly be substituted by application of vermiculture, especially in high yielding clone 90-510. Observed differences among clones in response to vermiculture application require further work on growth responses to changes in soil chemical parameters and microbial activity.

**Keywords:** Cuba, N fertiliser, sweet potato, vermiculture

## Trash and Green Mulch Effects on Soil N and P Availability

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Interest in the use of organic materials as mulch has been revived because of their beneficial effects on nutrient availability and role in improving soil productivity. Our objectives were to quantify the comparative effects of *Sesbania aculeata* as 'in situ' green mulch (IGM) and sugarcane trash mulch (SM) on soil N and P availability. The study was carried on a fine loamy soil at the research farm of C C S Haryana Agricultural University, Hisar, India (29°05'N, 75°38'E, 222 m elevation) for two years 1997–98 and 1998–99 at ratoon sugarcane (*Saccharum officinarum* L.) under shallow water table condition (0.75–1.65 m). The IGM (4 Mg ha<sup>-1</sup>), SM (6 Mg ha<sup>-1</sup>) and un-mulched (no mulching material) as main treatments, and different doses of inorganic nitrogen (urea) and phosphorous (single super phosphate) fertilizers as sub-treatments were arranged in a split plot experimental design with three replications. The mulches increased the availability of N and P to 11.9 and 16.1 % as compared to those of un-mulched over the two years. Application of 'in situ' green mulch and sugarcane trash mulch increased the availability of native phosphorous by 19.3 and 4.8 %, and of added phosphorous by 23.6 and 11.5 % as compared to those of unmulched plots. The higher availability of native and added phosphorous under 'in situ' green mulch was due to its lower pH value. These results suggested that *Sesbania aculeata* and sugarcane trash as mulching material may be used for enhancing the nutrient availability of N and P for sustainable soil productivity.

**Keywords:** Available N and P, mulch, *Sesbania aculeata*, sugarcane trash

## **Evaluation of Quality and Composition of Solid Organic Waste in Developing Countries (Morocco), and Comparison with Europe**

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Many developing countries are trying to eliminate their domestic waste more environmental friendly than before and at the same time to recycle its valuable material. While the industrial usable materials are at least partly reused, the organic matter is mostly dumped.

As an example the Moroccan solid waste contains about 73 % of weight organic matter, twice as much as in Europe. In contrast the portion of the dry valuable materials, particularly metal, glass and paper, is in Europe considerably higher than in Morocco. However due to the intensive use of plastic bags in Morocco, the portion of plastic is same as in Europe.

The composition of solid waste in Moroccan towns (Rabat & Agadir) mostly depends on the standard of living and daily activities (Market, commerce, Tourism, ...) in a district, as well as on the recovery of valuable materials before and during the waste collection.

The major portion of solid waste in Morocco consists of fresh vegetables, simultaneously the garden wastes are normally not collected with solid waste. Thus, it leads to constantly high water content in solid waste throughout the year.

Therefore, a direct wet garbage incineration is not efficient as waste elimination method. In opposite, composting can supply a humus carrier for organic poor soils through its high content of Organic material.

Also substantial costs of the environmental pollution can be saved through avoiding wild dumping and duration of dumps utilization can be increased. Whereby the high water content of approximately 70 % represents a problem for the composting starting phase, as the aerobic conditions are particularly difficult to assure due to the lack of structure material in the solid waste.

**Keywords:** Composition, composting, developing countries, Morocco, quality, solid waste

## **Ability of Watery Extracts of Composted Organic Waste from Urban Households to Control Airborne Plant Pathogens**

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The effect of compost applications on plant health has mainly been investigated regarding soil borne diseases. The few investigations on the effectiveness of shoot treatments with watery compost extracts showed that leaf pathogens were effectively controlled and that different mechanisms seemed to be involved. Additionally to systemically acquired induced resistance, some other antagonistic mechanisms of the microorganisms present in compost extracts were observed, including production of antibiotics, concurrence for nutrients or parasitism. In the present investigation, the effectiveness of watery extracts from composts that were produced from organic household waste in West Africa, was examined using the pathosystem tomato and *Alternaria solani*.

Applications of watery compost extracts successfully suppressed infection of *A. solani* on tomato. Different factors were checked for their impact on the effectiveness of the extracts and the density of microorganisms present in the extracts. Temperature and frequency of stirring significantly influenced the density of microorganisms and the effectiveness against *A. solani*. Daily stirring of the compost-water mixture during the extraction period (3 days) increased the density of microorganisms sevenfold and disease incidence was reduced by 27 % as compared to the treatment with only one initial stirring. The incubation of the compost-water mixture at 20 °C increased the number of microorganisms in the extract tenfold as compared to mixtures incubated at 30 and 35 °C. The extract incubated at 20 °C reduced incidence of *A. solani* by 66 % as compared to the control, whereas the other variants were less effective.

The formulation substances cellulose, alginate and xanthan were added to the extracts to increase their effectiveness against the pathogens. The extract enriched with xanthan reduced disease incidence on tomato by 23 % as compared to the extract without formulation substances.

Storage duration of the composts after their preparation significantly influenced the density of microorganisms present in the extracts and their effectiveness against *A. solani* on tomato. Those composts that were stored for a shorter period showed a higher number of microorganisms in the extract and a higher effectiveness of the extracts.

## Does HCN from *Pseudomonas fluorescens* Isolate T58 Contribute in Biocontrol of *Fusarium oxysporum* f. sp *lycopersici*?

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*Fusarium* sp. pathogens are a major cause of vascular wilt diseases on many cultivated crop plants. In the search for methods to control these diseases biological control using rhizobacteria is increasingly attracting favourable attention. In this study several bacterial isolates were screened for activity against *Fusarium* infection on tomato in the greenhouse. Plants treated with *Pseudomonas fluorescens* isolate T58 before inoculating with *Fusarium* had less infection and higher shoot mass as compared to the plants treated with *Fusarium* alone. Induction of resistance in the tomato against *Fusarium* was determined to be one of the mechanisms-of-action of this bacterial isolate. Additional *in vitro* tests showed that isolate T58 produces HCN, a volatile metabolite which is thought to play a role in biological control of some soilborne diseases. An objective was set to investigate the effect of volatile metabolites produced by *P. fluorescens* isolate T58 on growth of *Fusarium* spores and mycelia *in vitro*, and to investigate the effect of the volatile metabolites on plant metabolic processes which may contribute to induction of resistance. Results obtained showed that the volatile metabolites from isolate T58 suppress germination of *Fusarium* spores but do not reduce growth of mycelia although changes in pigment production in the mycelia were observed in the presence of the metabolites. Exposing tomato plants to the volatile metabolites caused a significant increase in peroxidase activity but there were only minor changes in the  $\beta$ -1,3-glucanase and chitinase activity and total protein content. Changes in peroxidase activity due to the presence of either a pathogen, biocontrol agent or resistance inducing chemicals have been associated with induced resistance. We have concluded that volatile metabolites from *P. fluorescens* T58 possibly contribute to biocontrol of *Fusarium* wilt on tomato through a direct effect on the pathogen and indirectly by triggering metabolic changes in the plant that contribute to induction of resistance.

**Keywords:** Biocontrol, *Fusarium*, rhizobacteria, tomato, volatile metabolites

## Importance of *Parthenium* (*Parthenium hysterophorus* L.) and the Role of Pathogens as Biological Control in Ethiopia

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*Parthenium* is an exotic invasive weed that originated in tropical America, now occurs widely in India, Australia, and Africa. In Ethiopia, it is also known to affect crop, animal and human health. *Parthenium* was observed growing in different habitats from hot, arid and semiarid low altitude (900 m) to humid high mid altitude (2500 m) in the survey area. It grows on any type of soil: sand, loam or clay and in different habitats: roadsides, wastelands, rangelands, villages and gardens, and in crop fields. Experiments on diagnosis, incidence and distribution of pathogens associated with *Parthenium*, and further evaluation of the potential pathogens as biological control agents were carried out during 1998–2002. Several fungal isolates of the genus *Helminthosporium*, *Phoma*, *Curvularia*, *Chaetomium*, *Alternaria*, and *Eurotium* were obtained from seed and other plant parts of *Parthenium*. However, most of the isolates tested were non pathogenic except *Helminthosporium* isolate which resulted in a leaf blight symptom similar to the infected plants in the field. Its virulence was very limited and required high humidity for infection. Therefore, it was concluded that these non-obligate fungal pathogens showed insignificant potential for biological control of *Parthenium*. The two most important diseases associated with *Parthenium* were the rust, caused by *Puccinia abrupta* var. *partheniicola* and the phyllody, caused by phytoplasma of fababean phyllody group (FBP). The rust, being accidentally and possibly introduced together with *Parthenium*, was commonly found in high mid altitude (1400–2500 m) while phyllody was observed in low to mid altitude regions (900–2300 m.a.s.l.) of Ethiopia, each with a disease incidence up to 75 % in some locations. Phyllody diseased plants were characterised by excessive branching, reduced plant height and leaf size, and alteration of floral structures into small leaf-like structures that lead the plant to sterility.

Study of the individual effects of the rust and phyllody disease on *parthenium* in different locations under field conditions showed that weed morphological parameters were significantly affected. Seed production capacity of *parthenium* was reduced by 42 and 85 % due to rust and phyllody, respectively. Virulence of *parthenium* rust collected from different locations showed that Ambo and Debre Zeit isolates were comparatively most virulent based on mean number of leaves infected per plant and mean number of pustules per leaf. From the distribution and effects on *Parthenium*, it can be concluded that Phyllody and rust diseases of *Parthenium* showed significant potential for use as a classical biological control of *Parthenium* weed in areas where the diseases are not present after the assessment of potential risk of specificity of Phyllody disease and identification of insect vector(s) that transmit phyllody disease.

**Keywords:** Biological control, Ethiopia, *Parthenium hysterophorus* L., pathogens

## Micro-Plate Colourimetric Assay for Endo-Acting Amylase, Chitinase and 1.3- $\beta$ -Glucanase Activities in *Chromolaena odorata* Roots Colonized with (V)A Mycorrhizal Fungi

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Some hypotheses and possibilities are discussed in the literature concerning the mechanisms of improved phosphorus uptake by roots of plants when infected with (V)A mycorrhizal fungi compared with uninfected plants. One of the hypotheses includes the role of enzymes in the symbiosis between plants and mycorrhizal fungi. In this investigation the activities of amylase, chitinase and 1.3- $\beta$ -glucanase in roots of *Chromolaena odorata* inoculated with the fungus *Glomus manihotis* or *Acaulospora longula* were compared with those of non-inoculated plants. An extraction with sodium acetate-acetic acid buffer (pH 5.0; 0.01 M; 10 ml g<sup>-1</sup> roots) and an assay procedure adapted to microtiter plates for measuring the activities of the mentioned enzymes were used. Enzymatic fissionable water- soluble polysaccharide derivatives covalently labelled on a pigment type of the Remazols (RBB = Remazol Brilliant Blue R and RBV = Remazol Brilliant Violet 5R) were applied as substrates for the enzymatic assays. An increased amylase activity could be determined in the extract of 12 weeks old roots infected with *G. manihotis* compared with 6 weeks old roots and uninfected roots with this (V)A mycorrhizal fungus. No amylase activity could be found in the extracts of roots infected with *A. longula* or of non-mycorrhizal roots.

Considerable chitinase and glucanase activities could be determined in extracts of the 6 weeks old roots colonized with *G. manihotis* and *A. longula* compared with relative low activities of both enzymes in the extracts of the uninfected roots. These activities decreased in the root extracts of both (V)A mycorrhizal fungi to the same level of non- mycorrhizal root extracts when the roots became 12 weeks old.

The results showed furthermore that the enzyme activities were correlated with increased P uptake and thereby improved plant growth, demonstrating that enzymes seem to play a role in the mechanisms of P uptake by mycorrhizal roots. However, further investigations are still needed.

**Keywords:** Enzymes, mycorrhiza, P uptake

## **Biology and Natural Control of Pest Millipedes *Spinotarsus caboverdus* PIERRARD (1987) from Cape Verde**

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Millipedes as a crop plant pest have been present in Cape Verde for 30 years. The species *Spinotarsus caboverdus* is well known as a feeder on crops of potatoes, sweet potatoes, cassava, pumpkins, corn and bean seedlings. The millipedes also destroy fruits like papayas, mango, bananas and pineapples by drilling into them as soon as they fall onto the ground.

With the aid of laboratory cultivation, we wanted to answer specific questions about the pest's development cycle and reproduction process, as there are still substantial knowledge gaps in those areas.

Females scatter the oval, whitish eggs individually on the ground. By means of 8 moltings the larva develops into an adult animal. The development of the larva under the laboratory conditions takes 7 months, and the adult animals have a life duration of approximately 8 months. All examinations of the development data so far have shown that the species *S. caboverdus* only produces one generation per year.

There are reasons to believe that the appearance and uncontrolled eruption in numbers of *S. caboverdus* is a result of the absence of its natural enemies, normally present in the country of origin.

The environment in Cape Verde, and, in particular, the traditional channel irrigation, seem conducive to the development of millipedes.

We know that carnivorous beetles and frogs capture millipedes in captivity. However, this does work in nature. The specific covert development cycle and the defensive chemicals that are present in millipedes provide effective defence against most predators. Some parasites could possibly act as biological control agents for *S. caboverdus*. Laboratory tests showed that fungi *Beauveria bassiana*, *Metarhizium flavoviride* and nematodes *Rhabditis necromena* could be possible biological control agents for the millipede in Cape Verde.

**Keywords:** Millipedes, natural control, *Spinotarsus caboverdus*



## **Plant Health Protection in Organic Coffee Cultivation in Peru: a Basic Programme for Obtaining and Applying Ecologically Acceptable Bio-Insecticides and Fungicides**

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In the Mayo river area of the Upper Amazon in north-eastern Peru a development project for ecological coffee production is under way. Highland Arabica coffee is produced by APROECO, a democratic and cooperative association of more than 800 small farmers and indigenous ethnic groups, with the assistance of PRONATUR, a private, ecologically orientated organization and GTZ, the German Agency for development. Emphasis is on fair trade practices and market orientated, sustainable production of shade grown organic coffee. Habitat conservation (especially high canopy old growth trees) is also considered extremely important.

Conventional methods of plant protection from diseases and pests nearly always endanger ecosystems, and also lead to an inconvenient dependency on commercial products. The Peruvian rain forest is known to harbour innumerable plants with properties making them useful as biological insecticides or fungicides, but much investigation and research has yet to be done.

Local crops are damaged mainly by the following: *Mycena citricolor*, *Pellicularia koleroga*, *Hemileia vasatrix*, *Hypothenemus hampei*.

A two-phase programme is described which **a)** offers a permanent pest and disease identification service to farmers, and **b)** seeks to obtain specific ecological products to combat the above-mentioned organisms.

### **Phase 1:** (March–December 2002)

- Research and development of extracts from locally collected plants. Basic formulations which later on can be copied by farmers for use in their own plots.
- Development of foliage fertilizer based on natural products rich in nitrogen, potassium and minor elements: guinea-pig and cattle dung, leguminous foliage etc.

### **Phase 2:** (November 2002–December 2003)

- Development of a microbial dynamizer from soil fungi (*Mycorrhiza* spp.)
- Development of organic fungicides derived from *Verticillium* spp. and from a *Trichoderma* sp. discovered locally.
- Development of an organic insecticide from local strains of *Beauveria* sp.

**Keywords:** Agro-ecology, biodiversity conservation, coffee, extension service, fair trade

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## **Shade-Grown Organic Coffee Production in Peru: a Project Linking Ecological and Fair-Trade Issues with Efficient Marketing**

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The Altomayo region in Peru is ideally suited to the growing of coffee; high-quality Arabica is harvested on small plots in highland Amazon rain-forest. Ecologically, this region is a bio-diversity hotspot, and efforts to maintain the primeval habitat of high canopy, like old growth trees are extremely important. Shade grown bird-friendly organic coffee has proved to be ideal, and at the same time assures better incomes. Some of the smallholdings are farmed by recently established migrant families from the higher Andean regions, others by small groups of native peoples of the Amazon rainforest.

With simple techniques involving partial felling only, no burning, mulch and compost, etc., the deficiencies of ancestral practices such as slash-and-burn are being overcome.

The farmers associated to introduce sustainable and organic practices. In 1996 the “Asociación de Productores Agroecológicos” (APROECO) was founded. This cooperative venture now has 872 members — all small farmers who have taken up growing coffee to IFOAM and SMBC standards in 50 000 ha of rainforest. They are supported by a team of specialists operated by PRONATUR, a private enterprise cooperating closely with GTZ.

APROECO is divided into 6 main geographical regions, with up to 7 committees each. Every member has a vote, and his or her say in decision-taking at meetings. This democratic approach has proved to be an efficient tool in advancing the aims of the Association. The interests of these independent smallholders are thereby taken up and channelled efficiently.

The change towards ecologically sound agricultural practices is monitored by the extension team. Their continuous presence in the field helps to introduce concepts of efficiency, product quality and environmental responsibility.

In 1999 APROECO/PRONATUR teamed up with GTZ (Proyecto de Desarrollo Integral Alto Mayo) receiving a local subsidy. The synergies thereby generated have resulted in efficient and transparent marketing support, in joint research projects (bio-insecticides and fungicides) and positive experience in linking commercial activity within commodity markets to cooperative systems, thus leading to a realistic and sustainable fair trade situation.

**Keywords:** Agro ecology, biodiversity conservation, coffee, extension service, fair trade

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## Comparison of Conventional and Organic Grown Fennel in Egypt

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Bitter fennel (*Foeniculum vulgare* MILL.) is an important crop for small farming in Egypt. Seeds are used as raw material for medical and aromatic products especially for the export to Europe. Due to these uses and high quality demands the processors prefer seeds grown according to the standards of the EU directive 2092/91 for organic products. This means strict regulations for the use of fertilizers such as avoidance of mineral nitrogen, soluble phosphates and limitation to raw potassium.

Field trials on two sites, a newly reclaimed sandy soil (Sekem) and an intensively used old cultivated soil (Nile valley) were conducted to prove the effects of different farming systems on seed quality. Fertilization practices have been compared based on plant nutrient applications in conventional farming, such as ammonium nitrate, super phosphate and potassium sulfate. These were compared to practices in organic farming such as compost, compost plus Azotobacter (for better mineralisation) or chicken manure for nitrogen supply, rock phosphate or rock phosphate plus elemental sulfur for phosphor and sulfur supply and feldspar for potassium supply. Experiments have been conducted during two growing seasons 1998/1999 and 1999/2000.

Results showed that conventional farming practices generally gave the highest yields for seeds and oil (3.1–3.4 t seeds/ha and 71–86 l oil/ha) followed by compost plus Azotobacter as nitrogen source, rockphosphate plus sulfur and feldspar for potassium supply which gave similar results (3–3.3 t seeds/ha and 60–82 l oil/ha). The composition of the essential oil had not been influenced substantially by the two different farming systems (no statistically significant differences were found).

It can thus be recommended that farmers in Egypt might grow fennel due to organic farming practices without substantial loss of income.

**Keywords:** *Foeniculum vulgare*, oil composition, oil yield, organic farming, seed yield

## **NECOFA, “Network for Ecofarming in Africa”**

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NECOFA is an Internet working platform established by senior agricultural experts from African countries in co-operation with the Food and Agriculture Development Centre (ZEL) of the DSE and the German Institute for Tropical and Subtropical Agriculture (DITSL). NECOFA is designed for the exchange of experience between senior agricultural experts within African countries as well other countries. The presentation will introduce NECOFA (South Africa). NECOFA SA is a young member in NECOFA and its establishment and structure will be described. The important steps in the establishment phase which National Conference will be described and then the Board of Directors and its functions will be explained. NECOFA SA is one of 9 member-countries and therefore the international platform will also be introduced. The international body and its history and general objectives will be described. The presentation is looking in the areas of the background of NECOFA SA, the target-group, the objectives, its activities and services, training and workshops. Thereby the networking aspect and its principles of operation will play a major role. Obtaining information, coordination and output are important issues. Lobbying is also an area of networking. Through the national conference the founding-members developed the policies of NECOFA and the basic constitution for the organisational structure. The constitutions of other member-countries in NECOFA were used as example constitution in the conference. An interim Board of Directors were appointed for a six month-time period. The organisational activities of the founding-members of NECOFA SA as well the practical work and the gained experience in the different areas around the organic farming will be described. The organisational structure is composed of three levels. The CBOs, which represent the activists at the grassroots level and the regional working NGOs for the provincial level. On the national level there are the Government and the nationally operating NGOs. The programmes within NECOFA SA will be described, which include training and exchange of knowledge and experiences. Other areas are workshops training to the farmers, seed-security and the growing and use of medicinal herbs. The forwarded plans for the implementation of the programmes will be introduced and first successful steps will be pointed out. The introduction of NECOFA SA will lead to an evaluation of the already worked areas, for a better support and development of the African Network.

**Keywords:** Internet working for development, NECOFA

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## **Impact of Ecological and Conventional Arable Management Systems on Chemical and Biological Soil Quality Indices in Nicaragua**

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We measured the activity and soil microbial biomass in volcanic ash soils from 10 sites under ecological farming (no pesticides, shallow ploughing, mulching, organic fertilizers, crop rotation) and 15 sites under conventional farming (pesticides, mineral fertilizers, deep ploughing). Our aim was to determine the effects of management system on soil quality and soil fertility in tropical Nicaragua in relation to soil type. None of these sites was irrigated. Conventional management led to significantly increased amounts of total soil P and a significantly larger biomass C-to-P ratio compared to ecological management. Almost all of the other microbial properties, i.e. soil basal respiration, ergosterol and biomass C were significantly improved by ecological management. Also the biomass C-to-soil C ratio was significantly increased, but not the metabolic quotient  $qCO_2$  or the ergosterol-to-biomass C ratios, indicating that the positive effects of ecological management were mainly due to increased C input rates. Biomass C, ergosterol, and basal respiration rate were significantly larger at the loamy than at the sandy sites. The same was true for the biomass C-to-soil C ratio, but the ergosterol-to-biomass C ratio and the metabolic quotient  $qCO_2$  were larger at the sandy sites. Our results demonstrate that ecological management is an important tool for soil conservation and sustainable management of arable land in Nicaragua. However, the decline in total P and the low P availability to soil microorganisms need attention as a precaution against P deficiency. The improvement was greatest at the loamy sites, although the effects of management system were in most cases independent of the soil type. For this reason, ecological management should be preferably promoted on loamy soils.

**Keywords:** Basal respiration, biomass P, ergosterol, P extractable, microbial biomass C, soil C, total P

## **Waste Heat Utilisation in a Tropical Greenhouse in Ruswil, Switzerland**

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The background for the project is the energy-law of the Canton of Lucerne that requires that 60 % of the industrial waste heat must be reused to minimise environmental impacts. In 1997 the idea was borne to use the waste heat from a Gas Compressing Station in a Greenhouse with tropical climate in order to produce tropical fruits and fish on a commercial basis. After a preparation phase of two years a greenhouse was built and operation started in springtime 1999 for a pilot phase of five years. The Greenhouse covers a surface of about 1500 m<sup>2</sup> and integrates an aquaculture system. The principal question behind this project is to proof the feasibility of the project idea on a technical, ecological and economical level. Papayas (*Carica papaya*), Bananas (*Musa acuminata*), Carambole (*Averrhoa carambola*) and Guava (*Psidium guajava*) are the most successfully produced fruits of the greenhouse; a complete list of all cultivated fruits is available at <http://www.tropenhaus-ruswil.ch/produkte/index.htm>. The project aims to create and close nutrient and water cycles within the greenhouse. The experiences show that the water-consumption can be covered with rainwater which is collected from the greenhouse roof. On the nutrient level the only input in the greenhouse system is fish fodder. The fish (waste)water is used to irrigate and fertilise the plants of the greenhouse. Studies show that the fruits produced in the greenhouse are more ecologically and better in taste compared with imported ones. The business experiences show that profitability is as high as with comparable farm products. The greenhouse project generates new income for the nearby farmers and creates a platform for public awareness in Ecological Engineering.

# Subsession 1b: Irrigated and Dryland Farming

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## Water for Agriculture — A Global Systems Analysis Perspective

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The global issues of water security and food security are closely linked. Sustainable plant production requires a sustained provisioning of water, either in the form of “green” or of “blue” water. The term “green and blue water” was introduced by FALKENMARK (1993) to better assess the role of water in plant production. Green water is defined as the fraction of water that is evapotranspired, i.e. the water supply for all non-irrigated vegetation. Green water can be called either productive with respect to plant production (if transpired by crops or natural vegetation) or non-productive (if evaporated from soil and open water). Blue water refers to the water flows in groundwater and surface water (river, lakes). It represents the water that can be withdrawn e.g. for irrigation or is available for *in-situ* water use like navigation. In areas without enough green water in the soil to achieve satisfactory crop growth, crops can be irrigated with blue water. The distinction between green and blue water helps to understand the linkages between rainfall, soil, land productivity and water availability for human water use. One example is rainfall harvesting, which increases the fraction of green productive water and decreases both the amount of green unproductive and blue water (the latter possibly being detrimental to downstream water users).

Another powerful term is “water productivity”, which can be defined as produced crop mass (or its economic value) as a ratio of the applied (or consumed) water volume (MOLDEN, 1997). While the term has mostly been used for irrigated agriculture, it is equally applicable in dryland farming, where many efforts are made to enhance productivity under drought conditions. Water being a scarce resource, the goal is to increase water productivity. To achieve a sustainable development, however, it is not only necessary to increase water productivity but also to take into account any trade-offs that might exist between water productivity and other (ecological) goals. An example are efforts to decrease water use for paddy rice production, which, however, requires increased inputs of nutrients and pesticides.

To increase water productivity under irrigated conditions, a good land and water management is required, which consists of a comprehensive and integrated set of measures related to technology, economy, institutional issues and knowledge transfer, and which should be based on a good knowledge about the dynamics of the system. As the dynamics of the system, in particular under the impact of global change, are influenced by processes and drivers at various spatial and institutional scales, a multi-scale approach that considers the interrelation between farm, community, basin, country and global scales is best suited to support sustainable development.

To address the linked issues of water and food security at the global scale, we have developed the global model of water availability and water use WaterGAP (ALCAMO et al., 2002), which, with a spatial resolution of 0.5°, computes both water availability (as surface runoff, groundwater recharge and river discharge) and water use (for irrigation, livestock, households and industry). The Global Hydrology Model of WaterGAP (DÖLL et al., 2002) provides, for example, information on how much water is potentially available for irrigation purposes (taking into account domestic and industrial water demands) and how this might change due to climate change.

The Global Irrigation Model of WaterGAP (GIM), simulates net and gross irrigation water requirements in each 0.5 degree grid cell as a function of climate, crop type (rice and non-rice) and the area that is equipped for irrigation (DÖLL and SIEBERT, 2002). A digital global map of the areas that were equipped for irrigation around 1995 was developed for this purpose (DÖLL and SIEBERT, 2000), and is now being improved in cooperation with FAO (<http://www.fao.org/ag/agl/aglw/aquastat/irrigationmap/index.stm>). GIM was tested against independent data of irrigation water use, and an uncertainty and sensitivity analysis was performed (SIEBERT, 2001). In the context of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), GIM was applied to assess the impact of climate change on global irrigation requirements (DÖLL, 2002).

As a next step, we want to improve GIM by modeling a larger variety of crop types, which is made difficult by the fact that FAO agricultural production country values do not distinguish between irrigated and dryland farming. Besides, it is planned to couple WaterGAP with a global agroeconomic model in order to derive consistent scenarios of the future food and water situation. These global scenarios can provide a framework for deriving water and food scenarios at smaller scales, which aim at supporting regional or local land and water management.

## **The Dynamics of Water User Associations in a Large-Scale Irrigation System in Thailand**

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The management of a large-scale irrigation system requires the co-ordination of activities among various groups and individuals. The establishment of such a system does not only consist of constructing infrastructure and planning optimal water allocation, there are also a range of fundamental socio-economic changes involved which had often not been sufficiently considered during the planning stage. The explanation for this lies partly in the unpredictability of socio-economic development and also in the extended time frame of social organisation which lag behind technological change.

The problem of not knowing how social systems will react to changes and how they will perform in a new setting cannot be eliminated totally due to the uniqueness and complexity of socio-technical systems. However, experiences with irrigation projects are growing and they might be helpful for better planning future changes in irrigation systems.

This paper deals with the evolution of Water User Associations (WUA) in a large-scale gravity irrigation system in Thailand. The WUA have been implemented starting in the late 1980s by the national irrigation agency, to organise farmer governed O&M on tertiary level. Main system O&M has remained under the regime of the national agency.

After having existed for more then a decade, conclusions on the sustainability of farmer associations can be drawn. It could be observed that the adaptation of legally prescribed organisational structures has been only valid for a minority of associations and some general weaknesses of these structures can be observed. On the other hand, a multitude of informal organisations has evolved which show ways for improving participation of water users.

A major assumption underlying this paper is that farmers' motivation for participation is a pre-condition for the sustainability of WUA. The actual participation situation, the motivation factors for participation, and the environmental and dynamic influences on farmers' motivation for participation are analysed.

**Keywords:** Farmers associations, irrigation organization, Thailand

## **Bewässerungsmanagementmodell: SUGIS**

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In vielen Entwicklungsländern wird der Betrieb und die Unterhaltung der Bewässerungsprojekte vernachlässigt, obwohl die Bewässerungsprojekte mit intensiven Bemühungen und hohen Kosten durchgeführt werden. Die Ursachen dafür liegen nach Ansicht vieler Experten weniger im bautechnischen, sondern mehr im Managementbereich. Gegenwärtig diskutieren viele Experten, Institutionen und Entscheidungsträger über die Neuplanung von Bewässerungsprojekten oder, im Gegensatz dazu, über die Verbesserung der bestehenden Bewässerungsprojekte, insbesondere im Managementbereich.

Die Bewässerungsprojekte in der Türkei sind charakterisiert durch eine geringe Managementpartizipation der Landwirte und Mangel an Bewässerungsmanagementmodellen. Bezüglich des Managements ist im Hinblick auf die Ausnutzung der Böden und des Wassers ein effektives und effizientes Managementinformationssystem in Bewässerungsprojekten der Türkei nicht vorhanden.

Der Einsatz eines Geo-Informationssystems (GIS) kann die Planungen von Bewässerungsprojekten und die Entscheidungsfindung durch gezielte Bereitstellung von Informationen wesentlich unterstützen. Vor der Konzeption eines hierfür geeigneten Systems ist es jedoch erforderlich, den gegenwärtigen Stand und neue Entwicklungen der GIS-Technik aus der Sicht des Anwenders in der Planung des Bewässerungsmanagements darzustellen und zu bewerten.

Bewässerungsmanagement ist durch eine Vielzahl von Informationsprozessen gekennzeichnet. Ein Bewässerungsinformationssystem ist als Summation aller Informationsverarbeitungsaufgaben in sämtlichen Organisationseinheiten der Bewässerung und dabei eingesetzten technischen Hilfsmitteln, Arbeitsverfahren und Betriebs- und Unterhaltungsaktivitäten definiert.

Die wichtigste Aufgabe eines GIS- unterstützten Bewässerungsmanagementmodells ist es, dem Projektmanagement, den Landwirten und den Nationalplanern rechtzeitig ausreichende geeignete Informationen für die Entscheidungsfindung zu liefern. Die Vorgehensweise des GIS-unterstützten Bewässerungsmanagementmodells lässt sich in vier aufeinander aufbauenden Schritte einteilen. Das sind Dateneingabe, Projektinformationsanalyse, Wassermanagement und Evaluierung.

In dieser Arbeit wird ein GIS-unterstütztes Modell zum Bewässerungsmanagement dargestellt. Das Modell wird vor allem an der Uludag Universität, Institut für Kulturtechnik der landwirtschaftlichen Fakultät (Bursa-Türkei) bearbeitet. Das Ziel ist die Definierung des Modells von SUGIS und die Nutzungsmöglichkeiten aus GIS im Bewässerungsmanagement zu determinieren.

**Keywords:** Bewässerung, Evaluierung, Geo-Informationssystem, Management, Türkei

## The Hydrology of Mountain Oases in Northern Oman

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Oasis agriculture in the desertic Northern Omani mountains is based on the millennia-old use of spring water. However, little is known about the hydrogeology of the generally small springs, their buffering capacity against drought periods which may last for several years and the movement of water in irrigated fields.

To address these questions, the flow of water in a spring network was monitored over 20 months in the oasis of Balad Seet. Water samples were analysed for their time of retention in the calcareous rocks of origin using their unstable isotope signatures (tritium/helium ratio). Soil moisture was measured in an alfalfa (*Medicago sativa* L.) field using dielectric probes within 14-day irrigation cycles. Quantitative data obtained were integrated into a three-dimensional model of the entire oasis watershed. This model was derived from several thousands of differential GPS measurements and laser-based distance measurements.

During the observation period, 120 mm precipitation had been measured, however only 50 mm might be effective for ground water recharge. In the same period, a decline of the spring outflows of 24% was observed. These observations and the results of the isotope analysis of the water indicate retention times of several years. This underlines the role of bedrock as a natural buffer system for water in this oasis watershed.

The measured volumetric moisture content in the upper 0.1 m of the soil dropped after a 35 mm water application within a few hours from saturation to 15% and steadily declined to 7% until the next irrigation event. The water use efficiency of the crops in this system is very high with apparently only minor small seepage losses necessary to avoid salinity build-up. The ancient channel irrigation system of this oasis with its nested terraces seems to be an elaborate form of adaptation to limited water availability on small land surfaces.

**Keywords:** GPS, hydrology, oases, oasis, Oman, terraces, water

## **Root-Shoot-Communication in Drought-Stressed Maize Is Modified by Atmospheric Conditions**

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Maize (*Zea mays* L.) was subjected to drought stress in a lysimeter set-up over two consecutive years. The lysimeter comprised 18 experimental basins filled with loamy sand and with a surface area of 4 m<sup>2</sup>. Maize was sown in early June in both years and grown for about three weeks before the treatments started. The objective of this study was to investigate the chain of signals ultimately leading to control of water loss from the plant surfaces. Early morning shoot-water potential, stomatal conductance and photosynthesis were measured at regular intervals during the drying cycle. Xylem sap was sampled from plants cut a few centimeters above the ground by guttation sampling. The sap was analyzed for pH, nitrate and abscisic acid concentration. Physio-chemical responses to drought differed significantly between the two years as a function of both rate of soil-moisture loss and atmospheric vapor pressure deficit (VPD) during the early phases of drought stress. Under conditions of low VPD plants adapted to the environmental changes through alterations in their physio-chemistry, including an increased level of abscisic acid in both xylem and leaves, leading to a stable water status in the plant. Under conditions of high VPD a transient peak of xylem abscisic acid was observed following the time course of VPD. Plants did not adapt to the drought stress and had a negative water status, low stomatal conductance and reduced photosynthesis rates despite the absence of increased levels of leaf or xylem abscisic acid. The chain of events leading to stomatal control and ultimately reduction in transpiration differed between the two climatic environments and may have been a direct effect of the difference in the rate of soil moisture loss. Implications for adaptation strategies to drought in relation to climatic conditions are discussed.

## Advanced Irrigation Scheduling for Lychee Orchards in Northern Thailand

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In the northern highlands of Thailand irrigation is performed in the dry season when water is scarce. Water for irrigation is been taken from creeks, which are also supposed to supply the farmers in the valleys. Thus, conflicts between highland and lowland farmers with ubiquitous.

In order to prevent water losses by inefficient irrigation, appropriate irrigation scheduling for lychee orchards is needed. Therefore the model CropWat 4.3 has been tested. However, the model generates too high irrigation recommendations. Sensitivity analysis detected that the crop coefficient ( $k_c$ -value) is the most sensitive parameter. As crop coefficients for lychee trees are not available, considerable miscalculations, based on the estimated values are possible. Furthermore, interactions between soil water suction and transpiration of lychee trees, which are important to predict water stress have not been investigated yet. Therefore, the goal of this study is to evaluate precise crop coefficients for lychee trees and to investigate the reaction of lychee tree transpiration to different soil water suctions.

The potential evapotranspiration of lychee trees ( $ET_1$ ) is determined by multiplying a potential reference evapotranspiration ( $ET_o$ ) with the specific crop  $k_c$ -value. Knowing  $ET_o$  and  $ET_1$ , the  $k_c$ -value for lychee trees can be calculated. Parameters for computing  $ET_o$  are measured by weather stations,  $ET_1$  will be determined by sapflow measurements using the Granier-Method. Since  $ET_1$  represents only water losses by transpiration the dual FAO approach (with separated  $k$ -values for plants and soils) for calculating  $ET_1$  will be adopted. The needed soil parameters have been analysed previously.

The impact of different soil water suctions to lychee tree transpiration will be detected by measurements of stomata conductance, transpiration rate and photosynthesis rate of lychee leaves. Simultaneously, water content measurements with TDR probes will be carried out. Using *in situ* determined teta-psi functions the corresponding water suction in the soil can be identified. By comparing leaf stomata conductance and soil water suction data it is possible to specify a proper threshold for the soil water suction when water shortage will affect lychee tree transpiration.

**Keywords:** Crop coefficient, evapotranspiration, sapflow, stomata conductance, TDR

## The Challenge of Knowledge Transfer in Irrigated Agriculture

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Irrigation farming is one of the most diverse agricultural environments to work in. A large number of key routines, many of which go far beyond the standard agronomic practice, are the daily task of irrigation farm managers and extensionists as they attempt to maximize profits in an ecologically sound manner. Since irrigated agriculture is the largest single user of water, handling this precious resource requires utmost professionalism also from other involved decision-makers to enhance the productivity and attractiveness of marginal rural land.

Under the complex framework conditions of irrigation farming, appropriate action can only be taken though with an unrestricted view on *all* of the technical, organisational and social aspects of the subject — especially in developing countries. It was long before September 11, 2001 that the need for a (much) more refined knowledge transfer approach in this multi-faceted agricultural discipline had been clearly identified. As farming increasingly faces ecological and globalisation limits, innovative strategies become inevitable in irrigated agriculture, too, especially in the light of threatening social unrest and the undeniable climate change ahead. Yet, in many parts of the world, irrigation development still gives rise to severe acute problems.

Unfortunately, over the years isolated monocausal approaches were deemed sufficient to tackle these problems. But knowledge transfer in irrigated agriculture can only be successful with precise holistic concepts, evolved from the very basics of the art. Irrigation engineering and management in theory and practice is the foundation, on which further capacity building of any irrigation professional has to take place now. Analyzing the situation in the few specialized training facilities, which survived the brain and fund drain over the past years, it is recognized that more human and financial resources must be reallocated in favour of this otherwise endangered science.

**Keywords:** Holistic approach, irrigation, knowledge transfer



## Long-Term Effects of High RSC Water and Ameliorative Strategies

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Consistent use of high RSC water may deteriorate the physical properties and increase pH and SAR of soil. Continuous use may reduce germination / the establishment of seedlings, retard plant growth and lead to a significant reduction in yields. Long-term investigations (1994–2001) with a permanent lay-out were conducted to measure the long-term effects of such water and explore mitigating strategies. The experiment consisted of the treatments; (1) Fallow plot without irrigation, (2) Fallow plot with irrigation of high RSC water, (3) Cropped plots irrigated with high RSC water, (4) Gypsum eq. Water requirement, (5) Sulphuric acid equivalent to gypsum requirement, (6) Combination of gypsum+sulphuric acid @ 50 equivalents and (7) Sesbania green @  $25 + \text{t.ha}^{-1}$ .

The design of this experiment was Randomized Complete Block Design (RCBD).

A normal soil was selected at SSRI campus. High RSC water ( $\text{EC}=1.4 \text{ dSm}^{-1}$   $\text{SAR}=6.5$  and  $\text{RSC}=5.7 \text{ m.eq l}^{-1}$ ) was used to irrigate wheat, maize fodder and rice crops. It was observed that soil pH and SAR was significantly increased after three years consistent irrigation of this water. Soil bulk density was enhanced whereas porosity and hydraulic conductivity were reduced significantly when no management strategies were adopted. Resultantly the crop yields were also cut short appreciably. However, mitigating strategies like application of gypsum, sulphuric acid and their combination as well as sesbania green manure proved successful to counter the ill effects of high RSC water on soil properties (chemical and physical) and crop yields. The yield of crops in the eight year was found to be almost 50 % higher in the management treatments (T4–T7) compared with the sole use of high RSC water because the soil became sodic here. No significant difference was found within the ameliorative strategies.

**Keywords:** High RSC water, irrigation, soil degradation

## Water Pumping for Irrigation in Moroccan Oasis

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Due to the shortage of irrigation water in the traditional “*khettaras*” system caused by drought, the farmers of the *Jorf* area have began to pump the underground water either from communal or individual wells. Currently, the *Jorf* area has more than 240 pumping stations including 4 which belong to cooperatives.

A study was conducted in 2001 with the aim of diagnosing this new type of pumping in this area. A technical and economical assessment of the pumping was done after a survey of more than 50 pumping stations.

After a description of the traditional irrigation system of *khettaras*, three main pumping station types were identified. Their equipments were studied: engines and motors, pumps, energy, accessories. The way of maintenance and the conception of these pumping stations were criticized.

Using data from the survey, an economical assessment was conducted. Several options were compared. The estimate of the pumping cost according to the total manometric head TMH showed that the use of butane gas mixed with gasoil is less expensive than the use of pure gasoil, but generates more breakdowns of the engine and that an appropriate electric installation is more economic than engine powered one. Energy saving possibilities was also identified and can be used by the farmers to improve their energy efficiency while pumping water for irrigation.

The maintenance quality and the follow-up of a pumping station affects its performances and therefore the cost of pumping. It is important to provide farmers with technical advice to help them making right decisions. Their organisation in cooperatives and associations facilitates extension activities.

**Keywords:** Irrigation, oasis, water pumping

## Water as a Natural Resource in Oases of the Oman Mountains

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Groundwater is the most important resource for the agricultural production systems in the desert country of Oman. Other inputs into the date gardens and crop fields are seeds, fertiliser, manure and labour. While the latter inputs can be controlled in amount and distribution, the former is given by the groundwater storage capacity of the surrounding rocks and the spring water outflow near the villages.

This research was conducted to investigate water availability and use in the course of a calendar year in two oases of the central Oman Mountains. Balad Seet is situated at the foot of the northern escarpment of Jabal Akhdar. Most of the 10 springs are found at the same altitude in the lower part of the steep cliff where a 1000 m thick layer of highly permeable carbonates (dolomites and lime stones) rests over red-greyish-green silt- and clay stones of the Muaydin Formation which had been deposited during Prepermian times. Monthly measurements of spring outflows over the last 20 months in the range of  $580 \text{ m}^3 \text{ d}^{-1}$  to  $760 \text{ m}^3 \text{ d}^{-1}$  indicate, that the spring outflows decrease by about 3 percent per months in longer periods of drought. Because of the large catchment area a rain event of 50 mm (measured at Balad Seet) stabilized the spring outflows for 8 months. Additionally about  $63 \text{ m}^3$  of groundwater are daily withdrawn using 14 wells, which have been dug into the wadi sediments. The wells are fed by seepage water from the valleys under the cliff and leaching irrigation water. The total amount of available well water is lower in drought periods than in periods after strong rain events. During the summer season 2001 62% of the cropping area of field crops had to remain under fallow because of the higher crop evapotranspiration rates and the slightly lower amount of available irrigation water from wells. Analyses of the water quality show a low level of salt content (electrical conductivity of  $505 \mu\text{S cm}^{-1}$ ).

The oasis of Maqta is situated in wadi Khabbah in the Al-Hajar Asha'sharqi range. Around Maqta dark coloured, often fractured ophiolitic rocks, mainly harzburgites, dominate. The groundwater circulates in the fractures of these rocks or in loose sediments of the wadis. The total outflow of the 22 widespread springs declined during the last dry year from about  $190 \text{ m}^3 \text{ d}^{-1}$  to about  $130 \text{ m}^3 \text{ d}^{-1}$ . Only 3 springs contribute with more than  $10 \text{ m}^3 \text{ d}^{-1}$  to the total outflow. To use each of these springs an extended network of storage basins and irrigation channels has to be managed by the farmers and the location of the fields is often very close to the springs. Because of water scarcity field crops are not grown during the summer season, but even during the winter season more than 50 % of the cropping area has to remain bare. Because of poorer water quality (high pH, higher salt content) the use of irrigation water is also more restricted than at Balad Seet.

Future investigations will also have to address how the number, location and outflow of the springs may have influenced agricultural development and settlement patterns over the millennia of the oases' existence.

**Keywords:** Geology, hydrogeology, irrigation, water quality

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## **The Resource Management and the Living Standard in Different Farming Systems according to Different Water Qualities: a Case from Jordan**

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It is generally agreed that over the last few years the water related problems in Jordan have been increasing. The demand for water has increased steadily over the years while the supply of water has become quite limited. The interest in wastewater treatment increased and the use of treated water for irrigation started.

This paper deals with the resources management in different farming systems referring to the specific classification of water quality. Differences between different farming systems and irrigation water quality are described. Also the socio-economic issues of families and farms are addressed. An analysis of how farmers adapt using the resources under the conditions of different water qualities in different farming system and how this adaptation reflects on their living standard is given. The paper aims to analyse the effect of different water qualities on the resource management in different farming systems under different conditions of water availability and water quality, also it aims also to analyse the effect of using different water qualities on the living standard of the farmers in these zones by using the cluster analysis as a methodology to determine the homogeneity groups of farmers in the study area regarding to the living standard to conclude if these homogeneity groups are different in using the quality of water.

The main results in this paper are: the use and management of resources differ in different farming systems according to the water quality classification. The use of like green houses and drip irrigation, and the value of investment also differ among farming systems. Thus, the use of different water qualities does not lead to differences in living standards of farmers.

**Keywords:** Farming system, living standard, low quality water

## **Evaluation of Land Suitability for Agriculture in the El-Salam Region of the North Sinai**

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In order to improve the country's self-supply with food and to relief larger towns from the nutrition-related consequences of a continuous increase in population Egypt extends its agricultural land along the El-Salam canal in the North Sinai. To utilise the precious water resources most efficiently, land has to be selected for irrigation according to its suitability for agricultural production.

In this region, the El-Salam Canal project supplies about 168.000 hectares with mixed water from the Nile and agricultural drainage water to reclaim and cultivate these soils.

This environmental study comprises of a soil survey of the coastal zone soils along the El-Salam Canal to assess the development activities in this area and to evaluate the soils.

Remote sensing techniques based on Landsat TM data and ground truth campaigns identifying physical and chemical properties of the main soil types in the area. These data were then transferred into a land evaluation program and the resulting maps gave an excellent guide to where sustainable agriculture can be implemented.

The results of land evaluation for the observed soils in the northern part of the Sinai peninsula lead to the classification in four classes (III, IV, V and VI) according to soil texture, profile depth, slope, and risk of wind erosion. The soils in grade (IV) are restricted by texture, soil profile depth and relatively higher salinity, as well as their texture and high calcium carbonate contents. The soils in grades (V) and (VI) are affected by extreme salinity, texture soil profile depth, gypsum, high carbonate content and poor drainage.

**Keywords:** Egypt, land evaluation, remote sensing, Sinai, sustainable agriculture

## **Soil Erosion and Land Use Effects on Phosphorus Dynamics in a Brazilian Watershed**

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Brazil is the fourth largest consumer of fertilizers, with an annual consumption of nearly one million tons of P and this amount is predicted to increase due to agricultural intensification. Whereas, in developed countries the oversupply of P triggers environmental problems, in most tropical countries P deficiency is the major economic constraint to farmers. The concept of balanced P fertilisation aims at a harmonisation of natural supply by soil and environment, the nutrient demand of the crop and inevitable losses to the environment.

The agricultural production systems fulfil the criteria of sustainability only, if the losses in this balances can be minimised whilst maximising crop productivity and economic profits. This paper deals with the significance of erosion processes in P losses. The study was carried out in a 2.200 ha catchment which is located within the sugarcane growing region of São Paulo State, Southeast Brazil 22°40'S and 47°47'W.

The region is characterized by heavy rainfall and severe soil degradation caused by erosion. Current land use comprises mainly of sugarcane (70 %) and to a small degree pastures (8 %) and natural forest (22 %). 300 soil profile samples were taken and analysed for texture, exchangeable cations, CEC, SOM, pH, available P, total P and total Fe using standard methods. Soil erosion and depositions were calculated using the Water Erosion Prediction Program (WEPP) hillslope version 99.5 (FLANAGAN & NEARING, 1995). It was found that land-use had a significant impact on the distribution of total and available P. Soil P was transferred from areas of high P input (sugarcane) to areas of low input (pasture, forest) due to soil particle erosion. Additionally, low input areas were found to have a higher soil organic matter content and moisture regime than high input areas and therefore a better buffering capacity for P.

**Keywords:** Land-use, phosphorus, soil erosion

## **Drought Tolerance Mechanisms of Pearl Millet**

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Two weeks old pearl millet plants (*Pennisetum glaucum* L.) were exposed for two weeks to drought in a climate chamber. Drought was induced by withholding water until the soil reached an pF value of 4.0 (medium drought stress) or 4.8 (severe drought stress), which was then maintained by watering the pots to a certain weight twice a day. The relative humidity was 40/60 % (day/night). In preliminary trials drought tolerant and drought sensitive genotypes were selected from genotypes, which have been received from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Then experiments were conducted with three drought tolerant and drought sensitive genotypes. At harvest, the living and dead parts of the leaves were separated and the living leaf area was determined. A source leaf (third leaf from the apex), a sink leaf (first leaf from the apex, which is still enclosed in the second leaf) and fine roots were immediately frozen in liquid nitrogen. The remaining plant parts were dried at 60 °C.

Drought reduced the CO<sub>2</sub>-assimilating area markedly by decreasing the single leaf area and the number of photosynthetic active leaves with increasing drought stress. The osmotic potential and the turgor potential of the source leaves decreased with increasing drought stress. Leaf folding in response to severe drought stress, which reduces the transpiring leaf area, occurred in all genotypes except in one drought sensitive line, which almost did not fold the leaves. Severe drought decreased the dry mass per unit leaf area decreased. The effect of drought on the glucose, fructose, sucrose and starch metabolism during the day and the night was different in sink leaves, source leaves and roots. The involvement of enzymes of the sugar and starch metabolism and sucrose transport in the effect of drought on the carbohydrate metabolism in source and sink tissues will be presented.





# Subsession 1c<sub>1</sub>: Resource Management and Biotechnology I: Genetic Resources, Neglected Crops and Seeds

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## Tropical and Subtropical Plants With Sweetening Properties: the Potential Source of Low-Calorie Sweeteners

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Plant species with unusual taste properties such as bitterness, sourness or sweetness, and others with a taste-modifying components, have long been known to man, although their exploitation has been limited (SUMMERFIELD et al., 1977). In recent years there has been an increasing demand for 'Low-calorie' sweeteners. Together with this trend, there is also an increase in the demand for healthy and natural food products. Therefore, and in order to address this need, there is an intense and ongoing search for alternative sweeteners (FAUS, 2000). The restriction on the use of artificial sweeteners such as cyclamate in the USA and other countries highlights the commercial potential for indigenous plant species with taste-modifying properties or sweetening principles (SUMMERFIELD et al., 1977). Recently, a number of plant constituents are employed as dietary sucrose substitutes in one or more countries, including the diterpenoid, stevioside (*Stevia rebaudiana* BERTONI), the triterpenoid, glycyrrhizin (*Glycyrrhiza glabra* L.), and the protein, thaumatin (*Thaumatococcus daniellii* BENTH.). Accordingly, there has been much interest in discovering further examples of potentially sweet compounds of natural origin, for potential use in foods, beverages, and medicines. Approximately 75 plant-derived compounds are presently known, mainly representative of the flavonoid, proanthocyanidin, protein, steroidal saponin, and terpenoid chemotypes. In current research directed towards the elucidation of further highly sweet molecules from plants, candidate sweet-tasting plants for laboratory investigation are obtained from ethnobotanical observations in the field or in the existing literature. Examples of novel sweet-tasting compounds obtained so far are the sesquiterpenoids, hernandulcin and 4 beta-hydroxyhemandulcin; the triterpenoids, abrusosides A-D; a semi-synthetic dihydroflavonol based on the naturally occurring substance, dihydroquercetin 3-acetate; and the proanthocyanidin, selliguaein A. Potential commercial value of naturally sweet substances stimulate a search for new plant sources of sweeteners (KINGHORN and KENNELLY, 1995).

**Keywords:** Ethnobotany, low-calorie sweeteners, sweet compounds, tropical and subtropical plants

## The Potential of Under-Utilised Fruit Trees in Central Sudan

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Sudan is the largest country in Africa with an area of more than 2.5 km<sup>2</sup>. The country includes various different ecological zones which are habitats for numerous plant species. However, only a few indigenous species have been promoted or researched and are under production in the field. Little attention has been paid to minor or under-utilised crop species like wild fruit trees.

The objective of this study was to emphasise the variety and multipurpose use of under-utilised fruit-producing trees, shrubs and palms in Central Sudan.

A number of very interesting under-utilised fruit trees were specified in the savanna belt of the Sudan. The fruits are often strongly used and an important diet for the rural people. Fruits like ‘nabak’ (*Ziziphus spinachristi*), ‘aradaib’ (*Tamarindus indica*) or ‘lalob’ (*Balanites aegyptica*) are available over the whole year on the market because of their demand and excellent storage capacity. They are a very important source of income for the rural population. The fruits have an exceedingly wide range of uses, i.e. food source, beverages and medicinal uses. They provide vitamins, proteins and minerals especially through periods of climatic stress as well as nutritional and financial deficiency. Examples for medicinal use of fruits are ‘garad’ (*Acacia nilotica*) and ‘gudeim’ (*Grewia tenax*). All of the fruits are harvested from wild fruit trees, no plantations are known so far. Most of the fruit trees provide multipurpose use, such as the ‘tebali tree’ (*Adansonia digitata*). The fibre of the bark is used for making ropes, baskets and cloths and the leaves are an important vegetable beside the common use of the fruit. In Sudan the overuse of those multipurpose fruit trees has become a significant problem. Some of them are nowadays in danger like the palm ‘dom’ (*Hyphaene thebaica*).

Most of those woody plants are highly adapted to harsh conditions like drought or heavy winds. They are very important for soil conservation and protection and play an important role to slow down the desertification process in Central Sudan.

**Keywords:** Central Sudan, desertification, fruit trees, under-utilised crops

## Estimation of Outcrossing Rate in *Hordeum spontaneum* and Barley Landraces from Jordan

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Previous studies conducted at the University of Hohenheim and ICARDA indicated that yielding ability and stability of barley could be improved in environments with drought stress by increasing the level of heterozygosity. This could be accomplished by developing synthetic varieties composed of germplasm with a high outcrossing rate. As a first step, we characterized the genetic structure of barley landraces and *H. spontaneum* populations collected from various semi-arid localities in Jordan to obtain reliable estimates of the amount and variation of outcrossing in this germplasm.

Natural outcrossing was estimated in 13 populations of *H. spontaneum* and 12 barley landraces from collection sites that covered high-low rainfall and altitude transects to detect possible environmental effects on outcrossing rate. Four Microsatellite markers were used to estimate outcrossing rate based on maximum likelihood methods and mixed mating models.

Low outcrossing rates were found in cultivated barley and its wild relative *H. spontaneum* ranging among populations from 0–1.8% with a mean of 0.32%. Somewhat higher, though not significant, outcrossing rates were observed in *H. spontaneum* than in *H. vulgare* populations under high rainfall conditions. A significant positive correlation was detected between outcrossing rate and average annual precipitation. However, a negative correlation occurred between outcrossing rate and monthly average temperature during flowering. Results suggest that high precipitations and cool temperatures during flowering may enhance outcrossing in cultivated and wild barley populations.

The rather low levels of outcrossing indicate that increased vigor due to heterozygosity has not been a major force in the evolution and domestication of *H. spontaneum* and *H. vulgare*, respectively. Stable seed production to secure survival under extreme heat and drought stress may be more important. Cleistogamy may be considered as an effective mechanism to warrant pollination even in drought-stunted plants with non-dehiscent spikes and to prolong pollen viability. Yet ICARDA's gene bank contains a number of drought-adapted accessions showing various degrees of open-pollination. This material is presently being evaluated for its outcrossing behavior. It is considered a valuable genetic resource for increasing the level of heterozygosity in actual barley gene pools and thus combining high yielding potential with superior drought tolerance.

**Keywords:** Barley, landrace, microsatellites, outcrossing rate, plant genetic resources, *Hordeum spontaneum*

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## **Development of a Bambara Groundnut Core Collection from IITA Germplasm Based on Characterisation and Evaluation Data**

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An important step towards the improvement of the productivity of Bambara Groundnut (*Vigna subterranea* (L.) VERDC.), an underutilised African grain legume, is the development of improved cultivars. In order to maintain the existing genetic diversity and fully utilise the available germplasm, a core collection from germplasm held at the genebank of the International Institute of Tropical Agriculture (IITA) was developed. To estimate genetic diversity within the collection, characterisation and evaluation data available from the “International Bambara Groundnut Database” were analysed.

Based on this data set a hierarchical cluster analysis was performed to identify groups of accessions with minimal within and maximal between group variability. Reliable cluster levels were selected based on stability of the clusters and distance between levels. At each selected level the most typical accession of each group was chosen as an entry in a core collection and representative of the group. Thus, a high genetic diversity is retained within the core collection at each level. Core collections were defined so that entries of each core collection are contained in the next bigger collection defined at the next level. The resulting set of core collections is called a “hierarchical nested core collection”. By using this structure the total number of entries does not increase, which facilitates the management and use of the core collections.

Since each entry in the core collection is regarded a representative of a group of accessions, there is strong linkage between the main collection and the core collection. This facilitates the use of all accessions of the genebank.

Information on agronomic and physiological traits can be linked with entries to the core collection and groups of accessions. For each cluster a profile of trait values can be assigned either based on means of all members or based on data collected from the core entry. These cluster profiles can be used to identify groups of accessions with desired features. Thus promising accessions can easily be identified, including genotypes with no available data for the given traits.

**Keywords:** Bambara Groundnut, breeding, core collection, genetic diversity, germplasm, neglected crop

## Pre Emergence Effect to Imbibition of Soybean Seeds

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Soybean (*Glycine max* L.) is grown in the irrigated areas in upper-north of Thailand. The most widely planted cultivar is Chiangmai 60 (CM60) which has cultivation limitation in that seed may not germinate or seed rot may occur if planted in clay loam soil and water logged condition. Therefore, this experiment was done to identify factors influencing on water absorption or imbibition degree and investigate imbibition pattern before seed germination process. In soybean seeds of 5 varieties, seed coat thickness before soaking as well as protein and lipid content of the seeds were determined. Seed weight before and after soaking were measured. After soaking, the coats from the seeds were picked out and dried and re-soaked for 12 hours for imbibition and then seed weight were measured. Measurements were also made to evaluate changes in seed length due to cell expansion after imbibition in closed and un-closed seed. This study found that the thickest seed coat occurred in SJ5 variety whereas that of CM60 was slightly thinner. At first stage of imbibition (within first 5 hours of soaking) water enters the seed in relatively high and steady rate. At the following stage (between 5 and 12 hrs.), the imbibition process slow down and seed reaches almost full capacity of hydration. In the initial stage of imbibition, the water absorption rates were similar in every line but CM60 variety had the highest concentration of water. This evidence probably result in higher protein contents in CM60 compared with others varieties which absorbed more water for metabolism process before germination. Moreover, its thicker seed coat allowed better water absorption. In this study, hilum and micropyle were found as important parts of the seed for the water entry in soybean seed.

**Keywords:** Germination, imbibition, seed coat, soybean seed



## **Influence of Propagation Date to Sprout Development of Enset (*Ensete ventricosum* (WELW.) CHEESM.) at Different Climates**

KARIN ZIPPEL

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Enset (*Ensete ventricosum*, family *Musaceae*) is widely distributed in eastern and southern Africa but cultivated only in southern and southwestern Ethiopia as staple food for about 15 million people in mixed subsistence farming systems. The main product is starch extracted from the underneath corm and the leaf sheaths. Moreover, all parts of the plant are used in household, agriculture and traditional medicine. Propagation is done vegetatively during the warmest and most moist season of the year.

Cultivation areas extend from 1700 to 3300 meters altitude with annual average temperatures between 8 °C and 22 °C and annual precipitation between 900 and 1500 mm. Dry periods last from 3 to 8 months. Therefore, different climates in the growing regions enforced the development of different propagation methods.

Different propagation methods were described for different climatic regions. These descriptions were compared with data from field trials at two sites (Debre Zeit, 1850 m and Addis Ababa, 2350 m) with different average temperature (18 and 16 °C) and rainfall patterns (2805 mm at 97 days and 2576 mm at 170 days). Propagation was conducted in January, April and August under different climatic conditions. Sprouts were examined for their vegetative growth as well as their mineral and carbohydrate contents after 2, 6 and 10 months.

Propagation times last according to the environment from December to May. Main propagation time is from February to March with high temperatures and rainfall. However, in few regions below 1900 m propagation is done in May to provide enough moisture during the long rainy season from June to September. At altitudes above 2400 m propagation is done already in December to provide enough heat. In this case special treatment is necessary to provide sufficient moisture. In one region propagation was practised always in February and March regardless of altitude but farmers at low altitudes complained about the quality of sprouts and often bought them from highland farmers.

These observations were proved by the vegetative measurements of the field trial while analysis of contents did not show any significant difference. For optimum production of enset sprouts propagation has to be adopted to the different climates.

**Keywords:** Climate, enset, *Ensete ventricosum*, Ethiopia, propagation, sprout development

## **Root Growth of Eight Different Varieties of the Grain Tef (*Eragrostis tef* (ZUCC.) TROTTER) from Ethiopia**

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Tef (*Eragrostis tef* (ZUCCAGNI) TROTTER) is a grain, mainly grown in Ethiopia. Soils in Ethiopia are often low in phosphorus. The cultivation of phosphorus efficient varieties is a way to use these soils more efficiently. The tef varieties DZ-Cr-37, DZ-01-1445, Local Brown, DZ-01-787, Local Yellow, DZ-01-354, Ambo Black and Ambo White from Ethiopia were examined in their early growth stage on the root criteria length of root hairs, length of main root, number of lateral and adventitious roots and root/shoot ratio. An extended and dense root system, long root hairs and a high root/shoot ratio are reasons for the phosphorus efficiency of a plant. With extension of the root system varietal differences for the length of main root criteria and number of lateral and adventitious roots increased: Local Brown showed significant differences compared to the varieties DZ-01-1445, DZ-01-787, Ambo Black and Ambo White in two experiments (temperate and tropical climatic conditions, respectively). The mean values for length of root hairs varied between 0.86 mm (DZ-Cr-37) and 1.06 mm (Ambo White) but showed no significant varietal differences. Rank lists based on the mean values of the varieties for all examined criteria showed that Local Brown achieved the best results followed by Local Yellow, DZ-Cr-37, Ambo Black, DZ-01-787, Ambo White, DZ-01-1445, DZ-01-354 under tropical climatic conditions and by Local Yellow/DZ-01-354, DZ-Cr-37, Ambo Black, DZ-01-787, Ambo White, DZ-01-1445 under temperate climatic conditions. With the exception of DZ-01-354 the order of both rank lists was the same. The results from the early growth stage show that differences between tef varieties exist in developing characteristic features which are important for phosphorus efficiency. Varietal differences may be confirmed in long-term studies for later growth stages. The identification of more phosphorus efficient varieties is necessary to be able to recommend suitable varieties for low phosphorus soils.

**Keywords:** Phosphorus efficiency, tef

## **Enset (*Ensete ventricosum* (WELW.) CHEESM.) in Subsistence Farming Systems in Ethiopia**

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Enset (*Ensete ventricosum*, family *Musaceae*) is widely distributed in eastern and southern Africa but cultivated only in southern and southwestern Ethiopia as staple food for about 15 million people in mixed subsistence farming systems. The main product is starch extracted from the underneath corm and the leaf sheaths. Moreover, all parts of the plant are used in household, agriculture and traditional medicine. Several landraces are grown for different uses and site requirements. Propagation is done vegetatively. It is cultivated in areas extending from 1700 to 3300 meter altitude with annual average temperatures between 8 °C and 22 °C and annual precipitation between 900 and 1500 mm. Dry periods lasts from 3 to 8 months.

Farming systems in 10 regions in southwestern Ethiopia are compared with regard to enset cultivation, arable crops, horticultural crops, animal husbandry and climate.

Enset cultivation and processing requires a very high seasonal labour input. In each region very specific techniques in enset cultivation were developed but others were found in all regions. Only slight differences are observed in the diverse use of enset. Few landraces were found in all regions, some in a very limited area and most landraces in a wider area with slow export to neighbouring regions. A mixture of different cereals, pulses, vegetables and fruits is cultivated according to the climatic conditions, some of them within the enset plantation. Animals are kept to provide manure. As a forage crop enset is used only in few regions depending on the availability of further forage crops or grazing areas.

Enset is cultivated in subsistence farming systems with little connection of the producer with the market, low prices, and production mainly for personal use. Due to intense soil tillage enset has a positive impact on soil fertility and micro climate, and shows soil preserving capabilities. Systems with enset are integrated production systems, whose different production lines correspond with each other. These systems respond much better to ecological or structural changes than systems which have only one or very few production lines.

**Keywords:** Climate, cultivation, cultivation systems, enset, *Ensete ventricosum*, landrace, processing, Southwestern Ethiopia, subsistence farming, sustainable agriculture

## Salak — the Indonesian Snake Fruit

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To maintain the biodiversity of food crops is one of the most important tasks for ecological research in the tropics and subtropics. Fruit science may play a major role in this context.

Indonesia is a rich source for plant species used for human nutrition. Most of the indigenous fruit species are unknown in Europe, but have been used as food source on the Indonesian islands for a long time. The peculiar salak or snake fruit (*Salacca* spp.) is a typical example for fruit species which are presently available only on local markets. The name “snake fruit” reminds on the fruit skin, which is very similar to a reptil’s skin in structure and colour. The fruit derive from small, spiny palm trees, growing as understorey plants in the tropical rain forests of the lowlands. The female plants of this dioecious species develop fruits of the size of a fig, whose edible portion is sweet and aromatic.

In Indonesia, salak is widely used as fresh fruit. The species *Salacca zalacca* is known to produce the best fruit quality. There are some local selections such as “pondoh” or “bali”.

Since the knowledge on salak is still incomplete, a bilateral project between the Centre for Plant Conservation, Bogor Botanical Garden (Indonesia) and the Fruit Science Department of Humboldt University Berlin is aimed at evaluating ecophysiological characteristics of different salak genotypes as well as fruit quality properties. The purpose of this study is to broaden the knowledge on the needs of this promising fruit species and to promote its production in Indonesia. This paper will present preliminary results on the effect of different water supply on growth, leaf gas exchange and leaf water potential. The experiments have been carried out in the greenhouses of the Fruit Science Department in Berlin.

**Keywords:** Indonesia, physiology, salak, snake fruit

## **Fodder Tree Research with *Moringa stenopetala* — a Daily Leafy Vegetable of Konso People, Ethiopia**

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*Moringa stenopetala* is native to southern Ethiopia, northern Kenya and eastern Somalia. It is the second most important domesticated *Moringa* species after *M. oleifera*. In the Konso area of southern Ethiopia, where stone terraces are a famous 'UNESCO World Heritage Site', *Moringa* leaves are eaten almost every day like spinach together with cereal balls. *Moringa* leaves are outstanding with respect to high contents of essential amino acids, Vitamin A and C. *Moringa stenopetala* is a fast growing tree on sites that are not severely acidic, not waterlogged and below 2000 m altitude. Due to its water storage capacity in the bottle shaped stem, *M. stenopetala* is adapted to semi-arid areas of 500 mm annual rainfall.

The objectives of a 3-yr collaborative field research program of the International Center of Insect Physiology and Ecology (ICIPE) and the Ethiopian Agricultural Research Organization (EARO) in Ethiopia are (i) to generate a germplasm pool for subsequent genetic improvement programmes by a collection mission in southern Ethiopia; (ii) to assess the natural variability in agronomic yield and quality characteristics and pest resistance of 36 local *M. stenopetala* provenances in comparison to three local collections and three introductions of *M. oleifera*; (iii) to examine the potential of tree fodder production systems as a biophysically and economically viable soil conservation practice for smallholder rural farmers; (iv) to quantify the yield potential and labour costs of leaf meal production from fodder trees in erosion control systems.

The methodology comprises a germplasm collection, multi-site germplasm screening and erosion control experiments with tree-grass contour hedgerows as well as palatability studies with humans and ruminants comparing farmer-selected with unselected provenances. Results are expected in 2003 to 2004.

**Keywords:** Erosion control, fodder trees, germplasm collection, *Moringa stenopetala*

## **The Opportunity Cost of Growing Local Landraces: Challenges and Implications for the Design of Incentives for *in situ* Conservation of Wheat Genetic Resources in Ethiopia**

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Throughout the centuries, farmers have been maintaining and developing crop seeds from the rich genetic diversity of naturally occurring crop species. It is only since the early twentieth century that a commercial production of crop seeds has started to replace these landraces. This trend has called for an intensive discussion in the literature motivated by the replacement hypothesis. The modern breeding activities as well as farmers' participation will continue to change the production systems of all farmers including those economically and ecologically marginalized. Even though the replacement hypothesis is not as straight forward as it might seem, a rapid change of production systems and uncontrolled loss of endemic plant genetic resources for food and agriculture may occur.

To control this trend, there is a need to understand forces deriving farmers to maintain or replace landraces on farm. One of these forces is the opportunity cost foregone by farmers while planting local landraces. This enquiry will, among other things, help policy to design community based, location specific and flexible incentives for those landraces threatened with extinction. This, in turn, ensures the future existence of wheat genetic diversity for the long-term national objective of over-all food security. To shed light on these issues, this paper analyses the 1999 Ethiopian rural household survey data collected by the Addis Ababa University in collaboration with USAID.

The results suggest that opportunity costs differ not only across farmers of different features but also across localities. Therefore, designing *in-situ* conservation strategy, which targets all farmers and localities uniformly, is a waste of resources. The remaining challenge, however, is identifying hot-spots for conservation and designing incentive mechanisms which are feasible considering social, economic and agro-ecological dimensions of the problem. Even though identifying hot-spots needs further genetic study, the financial and socio-economic incentives required for farmers to plant local landraces can be inferred from the results of the paper.

**Keywords:** Crop genetic resources, incentives, *in-situ* conservation, opportunity costs

## **Utilization of Non-Wood Forestry Products in Tropical Africa: Examples from the Sudan**

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Utilization of native woody species is important to the livelihood of the people in tropical Africa. According to the type of their utilization, non-wood forestry products (NWFPs) can be grouped into: foliage and fruits, tannins, gums and resins, oils and extracts, fibers, and medicinal products. The promotion of these valuable indigenous products can make an important contribution to alleviation of poverty by improving food security and economic welfare of rural population. As the ecological balance in arid and semi-arid environments is fragile, sustainable management of the ecosystem is a key to the containing degradation of the natural resources, while achieving sustained development and growth in these regions. There are substantial opportunities to develop new crop production systems (especially woody species) on degraded lands marginal to food production. The success of these production systems will depend ideally on increased production, increased distribution and marketing, and increased consumption. In the Sudan, as in many African countries, these activities are scattered between different agencies. It is therefore not surprising that only very few traditional products have been promoted with some success. We have recently established a research and development program which brings together different activities, such as identifying priority under-utilized crop species, designing sustainable management practices, developing post-harvest processing techniques, and developing marketing methods.

The main objectives of this study are to emphasize the significance of non-wood tree and shrub products found in the Sudan, to describe their utilization and to exploit procedures, opportunities and experiences that will greatly facilitate their development.

**Keywords:** Arid and semi-arid regions, land degradation, natural resource, non-wood forestry products, sustainable production, utilization

## **Community-Based Documentation of Indigenous Knowledge (IK), Awareness and Conservation of Cultural and Genetic Diversity of the Bottle Gourd (*Lagenaria siceraria*) in Kitui District, Kenya**

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The Bottle Gourd in Kitui District, Kenya is known locally as “Kitete” and refers to the species *Lagenaria siceraria*, *Cucurbitaceae*. Kitui District of Kenya, which is inhabited by the Kamba people, is a region that combines ideal growing conditions for Kitete with rich cultural knowledge about varied uses and types. For the Kamba people of Kitui District, Kitete is a key item of their material culture and it is found in virtually every aspect of their traditional life.

Kitete is grown to produce a great variety of containers and is also consumed as food.

Its use and value of late has been greatly undermined by the use of plastic and other related manufactured containers. This has caused an erosion of local knowledge and therefore threatening the local varieties of Kitete with extinction. The use of clay-sealed Kitete containers to store seeds for planting has been an effective local practice for cheap and safe chemical-free storage of seeds. The reduced availability of Kitete is having a negative impact on seed storage and food security in Kitui villages.

The Kamba culture is intricately intertwined with Kitete and therefore loss of its knowledge and the species would mean loss of the key items of this Kamba culture. Recent surveys have shown that the transfer of Indigenous Knowledge IK to the young generation is much less than before. Interest to use the plant among young families is also less. Any efforts to conserve the local varieties of the species would therefore need to go hand in hand with transfer of knowledge from the older to the young.

A two-year project aimed at “conserving the diversity of bottle gourd and its associated Indigenous Knowledge (IK) through awareness creation, increased cultivation, documentation and dissemination of IK” has been initiated. This project is being implemented by Kyanika Adult Women Group (KAWG) at a local village in the eastern part of Kenya.

The aim of this study is to present the method used to achieve IK and bottle gourd conservation as well as constraints and achievements of the project.

**Keywords:** Biodiversity conservation, Bottle gourd (*Lagenaria siceraria*), CBO, *Cucurbitaceae*, IK documentation, Kenya, PGR



## ***In situ* Conservation of Native Potatoes in the Peruvian Highlands**

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The central Andes and Peru are considered as one of the major centres of agricultural biodiversity. In the last 400 years various crop species, which originated in the Andes, were distributed worldwide. The most famous of them is the potato (*Solanum tuberosum*), which has become a staple food in many regions of the world.

Modern agriculture is characterized by uniformity of production and it depends totally on the genetic material developed from traditional varieties or wild crop relatives, which are used in breeding programs. Therefore, great efforts are done to prevent the disappearance of old varieties or landraces of the most important food plants.

This study was carried out in cooperation with the GEF-Project "Conservación *In Situ* de los Cultivos Nativos y sus Parientes Silvestres" in the Department of Huánuco, situated in the central Andes of Peru. The objective of the study was to identify the main factors that influence farmers' decisions in conserving old potato varieties. Overall 68 households from two watersheds were surveyed and the gathered data were analyzed and compared.

One important factor for the loss of old varieties was the market. Many farmers replaced their mixture of native varieties by modern ones or increased the number of commercial native potatoes because of greater market demand. One of the strategies for conserving old varieties is to find new markets for native potatoes and their processed products because most farmers try to increase their economic incomes. Utilization of native potatoes is often still restricted to uses at the family level, however, conservation of biodiversity will only be sustainable if it is combined with broader utilization.

Another finding was that traditional ways of life and conservation of the inherent biodiversity were strongly related. A relation between "cultural erosion" and "genetic erosion" has also been suggested by several scientists from the International Potato Centre (CIP) in Lima. But there is still a great deficiency in investigating this theme, which requires the definition of terms like "traditional culture" or "modernization", and which should be carried out by multidisciplinary teams.

**Keywords:** Andes, biodiversity, genetic resources, *in situ* conservation, native potato varieties, Peru

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## **The Allocative Potential of Property Rights to Plant Genetic Resources for Food and Agriculture (PGRFA)**

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The provision of property rights to genetic resources is called by economists in view of allocative efficiency, e.g. by SWANSON and GÖSCHL (2000), who diagnose a property rights failure to be the reason for the continued loss of plant genetic resources for food and agriculture (PGRFA).

No specific legal property right to PGRFA exists to date. This contribution examines how a legal right to PGRFA would have to look like in order to substantially affect allocation. It is assumed that the right would have to preclude others from the economically most valuable aspects/uses of the genetic information. Typical uses made of PGRFA are analysed, and five classes of use are identified. Existing property rights (e.g. the patent system and the system of plant breeders rights) are investigated for their potential to grant exclusivity to PGRFA and to the specific uses as identified above, respectively. Additional adjustments that could enhance the efficiency of the discussed property rights systems are outlined (e.g., the repeal of ‘breeders exemption clauses’ in the existing PR system).

It is concluded here that rather than with a property rights failure, we deal with a ‘physical properties failure’, i.e. with a good — PGRFA — the typical uses of which are extremely difficult/expensive to monitor and control even after the introduction of an intellectual property right specifically designed to protect these uses. Other economic properties of PGRFA specified in the paper also contribute to the putative low effectiveness of such an IPR. Additional adjustments that could enhance the efficiency of existing property rights systems are found to most likely have severe negative side-effects, e.g. would impede the flow of genetic resources that are broadly accessible today. An overall conclusion is drawn that a socially desirable allocation of PGRFA via the markets is unachievable even after institutional adjustments. Given the inherent public good character of the genetic information embodied in PGRFA, investment in the conservation and continued supply of PGRFA will remain a major public responsibility.

**Keywords:** Economics of property rights, genetic resources, intellectual property rights, plant breeding

## **Agricultural Utilization for Genetic Resources Conservatin of a Medicinal Plant from Chile: *Buddleja globosa* HOPE**

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In recent years, Chilean institutions have started to explore the vast native genetic resources of potentially useful plants, which could provide new raw materials, especially within medicinal plants that could be introduced to agricultural production. The domestication of native species helps to prevent them from extinction through indiscriminate use. In case of potentially marketable plants, it also helps to give an additional income to small farmers and poor people, simply by using a portion of their land to cultivate medicinal plants or spices.

As part of the projects “Domestication of different native species for potential industrial use” and “Study of cultivation of some native medicinal species of chile” carried out by the Faculties of Agronomy and Forest Engineering of the University of Talca, Chile, and financed by the “Fundación para la Innovación Agraria, FIA”, one of the investigated species has been *Buddleja globosa* (Loganiaceae) a native deciduous shrub called “Matico”, also known as “butterfly bush” in England. Its medicinal use is reported from the indigenous tribe of “Mapuche”, who used the “Matico” or “Panil” as a herb to cure wounds. Because of indiscriminate harvest from wild stands, only a few known native populations remain in Chile to date. Since its introduction to gardens in South America over 200 years ago, it has been a great favorite as medicinal and ornamental plant.

We studied the environmental characteristics of the species native habitats. Also, morphologic, phenologic and chemical characteristics have been determined comparing three native populations with plants randomly selected from the same populations cultivated at the experimental station of the University of Talca. These data add to the information being gathered with regard to the overall strategy followed for the domestication of “Matico”, which includes identifying origin and centres of diversity; collecting genetic material and further genetic improvement; determining the most appropriate regenerative or vegetative propagation method and studying agronomy and management in cultivation.

**Keywords:** *Buddleja globosa*, Chile, conservation, diversity, domestication, genetic resources, medicinal plants

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## Assessment of Triticum Landraces in Two Mountain Oases of Oman

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The Arabian peninsula and Oman, situated at the eastern edge of this peninsula, have an ancient cultivation history of both bread wheat (*Triticum aestivum* L. s. 1.) and durum wheat (*Triticum durum* DESF.; SCHWARTZ, 1939). However, given Oman's long geo-political isolation, little is known about the morphological variation, genetic structure, the agronomic properties (e.g. tolerance against heat, drought and salinity) and quality characteristics of these traditional wheat landraces. First wheat collections by the Omani Ministry of Agriculture differentiated a number of landraces (Sareeaa, Missani, Cooley, Hamira, Greda and Walidi) which were found to be increasingly replaced by higher-yielding modern varieties. The purpose of this pilot study was to collect wheat seeds from farmers' fields in two remote mountain villages of Oman, to reproduce them under uniform conditions and to subsequently conduct a morphological characterization of their botanic structure.

The results indicate that there exists considerable morphological variation within and between the five traditional landraces of wheat cultivated. Within two of the landraces grown on irrigated terraces, sized between 2 and 100 m<sup>2</sup>, two new botanical varieties of *Triticum aestivum* were identified. The genetic structure of both varieties is currently being analyzed by micro-satellite techniques and compared to the germplasm contained in the wheat gene bank at the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico. Comparative analyses of the varieties' agronomic traits, grain quality characteristics and possible physiological adaptation to drought and heat, the most important environmental constraints in their habitat will follow. In the next months more systematic surveys in other remote Omani mountain oases with rich environments will be conducted to study the diversity of Omani wheats with respect to the documented germplasm of this crop.

**Keywords:** Landrace, new botanical varieties, Oman, Triticum

## Construction and Exploitation of High Density DNA Marker and Physical Maps in the Perennial Tropical Oil Crops Coconut and Oil Palm: from Biotechnology towards Marker-Assisted Breeding

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The coconut palm (*Cocos nucifera* L.;  $2n = 32$ ) and the oil palm (*Elaeis guineensis* JACQ.;  $2n = 32$ ) are the two most important perennial oil crops of the tropics with the oil being the basis for both food production and industrial processing. The general objectives of a multinational project funded by the EC under the INCO-DEV programme are (i) to provide the methodological basis and molecular tools for improving the breeding efficiency in coconut and oil palm; and (ii) to develop DNA marker-based breeding strategies in collaboration with the most important countries in coconut and oil palm production and to directly transfer to developing countries small-scale technological solutions for the genetic improvement of these tropical oil crops. This is being achieved through the construction of high density molecular linkage maps in coconut and oil palm by developing SSR, AFLP and SNP markers, by performing comparative QTL analyses, by developing user-friendly molecular marker sets for future practical applications, by the generation of cosmid libraries for coconut and oil palm parents of the reference populations and physical mapping by SNP, and by synteny studies for coconut and oil palm in terms of comparative genome (microsequencing, SSR synteny) and QTL analyses. In the frame of these activities, cosmid libraries for coconut and oil palm representing some 4–5 genome equivalents were individualized, spotted onto filters and used in the isolation of important genes (oil biosynthesis, putative resistance genes). Different PCR-based DNA marker types were established to construct linkage maps for both coconut and oil palm. Polymorphic AFLP markers presented the majority of dominant DNA markers mapped. Currently, co-dominant SSR and SNP markers are being evaluated to serve as anchor markers for the integration of the available individual genotype-specific maps into general reference maps for coconut and oil palm. Mapping of QTLs related to flower morphology, nut production and oil content will be undertaken in the near future. The co-segregation of DNA markers with these QTLs will provide opportunities to breeders for marker-assisted selection in breeding programmes.

**Keywords:** DNA markers, genomics, linkage maps, synteny

## **Participatory Breeding Approach of Neglected Crops — Experience With Bambara Groundnut (*Vigna subterranea*) in Northern Namibia**

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The bambara groundnut (*Vigna subterranea*) is an under-utilised African grain legume, mainly grown by subsistence farmers in marginal cropping areas. Up to now, no systematic and coordinated breeding efforts have been used for a genetic improvement of the crop. In order to increase the productivity of the bambara groundnut the principle of participatory plant improvement is used in Northern Namibia.

With farmer and consumer surveys, specific preferences and desired traits as seed colour, early maturity are determined. This information is used to characterise an “ideotype”. Simultaneously germplasm and landraces are collected, multiplied and screened in on-station nurseries. Together with farmers and end-users promising material is selected from the nurseries. In one to two seasons of on-station trials the selected lines are thoroughly evaluated. A small sample of the accessions (3–4), selected to meet both, characteristics of the ideotype and superior agronomic performance, is then transferred to selected farmers in different agroecological regions for farmer-managed on-farm experiments. During the cultivation of this sample farmers have to attend a trivial protocol (not to mix seed, add a local variety as comparison, register growing conditions), but in general the farmer’s own cropping practise is applied. During the growing season technical staff is monitoring the crop growth and the farmers conception of the trial. If possible, field days or farmer-to-farmer visits are carried out for further dissemination of information. Data collection includes quantitative data (collected by the technical staff) and qualitative data (from interviews with farmers). Together with farmers and consumers a final evaluation of the trial including cooking and tasting is completing the cycle. All data and information is collated at the Research Station. The feedback from the on-farm-trials is used to refine the “ideotype”.

The concept described above is characterised by a strong interrelation between technical agricultural staff and farmers. Main results from the 2001/2002 on-farm experiments are presented. In a next step the existing indigenous knowledge will be combined with formal breeding strategies. At the end of the project a more general scheme will be developed which could serve as a blueprint for a breeding approach in other neglected crops.

**Keywords:** Legume crops, neglected crop, participatory breeding

## Field Survey on *Orobanche* Infestation of Faba Bean in Tunisia

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In Tunisia, faba bean (*Vicia faba* L.) is a major food legume grown for human consumption, as green pods or dry seeds, as well as for animal feed. However, the yields remain very low due to several constraints. In some areas, one of the most important constraints to faba bean production is the infestation with parasitic weeds of the genus *Orobanche*. To gain more information about the distribution and the impact of the parasitic weed, field surveys were carried out in April and May 2000 and 2001 in the major legume cropping areas of Tunisia mainly in the governorates of Nabeul, Bêjâ and Bizerte. These three governorates represent 54 % of the total faba bean growing area in Tunisia and contribute 62 % of the total production of this crop. 152 faba bean fields were investigated and the intensity of the *Orobanche* infestation was estimated using a scale from 0 to 6. Moreover, 90 farmers concerned by the *Orobanche* problem were interviewed to learn about their knowledge of the parasitic weed, their perceptions of the *Orobanche* problem and the control methods used.

Two *Orobanche* species were found infesting faba bean in the surveyed regions: *O. crenata* FORSK. which spreaded through the governorates of Nabeul and Bizerte and *O. foetida* POIRET which occurs only in the governorate of Bêjâ. *Orobanche* was present in 45 % of the surveyed faba bean fields. The infestation levels varied from low (rating scale 1 and 2, 43 % of the infested fields), to moderate or strong (rating scale 3 and 4, 29 %), to very strong (rating scale 5 and 6, 28 %). Average yield losses of faba bean due to *Orobanche* infestation was about 25.1 % in the three governorates. The infestation with *Orobanche* is considered by 70 % of the interviewed farmers as a very serious problem and 52 % of them observed an increasing infestation over time. Due to *Orobanche* the area allocated to faba bean is decreasing since many farmers gave up faba bean production. Thus, 84 % of the interviewed farmers in Nabeul have already abandoned faba bean production and 40 % in Bizerte intend to do it in the near future. The farmers' knowledge about the biology of the parasitic weed was very poor, 80 % of them did not know how *Orobanche* was reproducing and have never seen its seeds and 52 % have never seen the *Orobanche* underground stages. In general, no control methods are used by farmers except hand-pulling in case of low infestations. When asked about their interest to test different control methods, the majority of the farmers opted for chemicals (100 %), trap and catch crops (78 %) and resistant varieties, even small seeded ones (64 %).

**Keywords:** Control methods, field survey, *Orobanche* spp., Tunisia





# Subsession 1c<sub>2</sub>: Resource Management and Biotechnology II: Land and Crop Management

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## **Performance of Narrow Strips of Vetiver Grass (*Vetiveria zizanioides*) and Napier Grass (*Pennisetum purpureum*) as Barriers against Runoff and Soil Sediment Loss on a Clay Loam Soil (Andosol) in Kenya**

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The use of narrow grass strips as barriers against runoff and soil loss on steep slopes is a vegetative soil conservation approach that can be applied in developing terraces. The advantage of this approach is that it is cheaper, less labour intensive and takes less land out of production compared to other methods of soil erosion control. In this study runoff plots were used to investigate the performance of narrow strips of Vetiver and Napier grass as barriers against runoff and sediment loss on a clay loam soil (Andosol) in Tatton farm of Egerton University, Kenya, between January 2000 and August 2001. The amount of sediment and runoff from the plots, the depth of sediment deposition along the strips and growth rate of the strips were measured. A total of nine runoff plots, each measuring 16 m long by 2 m wide were used. The study site had an average slope of 8 % and the grass strips were located at the lower end of the plots. The experiment was a randomised complete block design having three blocks with Napier grass strip, Vetiver grass strips and no grass strip (control) as treatments. Compared to the control the runoff from the Napier and Vetiver grass strip plots averaged 46 % and 88 % respectively, while the sediment loss from the plots averaged 8 % and 52 % respectively. Compared to the control the deposition of soil sediment along Napier and Vetiver grass strips was significantly higher. The difference between Napier grass and Vetiver grass, in sediment deposition, was only significant during the first year of the study (2000) but not in the second year (2001). The growth rate in width and height of Napier grass strip was 84 % and 36 % respectively, higher than that of Vetiver grass. Napier grass was more effective in reducing runoff and sediment under the conditions of the study due to its faster growth rate, which enabled it to form a more effective barrier than Vetiver.

**Keywords:** Grass strips, *Pennisetum purpureum*, runoff, sediment, *Vetiveria zizanioides*

## **Local Perspectives on Legume Based Technologies: a Holistic Approach to Target and to Promote the Utilisation of Herbaceous Legumes in the Derived and Northern Guinea Savannas of West Africa**

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Two “baskets” of selected legume options with the potential to improve resource management while providing food and livestock fodder, were introduced in four representative villages in the Derived (DS) and the Northern Guinea Savannas (NGS) for participatory testing and evaluation. The aim of this participatory investigation was to assess farmers’ views of the suitability of the introduced legume options to contribute to their livelihoods and to identify species favoured in each environment as well as the intervening driving and inhibiting forces. Additionally, the knowledge of generic situational factors influencing legume adoption will help to appropriately target the right legumes for the right environment, or to develop an appropriate message to suit farmers’ criteria and perceptions. Assuming that farmers’ needs and perceptions would vary both according to biophysical and socio-economic factors such as human/livestock population density and market access, the DS and the NGS have been systematically divided into domains representing different intensification levels within which the research villages have been selected. Results of field discussions and constraint analyses at village level were used to design the basket of legume options as well as the emphasis for the message to be conveyed during introductory workshops. Throughout this process farmers’ self selection occurred and seeds were distributed according to farmers’ requests of the species they wanted to evaluate. The results presented in this paper were obtained during different phases of the evaluation period using workshops, field discussions and field days as collective evaluation techniques which were complemented by a semi-structured survey including matrix scoring and general ranking as participatory tools. The outputs show a contrast in the farmers’ acceptability behaviour with respect to the legumes between the NGS and the DS. Furthermore they indicate driving forces likely to improve farmers’ attitude towards legume based technologies and suggest further approaches that may contribute to the sustainability of resource use in West Africa.

**Keywords:** Action research, herbaceous legumes, participatory evaluation, savannah

## Typical Fence-Line Contrasts — Land Degradation in Southern Namibia

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Uncontrolled grazing has severe effects on the semi-arid rangelands in Southern Namibia. Alongside fences that separate different land tenure systems, land use induced changes to the phytodiversity were observed in many areas of Namibia. Within the framework of the multidisciplinary BIOTA Southern Africa project research was started in 2001 in order to develop standardised and also feasible concepts for the monitoring of degradation processes and the sustainable utilisation of biodiversity for degraded drylands in southern Africa.

In the *Nama-Karoo* in southern Namibia, the establishment of one km<sup>2</sup> large Biodiversity Observatories at the Gellap Ost Research Station and in the neighbouring *Nabaos* communal land, respectively, allows interdisciplinary investigation on the impact that different land use intensities have on the environment (JÜRGENS et al. 2001).

Preliminary results so far show that the open grazing system in the communal *Nabaos* land has led to a decline in the phytodiversity, especially in the low growing life-forms. An overall decrease in the cover values could also be recorded. Comparative field work from the seemingly intact habitats of the Gellap Ost Biodiversity Observatory shows that the loss of vegetation cover in the *Nabaos* communal land has also led to a decline in microhabitats and food sources for small mammals. A higher species diversity and density was recorded in the regulated farming area of the Gellap Ost Research Station (ZELLER et al. 2001).

We see the possibility that long-term multidisciplinary investigations in the Biodiversity Observatories could supply relevant information for the development of sustainable land use systems and also cost-effective rehabilitation measures for degraded drylands in Namibia.

**Keywords:** Biodiversity, drylands, land degradation, sustainable development

## Basis for a Sustainable Use of the Amazon Floodplain Forest

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The Amazon floodplain (*várzea*) is characterised by nutrient rich water and fertile soils due to the input of nutrients by the river. This periodically flooded fringe of the Amazon has already been used by the indigenous population before the European colonisation started.

How far sustainable agriculture and agroforestry may be intensified in this region depends on the supply and the consumption of nutrients. Particularly the floodplain forest with its high number of mostly nodulated legumes is suggested to be an important source of biologically fixed nitrogen.

Therefore, the focus of the study was to calculate the extent of plant N derived from atmosphere by the use of the  $^{15}\text{N}$  natural abundance method.  $\delta^{15}\text{N}$  values of legumes ranged from 1.4‰ to 5.1‰ in contrast to non-legumes with  $\delta^{15}\text{N}$  values between 3.2‰ and 6.8‰. Considering the importance value index of the legume species, then between 4 % and 5 % of the bulk plant N of the *várzea* forest derives from symbiotic  $\text{N}_2$  fixation. Leaf  $\delta^{15}\text{N}$  did not differ between the aquatic and the terrestrial period, pointing to an adaptation of the nodulated legumes to this extreme environment. Thus, symbiotic  $\text{N}_2$  fixation in the floodplain forest is a continuous process that is not affected by the flood pulse.

The N gain via  $\text{N}_2$  fixation is clearly higher compared to the loss by denitrification. If we compare all the known input and output paths of nitrogen, then we obtain a positive N balance. Therefore, we suggest a long-term retention and an accumulation of N within the *várzea* forest.

**Keywords:** Amazon, floodplain forest, legume trees, nitrogen fixation

## Land Use Zones and Land Use Conflicts Along the Main Road in the Liwagu-Labuk Watershed, Sabah, East-Malaysia

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In the Liwagu-Labuk Watershed, eight different land use zones have been identified. They cover areas beginning in the highlands close to Mt. Kinabalu National Park (ca. 1400 m a.s.l.) and ending at the highly productive waters of the Labuk estuary. Land use along the river basin changes from intensive vegetable production and tourism in the upper catchment, followed by areas with more extensive mixed agriculture and ending in the low lands with increasing areas of large scale oil palm plantations. The observed land use conflicts along the upper part of the river basin are attributed largely to competition for water by agriculture, tourism and municipal supplies; with inherent risks of water pollution by pesticides, fertilisers and waste water. Copper mining activities in adjoining sub-catchment further aggravate the risk of water pollution by suspended sediment and heavy metals. The proposed 120 MW Liwagu HEP Dam at the middle section of the river basin will flood agricultural land and may result in relocation and intensification of land use in the remaining areas therein. Along the lower part of the river basin, land use conflicts are due to increasing conversions from extensive small/medium scale agriculture and forest to intensive monocultures dominated by oil palm plantations. This intensification with a growing input of agrochemicals increases the risk of water pollution and soil erosion. Socio-economically, people are becoming increasingly dependent on these oil palm plantations, which are owned largely by private companies. Loss of social structures is an anticipated consequence of this development. A future project shall further investigate the reasons for land use conflicts in this area and develop sustainable land use concepts.

**Keywords:** Intensification, Labuk, land use changes, land use conflicts, Liwagu, pollution, social impact, water



## **The Security of Land Tenure in Rainforest Margin Areas: the Case of Central Sulawesi, Indonesia**

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The objective of our research in four villages in the vicinity of Lore Lindu National Park, Central Sulawesi, Indonesia was to

1. Identify factors that facilitate or impair tenure security.
2. Evaluate the relationship between land use and tenure security and its consequences on the stabilization of the rainforest margin.

We categorized the main factors influencing tenure security according to the level of decision making. If these decisions result in the desired outcomes depends on the socio-cultural structure of the community concerned.

The state provides the framework of formal proofs of ownership in the form of tax letters and certificates. Whereas the former is implemented in a very efficient manner in the research region the latter does not meet the demands of the local population, due to high costs and limited capacities of the land affairs offices involved.

The local administrative and political institution's impact on tenure security depends on power structures that do or do not allow the village head to sell land to migrants at will and to deny certain groups from access to conflict resolving institutions. Enforcement of state and customary law is stronger in villages with a high level of social cohesion.

On the household level, land security is primarily enhanced by permanent cultivation and land registration. The biggest number of land conflicts was caused by land sales that did not follow the procedure provided by the state.

We assessed the overall security of tenure as sufficient. Most respondents claimed their land to be secure and only few had lost any plots.

However, the forest cover in the research area has decreased considerably within the last five years. We therefore conclude that tenure security is a necessary condition for the stabilization of the rainforest margin but it is not a sufficient one: If access to forest is not efficiently restricted either by local institutions or the state, population increase will lead to further conversion of forest into agricultural land.

**Keywords:** Deforestation, Indonesia, land tenure, security, tropical rainforest

## **Participatory solutions of land use conflicts in protected area management in the Brazilian Atlantic Forest**

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Conservation of biodiversity in tropical countries often differs from development interests of local communities. Participatory approaches and tools are increasingly suggested and implemented to solve these conflicts. The use of participation as a solution for conflicts in management of protected areas is new in Brazil. The project “Doces Matas” is an example of international cooperation in the Brazilian Atlantic Forest, one of the most important hotspots in biodiversity conservation worldwide. Three different Brazilian institutions — two governmental (federal and state) and one non governmental organisation (NGO) — as well as the German Agency for Technical Cooperation (GTZ) are working together to protect the biodiversity in a sustainable and participatory way.

All three Brazilian institutions manage protected areas in the Rio Doce River Basin in the state of Minas Gerais, where few information existed about interests of local stakeholders and occurring conflicts. Therefore, the main objective of this research project is twofold: First to establish an overview showing the existing conflicts and second to document and evaluate the different participatory methods, as well as their contribution to conflict solution. The field work is carried out in collaboration with the Sociology Department of the Federal University of Minas Gerais.

The conflicts registered so far are mostly related to unsustainable land use in the buffer zone, such as burning to clear new areas and use of agrochemicals. The solutions sought by the institutions involve agricultural alternatives, like organic farming and agroforestry as well as environmental education. While the NGO is using methods adapted from the participatory rural appraisal to accompany changes, the two governmental institutions are collaborating with buffer zone organisations in different ways. Changes observed are the decline of fires in the protected areas and in the buffer zone. A higher demand on agricultural alternatives, such as organic farming practices is recognised, along with a raising concern about water quality and quantity in the buffer zones. Since the beginning of the project park staff motivation is higher in all three areas.

**Keywords:** Biodiversity, buffer zone, conservation, Minas Gerais, participation

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## **More Sustainable Range Use in Semi-Arid Eco-Systems through Adapted Management: a Case Study on Namibian Farms Based on Bio-Economic Models**

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Due to overuse of resources, especially over-grazing, and the application of non-suitable management practices such as low recognition of prevalent natural vegetation cycles in grass and thorn bush savannahs without considering long-term degradation processes, the range quality of many commercial farms has declined. A visible decreasing appearance of natural composition of grass and bush cover, bush encroachment and a decreasing biodiversity indicate lower stocking potentials for domestic livestock on large areas of farm lands. Therefore range degradation becomes a threat to the continuation of viable commercial farming in many semi-arid grass lands. As a response, on the one hand many farms seek to increase size and decrease intensity which leads to a declining number of farmers and workers who can make a living on the natural resource. On the other hand political pressure is increasing to encourage intensity of farming and to create job opportunities for a growing population. An immanent conflict arises which is portrayed by the need to assure better resource exploitation of natural savannah and the need to limit resource use to sustain future range quality.

In a case study on Namibian farms we show how improved and better adapted management practices can solve that conflict. In particular, we investigate the potential of using certain new techniques like natural combating of bush encroachment and combinations of wildlife and domestic livestock to prove the economic, ecological and social viability of these strategies. Furthermore, the impact of policy measures to sustain biodiversity and farm income is simulated. To approach our objective we have built farm models that include bio-physical aspects on the interaction of different domestic livestock and wildlife and a transition-state-model for vegetation dynamics. The models are designed around the maximization of discounted value added of different activities for sustainable range land use as to test a long-term perspective on profitability.

**Keywords:** Adapted range management, biodiversity, dynamic bio-economic models, policy measures, sustainability, wildlife

## **Impact Monitoring & Assessment — Instruments for Use in Rural Development Projects with a Focus on Sustainable Land Management**

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To what extent do development projects achieve their purpose and reach their goals? Are we doing things right and are we doing the right things? There is an on-going discussion among development agencies and their partners about how to determine the impact of development cooperation. “Impact Monitoring and Assessment” (IMA, Volume 1&2) is a contribution to this discussion.

IMA is designed for managers, staff and consultants in rural development programmes and projects who need to establish a monitoring system. Since there is no universal monitoring procedure, IMA provides some building blocks for the development of project-specific impact monitoring. Volume 1 contains a general description of an IMA procedure integrated into project cycle management (PCM). As part of a project’s self-evaluation, IMA is an instrument of reflection, learning and quality control throughout a project’s life cycle, in order to better adapt project activities to a changing context. Volume 2 provides additional tools, references, selected monitoring methods and examples from “sustainable land management” (SLM), an important component of sustainable development. These examples should also help projects in other sectors, such as health, education, infrastructure, etc., to adapt the basic IMA procedure to their needs. Whether an impact is considered positive or negative, sustainable or unsustainable, etc., depends on who assesses it (a farmer, his wife, a researcher, a policy-maker, etc.), and his or her interests (economic, social, ecological). Broad involvement by stakeholders during the entire IMA is therefore essential and can also play a central role in their empowerment. IMA is a contribution to local capacity building because it helps stakeholders to present their perceptions, analyse, negotiate and make joint decisions.

The present document takes constraints on time and money in development projects into account, and suggests only simple and therefore cost-effective tools and instruments that have already been tested in practice. The aim of IMA is thus to find plausible indications — and not scientific proof — of a project’s impact.

**Keywords:** Impact monitoring and assessment, participatory methodology, sustainable land management

## Effects of Light, Nitrogen and Propagative Sources on *Cirsium arvense* (L.) scop.

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*Cirsium arvense* (Canada thistle or Creeping thistle) is a noxious perennial broad-leaved weed in the Composite family, propagated by adventitious root and seed. It has an extensive, spreading root system and infests non-intensive arable farming systems mainly in Europe, North America and New Zealand. Understanding a response of plant to the environmental factors will permit integration of control methods and result in improved weed management in organic farming systems.

The concrete frame experiment under field conditions was conducted to determine the effects of light (full light and 85–95 % of shade), nitrogen (0 and 100 kg N/ha) and propagative sources (seed and root) on the growth of *Cirsium arvense*. Light was a main factor for *Cirsium arvense* growth. Statistical analysis showed very significant effects of light on plant height, biomass, sprout number, root diameter and survival rate. Constant shade reduced 58.6 % of height and 99.5 % of biomass. However, the transplanted plants were tolerant to shade at the establishment and early development. This plasticity appears to explain its persistence in the temperate zone. Nitrogen was not a limiting factor for early development of individual *Cirsium arvense* which responded to light more than to nitrogen. The plants grown from seeds were much larger than those from root fragments. The contribution of sexual propagation to the survival of this species should not be underestimated. The management of this weed relying on shade would be through using tall crop and shading cropping system. Nitrogen fertilizer would also be helpful to crop by suppressing this weed.

**Keywords:** *Cirsium arvense*, light, nitrogen, propagative sources

## **Nitrogen Use Efficiency of Some Maize Genotypes Improved or Selected for Tolerance to Low Nitrogen and Drought Stress**

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Nitrogen is often the most limiting nutrient in maize production in the West African savanna. One important characteristic of maize is its high and relatively rapid nutrient requirement. The soils for example must supply about 50–60 kg N (usually nitrate) ha<sup>-1</sup> in plant available forms for each ton of grain produced. In the West African savannah where maize is increasingly becoming important, inorganic fertilizer use is limited due to high cost and unavailability. One approach to reducing the impact of N deficiency on maize production may be to select cultivars, which are superior in the utilization of available N, either due to enhanced uptake capacity or because of more efficient use of the absorbed N in grain production.

Low-N tolerant variety trials that included promising varieties from diverse sources and hybrid checks were conducted in Mokwa (southern Guinea savanna zone) and Zaria, (northern Guinea savanna zone) of Nigeria. The treatments consisted of 15 entries and three N levels (0, 30, and 90 kg/ha). At each N level, the varieties were arranged in a randomised complete block design (RCBD) with three replications. The varieties ACR8328C7, ACR91SUWAN, DTSR-W, DTSR-Y, LNPC2, LNPC3, STR-EV-IWD and the hybrid OBASUPER1 produced the highest grain yields across N levels in both locations. Under sub-optimal N levels (30 kg N/ha), all these varieties out-yielded OBASUPER1. Among the high yielding varieties, ACR8328C7, DTSR-W, ACR91SUWAN, LNPC3 had higher nitrogen use efficiency (NUE) while the rest performed well because of high nitrogen utilization efficiency. Populations and pools with high yield under low nitrogen conditions have been identified and are being further improved.

**Keywords:** Drought, maize, nitrogen use efficiency, low-nitrogen tolerance

## **Detection of Water and Nutrient Pathways in a Small Catchment — the Tai Region Project on Hydrology**

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The Tai Region Project on Hydrology is financed by the DFG/BMZ and was initiated in 2001. It is an active cooperation between the University of Cocody-Abidjan (Centre Universitaire des Recherches et d'Application en Télédétection, CURAT — Côte d'Ivoire) and the Georg-August-University of Göttingen (Landscape Ecology — Germany). The interdisciplinary working group consists of Ivorian and German scientists, students and local collaborators.

The investigation site is located on the eastern border of the Tai National Park in Western Côte d'Ivoire (5°50'N/7°10'W). Within the main research area (covering an area of 1 km<sup>2</sup>) the Hana river enters the National Park after length of 8.5 km. The part of the watershed covers an area of approximately 60 km<sup>2</sup>. Cocoa plantations mostly older than 15 to 20 years are dominating the land use followed by coffee, hevea and the small farmholder's crops like maize, rice, yams and tarot, etc. To guarantee sufficient yield profits despite the old age of most cash crop plantations the intensified application of fertilizers and pesticides is obligatory.

It is the aim of the Tai Region Project on Hydrology to determine agricultural influences on the water and nutrient cycle within the small catchment as well as to identify the transport pathways. As they represent the dominating cultures within the catchment area two cocoa plantations (7 and more than 20 years respectively) as well as one forest site within the National Park have been selected and equipped with sampling units on bulk-deposition, soil water and groundwater. At each site a soil profile has been recorded. Pluviometers for the quantification of daily precipitation have been installed at two nearby fallow stations. Additional basic data are acquired by land use classification based on satellite images and interviewing the local farmholders concerning the application of agrochemicals. Furthermore, an attempt is made to develop an innovative method based on physical and chemical parameters to assess water quality of tropical rivers.

**Keywords:** Côte d'Ivoire, implementation of agrochemicals, land use classification, soil, water and nutrient pathways, water quality

## **A Microcosm Experiment to Evaluate Influence of Nutrient Release as Mediated by Diplopods from Litter of Agroforestral Species Using $^{15}\text{N}$ Marker**

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Understanding the ecology of the soil faunal community is essential for management of nutrient cycling by litter in sustainable agriculture. In central Amazonia, diplopods are the main decomposers for many litter types in agroforest plantations. A new approach of microcosm study is introduced here to examine the effect of litter quality on interactions of macrofauna with microfauna in decomposition and nitrogen release. Litter marked with  $^{15}\text{N}$  was used in integrated microcosms with standardised soil and collection of percolating water. Microcosms were developed that were cheap and easy to maintain so that high replicate numbers could be employed.

Plastic tubes of 20 cm diameter were used, giving sufficient space for incubation with macrofauna. Litter moisture was controlled by water application, which proved a critical factor in animal vitality. Leafs marked with  $^{15}\text{N}$  were cut fresh and artificially aged to produce homogenous litter of a quality found in the field. Animals were collected and artificial populations established. Microfauna regrew in soil and litter after remoisting. By including sieved soil from field study sites, effects of interactions between litter, microfauna and diplopods could be studied. Percolating water could be collected, without extensive collection systems. Nitrogen pathways were elucidated by using the isotope labelling technique.

The method employed is considered suitable for studying soil ecosystems by controlled experiments. Interactions between compartments can be tested directly within an integrated environment, which can be extended by adding further components.

**Keywords:** Decomposition, diplopods, litter quality, microcosm, nitrogen tracer, nutrient cycling, soil fauna



## **Role of Diplopods in Decomposition and Nitrogen Release from Litter of Different Qualities in Central Amazonian Agroforestry**

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Management of advanced agroforestral polycultures includes optimised synchronization of crop demand and nutrient release from litter. The importance of macrofauna in determining decomposition and nutrient release patterns in the tropics has been shown in various studies, but the nutrient pathways and ecological characteristics have not been elucidated.

A new approach of microcosm experiment has been developed to study the interaction of diplopods with microbes in decomposition of seven major leaf litter types occurring in a central Amazonian agroforest. Three different diplopod species were incubated with litter marked by <sup>15</sup>N enrichment in integrated microcosms along with microfauna/-flora only and soil only control. Leachate water was collected continuously and pooled after six weeks when replicates were terminated by destructive sampling. Terminal C, N and <sup>15</sup>N contents were measured in water and animals, and initial values also for litter and soil. Litter was analysed additionally for polyphenol content.

Mass loss and nitrogen release from litter showed clear patterns of dependency upon polyphenol and nitrogen content and were significantly higher under influence of the animals in good and medium quality species. Accumulation of C in soil differed from these patterns. There were marked differences in the influence of each diplopod species per gram bodyweight; for example, a smaller species mediated more than twice the increase in litter weight loss. Animal species showed clear differences in response to litter quality. Management implications and consequences for the importance of soil faunal ecology for nutrient release from litter are discussed. The developed microcosm method is considered a promising approach to study soil nutrient pathways and faunal effects.

**Keywords:** Amazonia, decomposition, diplopods, litter quality, Nitrogen, nitrogen tracer, nutrient flow, soil fauna, terra firme

## Nutrient Retention in an Amazonian Ultisol: Implications for Sustainable Land Use

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Knowledge about cation and anion exchange and pH buffering in soils is essential for developing an efficient nutrient management system, especially in tropical soils where nutrient retention capacity may be low. Sorption characteristics and pH buffering of an Amazonian Ultisol were studied in sequential batch experiments. Objectives were to gain additional information on the cation and anion exchange and pH buffer properties of this soil by using a coupled equilibrium model.

The cation exchange capacities in the surface soil and subsoil were below 30 mmol<sub>c</sub> kg<sup>-1</sup>, indicating that the soil is highly limited in retaining nutrient cations against leaching. The anion exchange capacity of the soils for both depths was small (1 to 4 mmol<sub>c</sub> kg<sup>-1</sup>), indicating insignificant retention of NO<sub>3</sub> and its enhanced losses in seepage water following non-adapted management practices such as high doses of fertilization. More protons could be buffered in the surface soil than in the subsoil. Addition of protons to the surface soil released equivalent amounts of M<sub>b</sub> (Ca, Mg, K, Na) cations because of CEC reduction, and an insignificant amount of Al. However, input of protons to the subsoil released large amounts of Al. The model satisfactorily predicted the sorption values for various elements in both depths, indicating that the main processes are understood.

The results indicated a very poor capacity of the soil for nutrient retention and pH buffering and a high risk of Al toxicity. Management options should substitute ‘slash and burn’ practices (which result in further nutrient losses) with mulch producing technologies and strive for only small additions of fertilizer (to reduce nutrient losses and avoid further soil acidification). A useful nutrient management strategy would include intercropping with legumes, but compensation for the increased acidification may be required.

**Keywords:** Amazonia, anion exchange capacity, cation exchange capacity, pH buffering, PHREEQC, ‘slash and burn’, ‘slash and chop’, soil acidification

## N Dynamics of Leguminous Tree Residues as Indicator Plant under Greenhouse Conditions

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In the Amazon, slashing and burning activities converted large areas of primary forest to intermittently used agricultural land. Thus, the fallow vegetation plays an important role to maintain or restore soil productivity. However, the intensification of land use has caused drastic reduction of the fallow period. Therefore, the soil quality has to be restored in shorter time period. The general objective of this work was to monitor the influence of leguminous tree species on soil N dynamics, simulating a situation when burning is replaced by mulching so-called *slash-and-mulch systems*.

The greenhouse experiment was divided in two parts: first, <sup>15</sup>N-urea fertilizer (3.92 mg N pot<sup>-1</sup> with 5.34 atom % <sup>15</sup>N) and leguminous leaf material (*S. paniculatum*, *I. edulis* and mixture) with N natural abundance were combined to assess microbial immobilization and soil fixation. The second experiment, N-urea fertilizer (3.92 N mg pot<sup>-1</sup> with N at natural abundance) and <sup>15</sup>N-labeled leguminous organic material from the same species with 0.392 atom % <sup>15</sup>N, and 0.390 atom % <sup>15</sup>N, respectively, were used to assess the amount of mineral-N that coming from organic matter decomposition and the extend of competition between microorganisms, soil + organic matter fixation, and rice absorption.

For all treatments, microbial net N-immobilization was higher than net N-mineralization after 50 days of rice plant growth. After 50 days of incubation, *S. paniculatum* and the mixture had C-to-N ratios of 16.5 and 14.7, respectively, which was significant higher than for *I. edulis* (13.0) and the control (12.5). Amounts of <sup>15</sup>N recover by rice in this experiment were significant higher ( $p < 0.05$ ) in the treatment with the mixture of the two species in comparison with the same species separately. The same trend was found in the cumulative total N in the plant and the cumulative plant biomass.

The treatment with mixture between two species had an intermediate cumulative immobilisation of <sup>15</sup>N by soil microbes, higher cumulative rice biomass and total N, and higher recovery of <sup>15</sup>N from urea fertilizer. This indicates that interaction of two contrasting leguminous species increase the nitrogen absorption by rice, apparently by an increase of mineral N and decrease of gross microbial N immobilization.

**Keywords:** Amazon, <sup>15</sup>N, N microbial immobilization, N mineralization, slash-and-mulch systems

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## **Effect of Depth of Water and Duration of Inundation on Rice-Weed Competition and Grain Yield of Rice in the Central Plains of Thailand**

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Rice is the main source of energy and income of the Asian people. It is also the dominant crop in smallholder agriculture. Rice yields are often reduced by weed competition. High labour cost of weeding has led to a widespread use of herbicides. Use of herbicides can cause problems, such as the development of herbicide-resistant weed ecotypes and weed resurgence. These are two most crucial situations that lead to the development of more toxic and longer-effective herbicides. Therefore, the use of non-herbicide weed-control measures has been favoured by many agriculturists. This study was conducted to determine the effect of depth of water and duration of inundation on rice-weed competition and grain yield in comparison to the traditional system of manual weeding and herbicide-based weed control.

The treatments were composed of five depths of water (viz. 0, 2, 4, 6 and 8 cm) maintained from seeding and two levels of weeding (viz. weeded at panicle initiation and non-weeded throughout the growing period). In a split-plot design with three replicates, these treatments were compared with the traditional system and also with a plot weeded with commonly used herbicides.

The population and growth of weeds were highest with 0 cm water depth. Increasing water depth from 2 to 8 cm significantly reduced both parameters. There was a significant reduction in the weed population in the plots treated with herbicides during the initial growing period compared to low water depths and the traditional system. Weeds that emerged later in herbicide treated plots caused significant yield reductions.

Rice plants at 0 cm water depth had a lower number of effective tillers and panicles per plant, which significantly increased with water depths up to 6 cm, and decreased at 8 cm water level. Removal of weeds at panicle-initiation (PI) enhanced grain yield compared to the herbicide-treated plots. Grain number per panicle remained almost unchanged at water depths from 2 to 8 cm with weeding at PI stage. However, increasing water depth significantly increased the grain number per plant even without weeding. The final grain yield showed no significant changes over water depths from 0 cm (4.1 t/ha) to 8 cm (4.4 t/ha) when weeding was practiced. Without weeding, the grain yields varied from almost zero to 4.4 t/ha with increasing water depth from 0 cm to 8 cm. This study revealed the possibility for reducing or even replacing herbicides with water management for weed control. This is a promising alternative for areas such as the Central Plains of Thailand.

**Keywords:** Rice-weed competition, transplanted rice, water depth, water management, weed management

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## **Sustainable Rehabilitation of Food Crop Production on Inland-Valleys Soils (Marais) in Central Rwanda. Agro-Ecological Conditions and Specific Pedological Determinations**

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Since more than thirty years, inland valley soils provide only an extensively used potential for substantial food production in Central Rwanda. In face of an average population density of about 300 inhabitants per km<sup>2</sup> and more than 90 % agricultural population, nearly the entire Rwandan uplands are already cultivated, primarily for smallholder food production. These agricultural areas are highly endangered by top-soil erosion and the permanent loss of nutrients. The predominantly flat and swampy inland valleys are widely spread landforms east of the Nile-Congo watershed. The mainly unused inland valleys represent the last arable land for the extension of food production especially in the surroundings of the cities.

At the end of the 1970s, the sandy gleysoils of the inland valleys (Marais) started to gain regional importance for cultivation but then fell back into fallow land again. Since 1995, some of them were re-opened and re-habilitated by cooperative food production projects with international support, i.e. the DWHH-Rugeramigozi Project.

The pedological and agro-ecological research was carried out adjacent to Gitarama in the Central Rwandan Uplands and around Butare in Southern Rwanda. All investigated areas are situated in the upper part of the numerous tributaries and sub-catchments which are branched out dendritically of the major river “Nyabarongo”.

The actual land-use of the valley fringes and the colluvial footslopes is the extensive tillage of manioc or beans whereas the valley bottom remains as swampy Gramineen thicket. In the projet areas the valley bottoms were cultivated with maize, soy and local varieties of beans.

In the valley bottoms stagnic to umbric gleysols are mixed with gleyic arenosols which contain a very low amount of gravel. As a consequence of the hydromorphic conditions characterized by wetness and low soil ventilation, the decomposition rate of plant remnants is low and the humic topsoils possess a high content of organic matter. The major pedological restrictions for agriculture are the sandy valley-bottom soils and the unsteady water supply during the dry season requiring careful irrigation techniques. The high nutrient leaching rates under inadequate production methods may also cause serious problems to the farmers.

**Keywords:** East Africa, food crop production, inland valley, Marais, Rwanda, valley bottom soils

## Relationships of Soil Microbial Indices in Secondary Tropical Forest Soils

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In Bacnotan, Philippines, soils from six secondary tropical forest sites developed from the same parent material, but differing in the present vegetation, in stand age, and in land use history were investigated. The aim was to assess the effects of these differences on the activity, biomass and community structure of soil microorganisms in the A-horizon. The six sites investigated revealed strong differences in soil organic matter and soil microbiological properties. Although these were all within the range described in the literature, our six tropical forest sites revealed several marked differences to forest soils from a temperate climate. The average ratio of microbial biomass C-to-soil organic C was 2.8 %, exceeding that of microbial biomass N-to-total N of 2.0 %. This means that the average microbial biomass C-to-N ratio of 14.1 exceeded the average soil organic C-to-total N of 10.1. The mean ratios of ergosterol-to-microbial biomass C and ATP-to-microbial biomass C were 0.19 and 4.3  $\mu\text{mol g}^{-1}$ , respectively, both very low. AEC (adenylate energy charge:  $(\text{ATP} + 0.5 \times \text{ADP}) / (\text{ATP} + \text{ADP} + \text{AMP})$ ) and metabolic quotient  $q\text{CO}_2$  reached average levels of 0.71 and 36 ( $\text{mg CO}_2\text{-C d}^{-1} \text{g}^{-1}$  biomass), respectively. The different ratios of soil biological and soil chemical properties could be assigned to three different factors by principal component analysis. The ratios soil organic C-to-total N, ergosterol-to-microbial biomass C, and microbial biomass N-to-total N formed the first factor, reflecting a decomposition pathway characterised by fungi. The ratios ATP-to-microbial biomass C, AEC and  $q\text{CO}_2$  were combined as second factor, characterising the specific metabolic activity of soil microorganisms. The third factor was loaded by the ratios microbial biomass C-to-soil organic C and microbial biomass C-to-N, characterising soil organic matter availability in relation to nutrient availability.

**Keywords:** Adenylates, AEC, ATP, basal respiration, biomass N, ergosterol, microbial biomass C

## **Determinants of Manure Use in Crop Production in Northern Guinea Savannah Zone of Nigeria**

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Soil nutrient depletion is very high in the Northern Guinea Savanna (NGS) agro-ecological zone of Nigeria due to intensive farming and inappropriate application of fertilizers causing negative balance in soil nutrients. The inappropriate management of soil fertility is a serious problem that threatens the sustainability of agriculture in zone. While the use of organic soil amendments in combination with inorganic fertilizers have been identified to be more sustainable, it is still not widespread among farmers in the NGS. Promoting the adoption of organic soil amendment methods requires knowledge about farmers' characteristics and the factors affecting farming. A survey of 400 farmers selected in Kaduna State, in northern Nigeria using a stratified random sampling technique was undertaken to assess the factors that influence the adoption of manure use in crop production. The Tobit regression analysis was used to model the factors. From the sample, 61 % did not adopt the use of manure while 39 % did. Among the adopters, 86.9 % practiced mixed farming, while 26.9 % belonged to farmers' cooperative societies. Also, 72.7 % of the respondent had easy access to the fertilizer market.

The Tobit regression analysis showed that membership of cooperative society, livestock ownership, practice of mixed farming, and inaccessibility to inorganic fertilizer significantly influenced the adoption and use intensity of manure. The elasticity estimates showed that 56 % of the total change in manure use intensity would come from marginal changes in the characteristics of adopters, farming method, as well as, membership in a cooperative society. Easy access to and, the low cost of inorganic fertilizer, militate against the adoption of manure use in crop production by farmers. The use of manure by farmers will improve significantly, especially through increasing farmers' awareness of the beneficial effects of manure, better on-farm manure management and inclusion of livestock in farm enterprises.

**Keywords:** Adoption, elasticity, inorganic fertilizer, manure, Nigeria, use intensity  
Tobit

## Soil Organic Matter Turnover in Pasture Sites Following Deforestation in the Humid Central Amazon of Brazil

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We studied the organic matter cycling characteristics in the humid central Amazon of Brazil. Total C and natural  $^{13}\text{C}$  abundance ( $\delta^{13}\text{C}_{\text{V-PDB}}$ ) in the whole soil and in the microbial biomass (labile pool) was followed along a chronosequence of pasture sites of 6 months up to 60 years after deforestation.

The  $\delta^{13}\text{C}$  natural abundance in the whole soil decreased from  $-27\text{‰}$  under undisturbed forest sites to  $-23\text{‰}$  in the 60-year-old pasture site, and from  $-30\text{‰}$  to  $-19.4\text{‰}$  in the microbial biomass.

An increase of total soil organic C in the whole soil occurred during the first 2 years of pasture establishment and was due to an increase in grass-derived C ( $\text{C}_4$ ). After this 2 years,  $\text{C}_3\text{-C}$  decreased by 25 % and remained at this level up to 8 years following deforestation. Thereafter,  $\text{C}_3\text{-C}$  declined steadily. Grass derived carbon was similar at all sites ( $\sim 8 \text{ g kg}^{-1}$ ) once the pastures were established after 2 years. In the microbial biomass,  $\text{C}_3\text{-C}$  declined by 60 % during the first 2 years of pasture establishment. From 2 to 4 years following forest cutting  $\text{C}_3\text{-C}$  increased for a short period and declined then steadily with pasture age. Contrary to the whole soil,  $\text{C}_4\text{-C}$  in the microbial biomass increased during the first 6 years following pasture establishment. Thereafter, it decreased continuously. The overall decrease of total C in the pastures with time following deforestation was due primarily to the loss of  $\text{C}_3\text{-derived}$  carbon. The loss of  $\text{C}_3\text{-C}$  from the system started much earlier in the microbial biomass compared to the whole soil. Sixty years following deforestation and pasture establishment the loss of  $\text{C}_3\text{-C}$  was 60 % in the whole soil and 80 % in the microbial biomass.

**Keywords:** Amazon, microbial biomass, organic matter transformation, pasture sites, whole soil



## **Soil Fertility and Soil Parameter Changes in Different Land-Use-Systems After Conversion of Natural Forest to Agricultural Land**

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Conversion of natural forest to agricultural land by small-holders is a crucial factor for deforestation in Indonesia. According to a common hypothesis, the decrease of soil fertility due to unsustainable land use-systems can force small farmers to clear new land for growing crops with acceptable harvest results. The situation in Central Sulawesi is unusual because of mostly fertile soil with high pH.

In the vicinity of Lore Lindu National Park in Central Sulawesi, Indonesia, soil samples were taken from 75 farmers' fields in 5 villages and analyzed for their plant-nutrient content. Samples were taken from three different land-use-systems, maize-fields (annual crop), coffee and cocoa-plantation (agroforestry) fallow fields and from natural forest as comparison. The sites were selected according to their age after clearcutting of forest, to estimate the change of soil parameters in time after the conversion of forest to agricultural land ("false time series"-approach). The soil was analyzed for org. Carbon, nitrogen, pH, phosphorus and the macronutrient cations. For every site information about the site-history, age, previous management was collected.

Additionally to this survey, input- and output-fluxes of nutrients were measured intensively on selected sites to estimate the mechanism of the change of soil parameters and to find the crucial factors affecting soil fertility. On the selected sites (maize, agroforestry and forest) lysimeters were installed to measure leaching, and harvest export of nutrients was measured. Rain samples were taken to measure input of nutrients and the input by fertilizer-application was measured. With data from climatic stations nearby a simple water-balance was calculated to estimate the leaching and evapotranspiration.

**Keywords:** Forest conversion, land use systems, soil fertility

## Soil Charcoal Amendments Maintain Soil Fertility and Create a Carbon Sink

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Soil nutrient and carbon contents are generally low in the highly weathered and acid upland soils of central Amazônia. In agro-ecosystems, high precipitation and temperature lead to a loss of soil organic matter (SOM) as carbon dioxide into the atmosphere and nutrients into the sub-soil. Patchily distributed anthropogenic soils (*Terra Preta do Índio*) of Brazilian Amazônia make an exception. These soils are rich in stable SOM and nutrients. SOM is especially important to the cation exchange capacity of soils. Recent investigations of GLASER et al. (2002) presented evidence that charcoal from incomplete combustion of organic material is a key factor in maintaining high levels of SOM. *Terra Preta* contains high concentrations of charcoal. In a series of experiments, we are studying the use of charcoal in agricultural praxis and management of a highly weathered Xanthic Ferralsolon terra firme north of Manaus. In a randomized complete block design with five replicates 15 amendment combinations are being tested on sorghum (*Sorghum bicolor*). During the second growing period a significant difference between NPK plus lime-fertilized plots and NPK, lime, and charcoal plots was observed. Charcoal amendments alone had no effect. These results are evidence of charcoal's nutrient retention and/or sorption capacity and its positive effect on crop productivity. Slash and char as alternative to slash and burn could be a further step toward sustainable agriculture in the tropics as well as toward the management of the carbon cycle by simultaneously transferring carbon to stable pools.

**Keywords:** Agroecology, alternative technologies, Amazonia, Brazil, carbon acquisition and nutrient fluxes, climate change, indigenous knowledge, nutrient retention, organic and inorganic fertilizer, slash-and-burn agriculture, soil C, soil fertility, Terra firme

## Testing Salt Tolerance of the Main Sorghum Cultivars for Semi-Arid Conditions of Sudan

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Sorghum is considered as the main food of more than 80 % of the population of Sudan. It is grown nearly in all regions of Sudan, mainly as rainfed agriculture. However, irrigated sorghum is also practised, particularly in the Gezira scheme, for farmers' local consumption. The increase of demand due to increase of population forces extension of sorghum cultivation in marginal areas, that are salt affected.

Because of environmental problems and infeasibility of reclamation in many cases, this study is an attempt to find feasible and practical means to cultivate salt-affected soils for sorghum production under semi-arid conditions in Sudan.

To attain sustainable sorghum production under such above mentioned conditions, six sorghum cultivars were tested against different levels of salt concentrations. Other than the control the three levels were 2, 4 and 8 dS m<sup>-1</sup> at 25 °C in the extract of the saturated soil paste. For artificial salinization NaCl was used because NaCl is found to be the dominant salt in salt-affected soils of the semi-arid conditions of Sudan.

The *Sorghum bicolor* (L.) MOENCH cultivars selected for this study were ICV 207, ICV 112, F. W. Ahmed, Elingaz Tabat and B/16, they were provided by the Sorghum Breeding Centre of Sudan. Germination percentage and seedling shoot dry weight were recorded at 3 and 7 days after sowing, respectively.

The preliminary results showed varietal differences in responses to different levels of salt. The sorghum cultivar F. W. Ahmed was found to be a high salt tolerant variety compared to the others. Nevertheless, different salt levels differ in their effect on both germination and seedling shoot dry weight for each sorghum variety. However, the high salt concentration, i.e. 8 dS m<sup>-1</sup>, showed a drastic effect on all varieties in both germination and seedling shoot dry weight.



# Subsession 1d: Precision Agriculture, Modelling and Land Use Planning

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## Precision Agriculture, Modelling and Land Use Planning

ANCHA SRINIVASAN

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Precision agriculture (PA) is a holistic management approach that originated in the early 1990s with the goal of optimising profitability and productivity while minimising the adverse environmental impacts in each spatial unit of the field. It is centred on sound use of agronomic principles, and involves variable application of external inputs and other cultural practices to match varying soil and crop conditions. Practical implementation of PA, however, is dependent on technological developments to collect, manage, analyse and utilise vast amounts of site-specific data. Rapid advances in both hardware (positioning and sensor technologies, yield monitors, variable rate applicators, etc.) and software (data collection, geographic information systems [GIS]) coupled with the availability of low-cost powerful computers has made PA a reality today. However, PA must not be viewed in terms of technology use alone, as its principles are applicable in a wide range of situations. Although PA is intuitively considered more efficient in input use than traditional agriculture, documentation of its economic and environmental benefits remains incomplete. Perhaps that is why only a small minority of farmers incorporated PA technology into crop management in 2002 even in developed countries. Adoption in the developing countries is very low so far, although concerted efforts are being made to promote it at various levels. In the keynote presentation, a brief introduction to the principles and component technologies of PA is given, with emphasis on driving forces for its adoption in the developing countries. A simple methodology for precision management of cropping systems is outlined and the conditions in which PA offers the greatest economic and environmental benefits are highlighted. The prospects and progress for PA adoption in selected cropping systems are also presented.

Precise management of water in agriculture has become crucial nowadays due to increasing demands from the industry and urban areas. As we learn from the work of AL-KARADSHEH et al., the next generation in irrigation scheduling is not just when and how much, but when, where and how much to irrigate. A cost-effective precision irrigation system must be capable of applying not only water but also various agro-chemicals. The development of new algorithms is vital, however, to successfully utilise and/or adapt the machinery for PA. The paper by SUTIASO et al. is interesting in this context, for it describes the development of an algorithm called “parallel parking theory” as part of the efforts to develop a trajectory path controlling method for autonomous farm tractors. Using this algorithm, the authors report significant improvements in the accuracy of the detection of target objects.

Application of PA concepts requires significant modelling efforts. For instance, determining the relationships between crop yield and various controllable (e.g., agro-chemicals) and uncontrollable (weather, topography, etc.) factors in cropping systems remains a challenging task. Environmental Policy Integrated Climate (EPIC) model, which can simulate both crop rotations and movement of agricultural chemicals, is useful in predicting crop yields and soil erosion. In this subsession, GAISER et al. report the applicability of a modified version of EPIC called EPICSEAR to simulate soil water balance and biomass production in maize-cowpea intercropping system in Brazil. It is worth noting, however, that different models yield different

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outputs, and that simulated results often differ widely from the actual conditions. LANGE et al. report such differences based on their studies on seepage in sandy loam soils of Brazil. SIEBERT and DÖLL analyse uncertainty and sensitivity of the Global Water Model WaterGAP, and DÖLL et al. examine the applicability of Global Water ModelGAP to estimate the impact of global change on water scarcity. FELDKAMP et al. address the issue of developing a new concept-oriented forage model, wherein the usefulness of a model is expressed by the probability that it drives the decision maker to an optimal decision.

Prior to introducing PA concepts, it is essential to assess the potential of agro-ecosystems on a regional basis, and identify the limiting factors for successful crop production. Inadequate land use planning and insufficient characterisations of local conditions remain major barriers for successful utilisation of arable lands. Many presentations address such issues relevant to the developing countries. Based on an agricultural zoning analysis, KARIMUNA and DENICH identify the principal limiting factors for agricultural land use in Sulawesi (Indonesia), while SULTMANN demonstrates the usefulness of remote sensing and GIS in land use classification in the Tai region of Cote d'Ivoire. MULINDABIGWI and JANSSENS examine the influence of land use systems on organic matter dynamics and water use efficiency in Benin, and SEREKE et al. describe a land evaluation study for achieving sustainable highland agriculture in Northwest Thailand. OSMAN and SAUERBORN examined long-term rainfall variability in Ethiopia based on an ongoing collaborative project between German and Ethiopian organisations. IBISCH identifies the need for integrating various objective methods for evaluation of the conservation status using socio-economic proxy indicators in conjunction with integrated land use planning in Bolivia. Two presentations look at the environmental quality aspects. MITRA et al. report the issue of methane production and emission in rice fields of the Philippines, and ROGGE describes the results of a survey on agrochemical use in Cote d'Ivoire. In most countries, the available information on agriculture is widely scattered but the Internet now offers new opportunities. BOJE et al. approach this issue on a national basis by introducing the new German information system for agricultural and environmental research.

All in all, the papers and posters presented in this sub-session offer a comprehensive approach to achieving sustainable agriculture through analysing opportunities and obstacles for PA, crop modelling and land use planning.



## Precision Irrigation: New Strategy for Irrigation Water Management

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Agricultural cropping systems depend on the use of water resources for survival, and water needs vary spatially in fields because of spatial soil variability (texture, topography, water holding capacity and infiltration and drainage rate), therefore, the need for irrigation may differ between different zones of a particular field. While moving irrigation systems apply water at constant rates, some areas of the field may receive too much water and others not enough. Precision irrigation, an existing aspect of precision farming just beginning to be explored, means applying water in the right place at the right amount. The use of precision agriculture for irrigation water management is still in the development stage and requires a lot of investigation and experimental work to determine its feasibility and applicability.

The availability of some low-cost data gathering methods, positioning systems and the development in computer programming will help in regulating the depth of water within a field. So the next generation in irrigation scheduling is not just when-how much but when, where and how much to irrigate. A precision irrigation system expected to have the ability to apply the right amount of water directly where it is needed, therefore is saving water through preventing excessive water runoff and leaching. So the suitable technology to control varying amounts of water in direction of travelling and crosswise has to be developed.

Federal Agriculture Research Center (FAL), Institute of Production Engineering and Building Research, Braunschweig, Germany in cooperation with the Department of Agricultural Engineering at the University of Kassel starts a research activity aimed to review the state of precision irrigation, to add necessary background information and to develop a strategy for its application. The future challenge is to build a rich database in order to formulate a complete decision support system for precision agriculture, including all field activities i.e. irrigation, fertilisation, tillage, plant protection and weed control. The presented project contributes to reduce the use of scarce water resources.

**Keywords:** EM38, irrigation scheduling, precision agriculture, precision irrigation, spatial variability, water holding capacity, water saving

## **Simulation of Biomass Production and Soil Water Dynamics on Highly Weathered, Acidic Soils in the Tropics with the EPICSEAR Model**

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The EPICSEAR model is a newly developed version of the EPIC model for simulating crop production and nutrient uptake on highly weathered, acidic soils. It has been used to simulate soil water dynamics and biomass production of an intercropped Maize/Cowpea system with and without fertilization on an Alumi-Haplic Acrisol with high aluminium saturation. The simulation results were used to evaluate the effect of fertilization on water use efficiency in rainfed agriculture on similar sites in the Northeast of Brazil.

The simulation results were checked against soil water and biomass measurements of a field trial in the semiarid Northeast of Brazil. The field had been previously used for Maize/Cowpea mixed cropping and the effect of complete fertilization (C) on soil water changes, nutrient uptake and biomass development was evaluated in a randomized complete block design with four repetitions compared to the control treatment (CR) without fertilizer application. Depending on the parametrization of soil hydrological properties, the biomass production and grain yield of both treatments (C and CR) was reasonably well represented by the model (underestimation of total above ground biomass by 10 to 19 % in the year 2000). The changes of the absolute soil water content were better represented when field capacity and wilting point were measured in the laboratory or calculated from pedotransferfunctions compared to EPIC estimates. The calculated transpiration coefficients in the treatment with complete fertilization ranged between 788 and 963  $\frac{1}{\text{kg}}$  dry matter, whereas those in the control were between 1124 and 1282  $\frac{1}{\text{kg}}$ . The results demonstrate the extremely high transpiration coefficients of a maize/cowpea intercrop on this test site and the increase of water use efficiency by up to 43 % when mineral fertilizer is applied.

**Keywords:** Acid soils, Northeast Brazil, simulation, soil water balance, transpiration coefficient

## **Agricultural Zoning Based on Biophysical Land Properties in Southeast Sulawesi, Indonesia**

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On Muna Island, Southeast Sulawesi, agricultural land becomes increasingly a limited resource. In Kusambi district (282 km<sup>2</sup> = 6 % of Muna Island), slash-and-burn agriculture is still predominating and is one of the main factors for deforestation, land degradation and biodiversity losses due to increasing population density and resettlement programs. Also, agricultural land is increasingly being transformed into non-agricultural land. The main objective of this study was to assess the potential areas in Kusambi district which are suitable for the locally most important annual and permanent crops. The assessment is based on biophysical land properties, such as climate, soil, and vegetation cover, and envisages to establish a land-use zoning. Ninety-three land units were identified and then classified according to their suitability for the 23 most important annual and plantation crops as well as fruit and forest trees of the study region. The land suitability was classified into five groups: very suitable, moderately suitable, marginally suitable, currently not suitable and permanently not suitable. The information was analysed and visualized with a GIS and revealed that the major part of Kusambi district is suitable for field crops, while forest trees, except teak, are suitable only for the minor part of the district. Sixty-eight to 79 % of the district are suitable for the cultivation of irrigated rice, upland rice, maize, soybeans, peanuts, cassava, mung beans, and sweet potatoes, 52–80 % for fruit trees, but only 33–53 % for forest trees. The results show that drainage problems, slopes, nutrient deficiencies, and water shortage are the principal limiting factors for agricultural land-use in the study region. The results will be discussed with regard to regional land-use planning.

**Keywords:** Agriculture production, annual crops, forest trees, land suitability, land use planning, tree crops

## Empirical Validation of Applied Forage Models

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Forage production models, together with forage budgets, can serve as an important decision support tool for farmers. In extensive grazing situations the estimation of the stocking-rate is one of the most important uses of forage budgets. A precise estimation of the adequate stocking-rate depends on the accuracy of the estimations of forage availability and forage allowance. The objective of this work is to present a method which evaluates the accuracy of forage models. Variables affecting the accuracy of the estimations of the stocking rate but not included in the forage model are assumed that belong to the decision-making context.

In the proposed method, the usefulness of the forage model is expressed by the probability that it drives the decision-maker to adopt the same stocking rate adopted with real forage availability. This method assumes that it is not necessary that the forage model predicts exactly the real forage availability, and that there is a range of values leading to the same decision. This range is defined by the maximum admissible error (MAE). The MAE adopts the highest of four sources of error: (1) demand model error; (2) estimation error; (3) continuity error; and (4) inflexibility error. MAE value depends on both the decision-making context and the sampling procedures. The observed means (Obs) follow a t-distribution. The area under the density function curve within the range estimated mean (Est) $\pm$ MAE/2 is the probability that the model leads to adopt a stocking rate equal to the one adopted with the real forage availability.

Averaging the probabilities of all the Est-Obs pairs gives the overall probability that the model leads to adopt the same stocking rate adopted with real forage availability (P) given a certain decision-making context.

This method allows validate models stressing their intended use. Users of the forage model, i.e. decision-makers, can easily understand results of the proposed method.

**Keywords:** Applied models, decision-making, empirical validation, forage models

## **The Global Water Model WaterGAP 2: Hydrology Model and Water Use Model**

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WaterGAP, a global model of water availability and water use, has been developed to assess the current water resources situation and to estimate the impact of global change on water resource issues, in particular on water scarcity. With a spatial resolution of  $0.5^\circ$ , the raster-based model is designed to simulate the characteristic macro-scale behavior of the terrestrial water cycle, including the human impact, and to take advantage of all pertinent information that is globally available. WaterGAP consists of two submodels, the Global Hydrology Model, and the Global Water Use Models. Both models are linked: consumptive water use leads to a reduction of river discharge, and the comparison of water use and water availability (as river discharge) provides an indication of water scarcity. The Global Hydrology Model computes total runoff (sum of surface runoff and groundwater recharge) and river discharge. **1)** For each cell, the daily vertical water balance (canopy, soil, open water) is calculated. **2)** The total runoff from land is partitioned into surface runoff and groundwater recharge and is then transported to the downstream cell (via lakes and wetlands). The model is calibrated against measured discharge for 50 % of the global land area its performance has been tested. The Global Water Use Model computes withdrawal and consumptive (fraction of withdrawn water that evapotranspires) water use for irrigation, livestock, households and industry. Sectoral water use is calculated as a function of driving forces of water use (e.g. irrigated area and climate in the case of irrigation water use) and model parameters (e.g. crop coefficients). Model results of WaterGAP can be used, for example, to assess where water is available for additional irrigation or to estimate the impact of climate change or increased water use on river discharge and thus ecosystems.

**Keywords:** Global model, irrigation, river discharge, water resources, water use

## **Concepts and Methods for the Development of Ecoregional Conservation and Resource Management Visions — the Example Bolivia**

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Bolivia is one of the most biodiverse countries of the world. The 15 ecoregions and their high level of ecosystem and species diversity are a result of an enormous geodiversity and the location of the country within several biogeographic transition zones. In contrast to most other tropical countries, Bolivia is characterized by several vast ecoregions, especially the speciose Andean and lowland forests, that present a rather good conservation status and a low human population density. Therefore, the country offers ideal opportunities for the implementation of a proactive and integral land-use and resource management planning that considers both traditional land-use-based planning criteria and biodiversity conservation priorities. Until now, most land-use planning has been done without adequate participation of the conservation sector. Partially, this may be due to the lack of methods that facilitate the integration of land-use and conservation planning aspects. Ideally, the integrated land-use planning should start at the national scale and, then, be implemented at ecoregional and local scales. During the identification of conservation priorities it is important to take into account ‘classical’ conservation-relevant aspects like diversity and endemism patterns. However, this approach is too static if not complemented by other elements. Recently, it becomes very clear that inevitable environmental (and socioeconomic) changes and arising conservation necessities must have a strong influence on the conservation priorities. Functionality and viability of biodiversity components may be more important than the adequate representation of all unique manifestations of biodiversity. Quite often, the relevance of the conservation status of the ecosystems to be conserved is neglected. Thus, it is necessary to integrate objective methods for the evaluation of the conservation status in the priority-setting exercise. Examples are given how this step can be accomplished making use of socioeconomic proxy indicators. Finally, the Bolivian ecoregional conservation visions are presented: from strict nature protection (5 % of the country’s area), e.g. in the case of the best conserved portions of the montane rain forests, to sustainable land and resource use and/or restoration of the productive potentials (50 % of the territory) and intermediate visions.

**Keywords:** Biodiversity, Bolivia, conservation, ecoregions, land use planning

## **Land Use Classification by Remote Sensing Techniques and GIS in the Tai Region Project on Hydrology (Côte d'Ivoire)**

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The investigation is part of the Ivorian and German cooperative project “Detection of water and nutrient pathways in a watershed in Western Côte d'Ivoire” (financed by the DFG/BMZ programme) which was initiated in April 2001.

Taking into account that the Côte d'Ivoire covers more than 50 % of the worldwide cocoa production and the Soubré region in the Western part covers 30 to 40 % of the Ivorian market the high agricultural and therefore human impact on the natural environment and especially the pressure on the Tai National Park is of major concern.

For this reason, the investigation site which is located in this area, evidently is dominated by cocoa and to a lower extent coffee cultivations. Land use and actual vegetation classification is done via two Landsat 7 ETM images taken in February and April 2001, groundcheck and GIS methods.

Results show that different regions between the National Park and the main traffic link (Gagnoa–San Pédro) can be identified. With increasing distance to the Park the small- and medium-scale cultivation areas of cocoa, coffee and annual crops (< 1 to 2 ha) are increasingly replaced by large-scale plantations of hevea and oil palms.

To cope with the problem of classifying smaller lots and/or identifying different cultures with similar reflectance, a summarizing analysis is striven for, which leads to the following classification: cash crops (above all cocoa, coffee, oil palm and hevea), annual crops by means of subsistence culture systems (maize, rice — rainfed and irrigation —, banana, manioc, yams, tarot, leguminoses, different spices and legumes), forest sites with further differentiation between primary, secondary and degraded forest and fallow.

**Keywords:** Côte d'Ivoire, GIS, land use classification, remote sensing

## **Influence of Land Use Systems on the Organic Matter Dynamics in the Upper Ouémé Catchment in Benin**

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This study analyses the influence of the land use systems on the organic matter dynamics. In the upper Ouémé catchment in Bénin, the villages of Dogué and Sérou were selected respectively according to two criteria: villages, with and without, land to clear. Four land use systems have been determined in each village: forests, fallows, cashew plantations and seasonal crops. Observations and quantitative data collection began in June 2001.

The litter production during the period June 01 – March 02 is higher in the Serou forest ( $6.8 \text{ T}_{\text{ha}}$ ) and in cashew plantations ( $4.0$  and  $3.5 \text{ T}_{\text{ha}}$ , respectively in Sérou and Dogué) than in the annual crop systems and in the fallow land. The litter production under forest and cashew plantations in Sérou was higher than in Dogué. In the former site, sandy soils result in quick water loss, increased litter fall and slow litter decomposition. On the contrary, in other systems like on fallow land or in the forest of Dogué, bush fires and the burning of the harvest residues destroy all the litter and recycle the carbon in form of gases into the air. The cashew systems as well as the forest of Sérou are carefully protected against the fire. During the study it has been found out that every year, the waste of biomass through burning is approximately estimated at  $3.2$  and  $2.6 \text{ T}_{\text{ha}}$ , respectively in Dogué and Sérou. Finally, the  $\text{CO}_2$  emission through the soil, which reflects the soil organic matter, was higher ( $13.9\text{--}17.1 \text{ kg}_{\text{ha h}}$ ) in the forest than in the other land use systems and was, in general, higher in Dogué than in Sérou (except in the forest).

Summary, the forest of Sérou as well as the cashew plantations in Dogué and Sérou can be defined as a  $\text{CO}_2$  sink. The  $\text{CO}_2$  emission through the soil under different land use systems was higher in rain season. The burning and deforestation are important factors of the  $\text{CO}_2$  emission in upper Ouémé Catchment.

**Keywords:** Biomass production, land use, soil  $\text{CO}_2$  emission, water use efficiency



## **Soil Survey and Evaluation of Agrochemical Implementation on Hydrology: the Tai Region Project (Côte d'Ivoire)**

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In the framework of the project “Detection of water and nutrient pathways in a watershed in Western Côte d'Ivoire” (financed by the DFG/BMZ programme) soil conditions and the implementation of agrochemicals have been surveyed from November 2001 to February 2002.

In Côte d'Ivoire cocoa farmers have increasingly implemented nonshaded suntolerant cocoa tree hybrids. These systems require a considerable input of agrochemicals and technical support. Cocoa diseases and pests are currently causing losses of an estimated third of the total cocoa crop yield.

The region of Soubré, within which the investigation site is situated, is dominated by cocoa cultivation. The above mentioned problems are of major importance for the local farmholders. Detailed soil profiles and complementary soil sampler samples show that the upper slopes are dominated by ferralsols with lateritic layers and high percentages of skeleton of more than 40 %. Light-brown Cambisols are found in the “bas-fonds” (inland valleys). Detailed results are given.

Interviews with local planters indicate no significant changes regarding the implemented agrochemicals, their application, treatment and techniques for the last three years. In addition, the results show that an amelioration of application amounts and techniques could be achieved.

Based on these data, an investigation of pesticide concentrations in soil water, groundwater and river water is carried out. Within the investigation site the applied substances area following: diazinon, endosulfan, lindan, methidathion, deltamethrin, propanil, paraquat dichloride, thiamethoxam and DDT. Included are the metabolites of alpha-, beta-, and endosulfansulfate, lindan (further HCH-isomers) and DDT (DDD, DDE). Pesticides are sprinkled twice a year, the main dose is given in July/August and a further in December/January.

**Keywords:** Agrochemical implementation, Côte d'Ivoire, soil distribution

## **A Preliminary Assessment of Characteristics and Long-Term Variability of Rainfall in Ethiopia — Basis for Sustainable Land use and Resource Management**

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Ethiopia had a long history of agricultural and meteorological drought during the last century, and is still suffering the same in many regions. The consequent agricultural crisis exposed Ethiopia to reoccurring famine vulnerability. For example, in 1984/1985 Ethiopia lost annual agricultural production of about a million tons. Nonetheless, the impacts of past climate variability on the agro-ecosystems, the land resource management and the agricultural development strategies were not satisfactorily addressed. The primary reasons being a lack of systematically documented baseline information on the characteristics and long-term variability of rainfall, and the absence of preliminary studies into these.

This collaborative project between the universities of Bonn and Cologne and different institutions in Ethiopia (for example the Ministry of Agriculture), sponsored by the Friedrich-Ebert Foundation, aims to fill this crucial information gap. The output of the study is expected to generate useful input material to plan future agricultural development, food security and sustainable resource management. The study focuses on the central highlands of Ethiopia (7°02'–11°46'N and 36°27'–40°12'E). Precipitation data from 1898–1997 were analysed. Basic statistical analyses were made, normality and representativity tests were done. Trend and persistence analyses were conducted. Irregularities were noted in the original data set, due primarily to the lack of systematically documented agro-meteorological data. Summer rainfall in the study area tends to decrease. Yet, extremely high rainfall was noted. The area was predominantly characterised by positive rainfall deviations from the long-term mean in the first and negative deviations in the second half of the 20<sup>th</sup> century. Agricultural crisis and extreme soil erosion in Ethiopia coincide well with historical lows of precipitation. Data management should be improved. Reliable agro-meteorological stations should be established, with reasonable spatial distribution. Water resource management measures and supporting policies should be thoroughly designed and strictly implemented to tackle the challenges of agricultural crisis. Future agricultural research should incorporate agro-meteorological research, to ensure efficient resource management and sustainable agricultural development.

**Keywords:** Central highlands, Ethiopia, land use strategies, long-term rainfall, resource management, statistics, sustainable development

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## **Methane Production and Emission from Rice Soils and Their Variations in Topsoils, Subsoils and Their Blend**

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The total annual emission of methane (CH<sub>4</sub>) is estimated to be 500 Tg y<sup>-1</sup>. The growth rate of CH<sub>4</sub> has, on average, been near zero during 1999 and 2000. While rice fields were identified as a source of methane, the intensity of methane release to the atmosphere depends on a number of factors including soil parameters. While CH<sub>4</sub> production potentials of topsoils have been studied in detail, the inherent production potentials of the subsoils and its comparison with the production potentials of the topsoils are lacking. A laboratory and a greenhouse experiment was conducted with three rice-growing soils from Luisiana, Maahas and Pila in the Philippines. Soil samples were collected from two layers, i.e. 0–20 cm (topsoil) and 30–50 cm (subsoil). Sub-samples of air-dried topsoil and subsoil were blended in 1:1 ratio and mixed thoroughly in a big plastic container using distilled water as dispersion media. Laboratory incubation and greenhouse study was carried out with these 3 combinations of soils (topsoil, subsoil and 1:1 topsoil:subsoil) for the all three different soils. IR-72 rice cultivar was used for the CH<sub>4</sub> emission study. Total N content of soil found to be a more reliable indicator than total C for CH<sub>4</sub> production from flooded rice soils. The trends of CH<sub>4</sub> production and emission rate were significantly different for the same soil. The amount of CH<sub>4</sub> emitted ultimately through the rice plant was almost 75 % less than what actually produced in the topsoil. The CH<sub>4</sub> peaks generally appeared late in presence of the rice plant. The CH<sub>4</sub> production and emission capacity of any soil went down with the depth and this was not only due to the reduced carbon content at lower depth soils but also due to other soil parameters like Fe, Mn and soil texture. The results indicate that methane emission can well be predicted from the CH<sub>4</sub> production potential of a soil, which will help to avoid the high labour, cost and time involved in the CH<sub>4</sub> flux measurement.

**Keywords:** Emission, methane, Philippines, production, soil properties, subsoil, topsoils

## **GARDEN: The New German Information System for Agricultural Research for Development, Environment and Nutrition**

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Recently the German research community for agricultural research for development (ARD) got its own web-based information system ([www.GARDEN-infosys.de](http://www.GARDEN-infosys.de)).

This system does not only focus on agricultural sciences but also includes environmental issues, nutrition and other related fields.

Its objective is to gather the nationwide scattered information and give central access to all relevant German internet sources. Thus it aims at creating transparency in German ARD, facilitate networking and coordination of research as well as further cooperation on national and international level.

The joint project of GARDEN-infosys.de emerged from a workshop of the German ministries BMVEL, BMZ and BMBF as well as DFG and BEAF. Started in 2001, it is supported by BMVEL.

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- **expert** database for individual online registration (password protected)
- German **funding** for research projects.

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their relevant data using the “Add ...” buttons on the various pages. You have the opportunity to present your institutions (website), research activities, news, events etc. to the wider public without any cost.

Since GARDEN-infosys.de is also part of the European Information System for ARD ([www.EARD-infosysplus.org](http://www.EARD-infosysplus.org)), German data will be displayed in both systems. In this way GARDEN-infosys.de supports the European efforts for innovations in agricultural research for development.

**Keywords:** Agricultural research, environment, German information system, nutrition, participation, services

## **Land Evaluation for Sustainable Highland Agriculture in NW-Thailand (PangMaPha) — With Special Respect to Soil and Water Resources**

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The population of Northern Thailand steadily increased in the last decades and levelled agricultural land is scarce. Consequently, agriculture increasingly shifts towards steep sloping land of the mountains. Furthermore, the increasing land and water shortage forces the farmers to shorten the traditional fallow periods more and more. These factors caused a trend towards declining site productivity and increasing food deficiency for the smallholding highland population. Maintaining productivity and creating technological options for development are therefore the most important issues to agricultural research. Greater efforts should be made to develop conservation strategies in accordance with the needs of the local people and to achieve stabilisation of tropical highland agro-ecosystems.

The objective of this research activity is to physically evaluate existing and alternative mixed cropping systems under special consideration of water availability and soils, in a mountainous limestone area. Potential contribution of different conservation strategies to improve the present slash and burn agriculture will also be evaluated. Additionally, opportunities and constraints of organic agriculture will be discussed. The project is an interdisciplinary activity and connected to the Special Research Programme 564 "Sustainable Land Use and Rural Development in Mountainous Regions of Southeast Asia"

The first step was to analyse the soil conditions of a representative area (Sopong) in the limestone environment, located in Mae Hong Son province. Physical and chemical soil parameters necessary for the crop evaluation have been either determined in the field or analysed at the Chiang Mai and Hohenheim Universities. In the limestone area hilltribe farmers have been interviewed concerning their farming system and related problems.

As a next step, a simple water balance model will be run with the examined soil physical parameters and real climatic data collected from the local meteorological service. Focus is on the identification of water stress periods. This modelling step is taking place in Hohenheim.

As final result these data provide the basis for a site and cropping system evaluation according to the parametric FAO/ITC Ghent approach.

**Keywords:** Highlands, land evaluation, mixed cropping, organic farming, soil fertility, water stress

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## **Session 2: Animal Husbandry and Welfare**

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# Subsession 2a: Animal Husbandry and Breeding

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## **Livestock Development for Rural Poverty Reduction: Issues and Options**

PERIN SAINT ANGE, A. SIHAMED

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1. Combating the causes of rural poverty is pivotal for global poverty eradication. This was expressed in the Millennium Development Goals (MDGs) which — if realised — would lead to the eradication of extreme poverty and hunger, promotion of gender equality, provision of universal primary education, reduction of child mortality and improved mental health, elimination of pandemic and other diseases, and ensured environmental sustainability.
2. Most of the rural poor reside in the marginal areas characterised by low soil fertility, rugged terrain, remoteness and poor infrastructure. These areas are drylands with low and erratic rainfall or wetlands with excessive rain, mudslides and eroded watersheds. The marginal and resource-poor areas could be flat plains or hilly and mountainous areas. The common feature of these areas is their vulnerability and inability to cope with natural or human induced shocks which depletes, erodes or threatens the livelihood assets of their marginalised populations.
3. The rural poor are economically insecure with low and unsteady resource availability and are very sensitive to the slightest changes in external factors. The rural poor are “functionally vulnerable groups” such as: smallholder farmers, landless, nomadic pastoralists, hired herders, ethnic minorities, indigenous people, artisanal fisherfolks, displaced refugees, or female / young / elderly headed households (IFAD: *The State of World Rural Poverty*, 1992; *The Rural Poverty Report 2001*; and *The Rural Poor: Survival or a Better Life* — WSSD, 2002). The livelihood of the poor can be sustainable if this can cope with and recover from stresses and shocks and can build or maintain its capabilities and assets. Most (75 %) of the 1.5 billion people living in extreme poverty are rural, and 66 % of them at least half of them (0.74 billion) depend completely or partially on raising livestock (THORNTON et al. 2002). The poor smallholders keep nearly one billion livestock. Livestock raising is one important activity which, if properly developed and sustained, could lead to the exit of the impoverished rural households from the poverty cycle.

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4. Livestock contribute to the sustainable livelihoods and security of the rural poor in many ways; as *Natural Capital* (meat, milk, wool, hide, rangeland, and pasture); source of *Financial Capital* (cash, saving, credit, insurance, gifts, remittance) and *Social Capital* (traditions, wealth, prestige, identity, respect, friendship, marriage dowry, festivity). Most of the rural women manage livestock and process livestock products. The elderly and the young participate in raising the small stock and therefore, become economically active members of the family labour force. Livestock offer the poor and poorer families sources of high quality nutrition especially for the pregnant women and for improving the cognitive skills and mental growth of the children. Also, livestock offer the smallholders and pastoralists low cost and efficient source of Animal Source Foods (ASF) from, otherwise, poorly utilised primary production. However, lack, insecurity or instability of resources and inputs keep livestock raising a “resource driven commodity” which can not respond to market demands in a competitive and sustainable way.
5. There are opportunities as well as weaknesses and threats which need to be kept in mind while attempting to research or invest in livestock development for rural poverty reduction. The increasing demand for livestock products in the developing countries, the global trend toward urbanisation, the rise in demand for cereal based feed, and shift in livestock production from temperate to humid areas are leading to the so called *livestock revolution* (DELGADO et al. — IFPRI/ILRI/FAO —, 1999,2001) where the livestock sector is projected to being the most important agricultural sector in terms of added value and land use (DE HAAN, C. et al. — The World Bank, 2001). The developing countries, where the majority of the rural poor live, are projected to be the most important contributors to this growing market. Such realities should stimulate stronger partnership among the development community (research, IFIs, governments) in order to support the developing nations to develop sound livestock sector strategies. On the other hand, addressing this huge shift in volume and locations of livestock production would require stricter environmental and public health regulations, and would entail the need for technological improvements which require long-term commitments and considerable financial and human resources (DE HAAN, C. et al. 1997). Furthermore, we must acknowledge that this rapid expansion of livestock development might “crowd out” the poor as economies of scale in production and marketing and inequitable application of environmental regulations will favour the larger units. In addition, there will be a shift in the functions of livestock as mechanisation replacing animal traction and inorganic fertiliser replacing manure. Moreover, and without pro-poor strategies aiming at increasing the capacity of the poor to improve productivity and efficiency and without measures and incentives to destock and restock their

herd and flocks, the rural poor will be not be able to cope with low and unsteady resource availability and will be the most effected by the negative aspects of the natural and economic changes. Beside the *potential serious equity effects* of this concentration, it might also lead to greater vulnerability to epidemic disasters (FMD, biological warfare, anthrax) and food safety. Both policy and technological research to ensure that the needs of poor livestock keepers are adequately taken into account is therefore required.

6. The earlier research and development projects focused on increased productivity and did not pay attention to sustainability of assets and resources and equity issues (SIDAHMED; IFAD -LRKB WebPage 2002). Attempts to support livestock development during the last 50 years were mostly through unsuccessful sectoral and large scale mega projects aiming at the alleviation of the production constraints (e.g. breed improvement to attain increased milk or meat yield or quality; improved feed conversion co-efficient; improved animal health) — (SIDAHMED, Eschborner Fachtage '99; IFAD/DANIDA. WB: GISLP under preparation). The second generation of projects featured complex and integrated rural development working in geographic enclaves which were not NRM oriented and did not care for biodiversity and environmental health of the resources as well as the local knowledge, household labour and food security.
7. These and other failed attempts and donor fatigue lead to the evolution of a new paradigm of pro-poor livestock development which takes into consideration all of the causes of poverty of the smallholder or the pastoralist. The development community realised that the focus on *technology driven* rather than *demand driven* programmes has limited the involvement of livestock producers in decision making and has impaired the capacity of the technologists to interact with the social and economic scientists. Also realised was the lack of vision about population dynamics (e.g. the Cattle Posts failed because the assigned areas could not hold the increasing number of people and their livestock); resource vulnerability; the need for incentives (marketing outlets, prices, etc); concern for food security; and concern for human health and wellbeing (e.g. current research on animal source foods in the diets of children in developing countries — GLCRSP — USAID, 2001). As a result a generation of new holistic and community-based livestock development has emerged recently. We believe that working with the poor and building broader coalition with a large scope of stakeholders is a step in the right direction.
8. Equally noted are the progressive linkages and complementarity between upstream (scientist managed) research and down stream (demand driven) research. One example of such a breakthrough is the development of a simple, inex-

pensive, heat-stable, and highly efficacious recombinant vaccine and a rapid diagnostic kit for rinderpest at the International Laboratory of Molecular Biology (ILMB) at the University of California Davis (YILMA, TILAHUN, et. al. published in Science, Nature/Biotechnology and others, 1988–2002). Both the vaccine and the test, tailored-made for developing countries, permit one to distinguish vaccinated from infected animals. This research is a true example of a problem driven research which was the intermarriage between grassroots field experience and advances in biotechnology.

9. Other examples are driven from IFAD's experience in supporting investment projects in the NENA region. First, the results of basic and applied research on barley and sheep breed improvement were tested in collaborative tasks involving the farmers and the scientists (ICARDA and the NARS). This was followed by funding investment projects which support community driven tasks where the farmers for example were engaged in the production of better quality sheep breeds or in community practices which assisted in reversing rangeland degradation (SIDAHMED; IFAD-LRKB WebPage 2002).

## The State of Poultry Production and Breeding Systems in Malawi

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Poultry production in Malawi is categorised into rural, smallholder subsistence oriented and urban, commercial oriented sectors. The rural poultry sector constitutes close to 80 % of the population, mainly found in rural areas. Poultry species consist of chickens (83 %), pigeons (14 %), ducks (2 %) and few turkeys and guinea fowls. Birds are raised in small flocks of one to 20 animals with mixed age-groups of local populations. Uses are multipurpose, ranging from food for human beings, sale for income and food shortage buffer, socio-cultural to asset and gender status functions. Despite their dominance in rural areas, local poultry are available in urban households. It is speculated that local poultry have a commanding proportion of the market in major cities. This observation is yet to be documented. Uncontrolled random mating is practised, which is often modulated by indigenous breeding practices. Major constraints include Newcastle disease that wipes out flocks during dry periods of the year, poor and extended growth and low reproductive potential with high chick mortality.

Commercial poultry production dominates in urban and peri-urban areas primarily for commercial broiler and layer production. Over 80 % of production is on small-scale backyard system in households of working class people. Batches of 100 to 500 broiler strains are common, with at most three batches per annum. The main employment is the capital source for such production, supplemented by short-term loans. Major constraints of layer production are poor management in terms of feeding and disease control, input and output market uncertainties that result in high chick (up to 37 %) and feed (over 80 %) costs and poor quality feeds. There is growing demand for poultry products due to urbanisation (human population grows by 4.5 % p.a.). Policies that will promote rural poultry production will also increase income contribution to the rural human population (76 % of the national population).

**Keywords:** Breeding, commercial poultry production, Malawi, rural poultry production

## Genetics of Growth Traits in Bolivian Llamas

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Llama breeding plays an important role in the High Andes of Bolivia, because of the extreme environment that limits the cultivation of any kind of crop plants. All products of llamas are used within the local community. The University of Hohenheim, Germany works together with the local NGO ASAR (Asociación de Servicios Artesanales y Rurales) and the Universidad Mayor de San Simón, Cochabamba, Bolivia and the University of Agricultural Sciences, Vienna, Austria, on a project with the aim of providing a comprehensive description of the system of llama keeping and investigating possible pathways for improvement.

Genetic selection is one way of improvement. Changes in performance achieved by selection are usually small but in contrast to other kinds of improvement they are permanent and cumulative. To evaluate the opportunities for genetic selection, phenotypic and genetic parameters for the traits of interest were estimated. Results presented here concentrate on such parameters for growth traits.

Two different types of llamas were distinguished. “Th`ampullis” are regarded as “wool-llamas” with notably higher fleece yields than “Kh`ara” which are assumed to be meat-oriented llamas with reduced fleece growth.

Growth curves for the two types for the five body measurements body weight (BW), height at withers (HW), body length (BL) chest circumference (CC) and abdomen circumference (AC) were described with the nonlinear Brody function  $y(t) = a * (1 - b * e^{(-k*t)})$ . Differences in the rate of maturing and size at maturity were found between females of the Th`ampulli and the Kh`ara types. The two sexes (only compared in the Th`ampulli type) showed also differences in rate of maturity and size. Heritabilities and genetic correlations were estimated using animal model procedures where all information came from mother-offspring relationships. Heritability estimates were 0.36, 0.27, 0.15, 0.09 and 0.11 for BW, HW, CC, BL and AC, genetic correlations varied between 0.55 and 0.94. Heritabilities and genetic correlations of body measurements are similar to estimates from other livestock species. This indicates that changes by genetic selection are quite easy. Given the high adaptive value of body size, care has to be taken regarding selective changes under the extreme environmental conditions of the High Andes.

**Keywords:** Body measurement, heritability, llama, weight



## **Organisation of Sustainable Breeding Schemes for Smallholder Dairy Farmers in the Highlands of Ethiopia**

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Development projects have been carried out to improve dairy cattle productivity in the Ethiopian highlands by introducing crossbred dairy cattle and by improved management. Farmers have become aware of the benefits from improved dairying: better income and nutrition. Thus, there is increasing demand for crossbred dairy cattle in the Ethiopian highlands. Crossbred dairy cattle have been produced mainly on government farms using local cows and imported semen. Heifers used to be distributed after confirmed pregnancy. Very recently upgraded bulls were also distributed for natural mating at village level. However, there is yet no active breeding programme for smallholder farmers that could sustain the dairy development efforts. The production and use of breeding bulls from on-farm performance tested cows could be an option for a sustainable breeding scheme under smallholder farmer conditions.

The objective of this work is to propose a sustainable breeding scheme based on a young sire programme in order to provide bull service for smallholder farmers in the Ethiopian highlands.

Ethiopian smallholder farmers are organised in peasant associations, the smallest administrative unit in rural Ethiopia. About 200 farmers form part of one peasant association, each of them keeping about two crossbred cows. A young sire breeding scheme is suggested as breeding scheme in order to improve and maintain the milk performance of the crossbred cows. To start such a programme bull dam candidates have to be identified by milk performance testing.

The mating service is supposed to be natural where one bull serves on average 40 cows. Setting a bull's useful life to be three years there is a need of about 4 bulls per peasant association and year. The number of bull dams needed per year is a function of the number of bulls needed per year, sex relation, survival rate, success of mating, pre-selection on morphologic criteria and period while using the cows as bull dams. Considering all these factors, about 11 bull dams per peasant association and year have to be provided. Milk performance testing in a reasonable extent has to be incorporated into the association's activities as well as vocational training for the farmers.

**Keywords:** Breeding scheme, dairy, Ethiopia, small holder

## **A Critical Reflection on Methodological Traditions in the Assessment of Animal Welfare with Relevance to Tropical Livestock Agriculture**

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Although different approaches in the assessment of animal welfare are established, the appropriateness of methods is still under debate. The adoption of animal welfare concerns to developing countries raises further questions. In view of a suitable local and global decision-making in the area of animal welfare based on a sound scientific argumentation, it is regarded to be helpful to receive deeper insight in scientific principles. The aim of the study, therefore, is to critically reflect on methodological traditions in the assessment of animal welfare. Regarding the term of animal welfare it is stated that welfare of farm animals is orientated towards both the physical and mental well-being of animals. There is an agreement about animals' subjective experience as a reference for the assessment of animal welfare. In addition, it is widely accepted that the concept of animal welfare involves also value judgements. The scientific assessment of animal welfare is mainly concentrated on measurements in relation to animals' physiology and behaviour. Contemporary science is grounded on the methodological tradition of the 17<sup>th</sup> century French philosopher René Descartes. According to this philosophy, the scientific research process is characterized by a subject-object-dualism rather than following an integrative view. Scientific knowledge must be based on objective facts. Mental processes in animals, as they are identified in the concept of animal welfare, are *per definitionem* no matter of scientific investigation. The assessment of values creates a problem when using conventional scientific methods. Values fall in the realm of ethics. Animal ethics emphasises moral standards on the treatment of animals and establishes norms for human conduct. In Western tradition, the justification of these norms is based on general principles or theories which claim universal validity. Since the applicability of Western ethical standards to other cultures is doubted, the view of ethical relativism is considered more appropriate. The relativist position holds that ethical standards depend upon, or are relative to, an individual's historical, economical, geographic and cultural-religious background. It is concluded that prevailing research traditions offer limited access to some elements of the concept of animal welfare. Additional reflection is required in the context of animals' subjective experience and the ethic-value-complex.

**Keywords:** Animal welfare, assessment, ethics, methodology, tropical livestock agriculture

## **Fencing and Sheltering Increases the Number of Marketable Lambs in Northern Patagonia, Argentina**

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Extensive sheep farming for wool production is the main form of agriculture in the arid and semi-arid plateaus of Patagonia, Argentina. The decrease of the world market wool price, lack of diversification and the low level of use of technology turned this system economically non-viable. Increasing the number of lambs for sale is an option to improve the economic situation. At the experimental station of INTA Bariloche, two management practices were evaluated to increase the number of marketable lambs: **1)** Closed grazing areas with electric fences during lambing season to improve the energy balance in pregnant and lactating ewes and protect the lambs against predators. **2)** Build sheds in this fenced paddocks to protect the newborn lambs. Six flocks were surveyed with a total of 1.264 sheep. On average the productive parameters observed were 53 % of lambs at marking time (three months age), 7 % of adult mortality and 20 % of lamb mortality. Fences were introduced on a smallholder farm (300 sheep). After 4 years of observations marking increased steeply to 83.3 %, the lamb mortality was reduced to 3 % and the adult mortality to 4 %. The number of saleable lambs projected from year 9 onwards was 3.8 times higher than without fences. The number of culled animals increased to 59 % and wool production decreased to 4 %. The cost-benefit ratio using 7 % interest rate was 3.28 and using 25 % interest rate was 2.36. Inside the fenced paddock, using sheds did produce significantly ( $p < 0.003$ ) more lambs than without sheds. The additional gain can be expressed as a cost-benefit ratio, which was 1.53 and 1.14, using 7 % and 25 % of interest rate, respectively. Concluding, fencing and sheltering decrease lamb mortality and increase small farmers' net income.

**Keywords:** Electric fences, lamb mortality, Patagonia, sheds, sheep

## **Doe Productivity of Kacang and Peranakan Etawah Goats and Factors Affecting them in Indonesia**

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Indonesia is situated between the 6° and 11° north latitudes and 95° and 141° east longitudes. Temperature 23–31 °C daily in the low plains and 18–27 °C in the lower plateau. Indonesia consists of 17.000 islands, land area covers 1.8 million km<sup>2</sup>.

In Indonesia nearly 99 % of small ruminants like goats and sheep are found with smallholders. The contribution of goats for income is substantial.

The major breeds of goat in Indonesia are the Kacang (indigenous) and Peranakan Etawah. Kacang is a local breed of goat, relatively small, compact body frame, erect ears and short horns. Peranakan Etawah goats descend from crossings between the Kacang with Etawah (Jamnapari) goats. Known as PE goats, are distinctly different from Kacang goats with a larger body frame, long hanging ears, convex face and larger horns.

This study aims to ascertain the level of productivity of PE and Kacang goat, and to identify factors affecting production level under a Village Production System.

The study commenced in 1999 and finishes in 2002. Records of 280 (PE) and 200 (Kacang) does have been kept by smallholders at Purworejo and Grobogan. Parity, birth type, litter weight at birth, litter weight at weaning (of doe) and birth weight, growth rate till weaning, weaning weight, body scoring and leg conformation index (of kid) were examined. The data were analysed with a general linear model.

The curves are similar to the findings of ANGGRAENI et al. (1995) and SODIQ (2000, 2001) who recorded mortality rate till weaning at less than 10 %. Birth type of PE and Kacang goats were affected by parity. Kidding difficulties was not affected by parity, birth type and litter weight. Birth type, weight at birth and weaning, and growth rate till weaning were affected by parity, birth type and sex.

**Keywords:** Goat production, Indonesia

## Goat Husbandry for Extensive Use

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Most goats are mainly kept in the Tropics and Subtropics by a poorer population for subsistence reasons.

Marginal locations for goat husbandry are often determined by geographical and climatic location. Arid and semi-arid areas, low feed quality and small supply, areas with increased risk of illness, topographically difficult locations, little know-how and an extensive production orientation characterize these locations.

For successful husbandry choosing suitable stock is important. According to their genetics, the breeds and their capacity should be adapted to the climate and marginal supply of feed.

The aim of this goat breeding programme is to achieve a breed by crossing for extensive production with:

- a good breeding capacity
- robustness, weather hardiness and resilience
- an adequate muscle build
- good, frugal feeding capacity

Three breeds were chosen: German Alpine (good milk capacity), Boer (good meat capacity) and Cashmere goat (robustness and good fibre capacity).

The crossing programme is now in its final phase. One aspect is the surveying of the breeding capacity and robustness of the final breeding group (third generation) to record the current breeding level.

Productivity and robustness are basically the most important quality characteristics.

Endoparasites are one of the most prevalent causes of small ruminant losses. The costs caused by this are immense. Infestation with various Trichostrongylidae cause the main losses.

Parasite resistance and/or other illnesses are important for economic and ecological reasons. Due to reduced or non-use of anthelmintika grazing areas are less burdened or not burdened at all by faecal residual substances.

**Keywords:** Extensive husbandry, goat, landscape management

## Effect of Crossing Indigenous Awassi Sheep Breed with Mutton and Prolific Sire Breeds on Growth Performance of Lamb in Jordan.

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The objective of this study was to evaluate the effect of crossing on body weight and growth ability of lambs from birth to weaning, including the effect of litter size, sex, dam age, dam weight at mating, dam weight after lambing and year of rearing.

The study was carried out on the Awassi sheep flock and their crossbreds with the breeds Charollais and Romanov maintained at the Agriculture Centre for research and production at Jordan University of Science and Technology, Irbid.

In the years 1999 and 2000 the live weight was determined in 192 lambs (70 Awassi, 63 Awassi × Charollais F1 crossbred and 59 Awassi × Romanov F1 crossbred) at birth and subsequently every fortnight until weaning by weighing on digital scales with accuracy of 0.1 kg. Average live weight of lambs at birth was  $4.20 \pm 1.15$  kg and at the age of 15, 30, 45 and 60 days  $8.72 \pm 2.12$  kg,  $12.12 \pm 2.77$  kg,  $15.50 \pm 3.70$  kg and  $19.27 \pm 4.59$  kg, respectively. ADG of lambs from birth until weaning was  $248 \pm 0.07$  g.

Genotype of lambs, litter size affected ADG, live weight of lambs at birth, 15, 30, 45 and 60 days significantly ( $p \leq 0.05 - 0.001$ ).

Investigation of the effect of sex on live weight of lambs at birth and at 60 days showed that the differences between males and females were statistically significant ( $p \leq 0.05 - 0.01$ ). Differences in ADG and live weight at 15, 30 and 45 days according to dam age were significant ( $p \leq 0.05 - 0.01$ ).

The effect of dam weight at lambing on ADG, live weight of lambs at birth, at 45 days of age and until weaning was not confirmed. Regressions of BW, ADG and weight at 15, 30, 45 and 60 days age of lambs on dam weight after lambing were significant ( $p \leq 0.001$ ).

Likewise, live weight of lambs at birth, ADG until weaning and live weight at 15, 30 a 45 days of age were affected by the seasons of lambing ( $p \leq 0.01 - 0.001$ ).

**Keywords:** Awassi, Charollais, crossing, growth ability, Romanov, sheep, systematic effects

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## **Heritability Estimates of Protein %, Fat %, Lactose %, Non Fat Solids and Total Solids of Dairy Cattle in Northern Thailand**

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Heritability is the ratio of additive genetic variance to phenotypic variance. The possible range of values for heritability is 0 to 1.0, because additive genetic variance is a part of phenotypic variance. Phenotypes are measured traits influenced by genetic and environmental effects. The higher the heritability the greater the genetic control on the trait, and the more rapidly selection will result in genetic progress. Fat, protein and milk yield as well as size of the individual have high heritabilities. Fertility has low heritability. This research estimated the heritability of protein %, fat %, lactose %, non fat solids and total solids in 530 dairy cows with the lactation days ranging from 1–400 in Chiangmai, Chiangrai and Lamphun Province. The animal model BLUP was used and the fixed effects were herd-year, season and % of Holstein Friesian while the covariable was days in milk.

The results revealed that mean, standard error of mean and variance of protein % were 3.22, 0.028 and 0.42; of fat % were 4.41, 0.098 and 5.07; of lactose % were 4.66, 0.017 and 0.15; of non fat solids were 8.55, 0.024 and 0.29 and of total solids as 12.96, 0.096 and 4.88 respectively. The additive genetic variances of protein %, fat %, lactose %, non fat solids and total solids were 0.041, 0.130, 0.022, 0.036 and 0.963 respectively. The residual variances of protein %, fat %, lactose %, non fat solids and total solids were 0.079, 0.212, 0.069, 0.238 and 2.736 respectively. And the heritability of protein %, fat %, lactose %, non fat solids and total solids were 0.342, 0.379, 0.238, 0.133 and 0.260 respectively.

**Keywords:** Dairy cattle, heritability

## Variation of Skin Colour among Holstein Friesian Cows of Northern Thailand

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In Northern Thailand there is an increase in the replacement of the heat stress adapted indigenous Thai cattle with improved breeds through crossbreeding with Holstein Friesian from temperate climates. The result is a tendency to a dairy cattle population with more dark skin colour. Friesian cows with dark skins may have more difficulties to adapt because of the high humidity and temperatures. The percentage of black and white skin colour in Holstein Friesian cows influences milk production. The black skin absorbs more environmental and solar radiation while the white reflects more. This predisposes black cows to more heat stress. Climatic stress especially from heat and solar radiation decreases milk production, changes milk composition and lowers reproductive performance. Therefore the skin colour is of importance to dairy farming as it may cause significant economic losses. The objective of this study was to determine the distribution of dark skin colour among 2,107 Friesian cows in Chiangmai, Chiangrai and Lamphun Provinces. The area of distribution of white and black coloured patches on the entire body was measured.

The results revealed a wide variation in skin colour. The white colour had a mean distribution of 27 % ( $\pm 0.65$  standard error), variance of 885.11, skewness of 0.96 and a median of 15 %. Most of the cows had larger black than white coloured skin areas. In 50 % of the cows, the white coloured skin areas covered less than 15 %. The results suggest that the present Holstein Friesian population of Northern Thailand may not be well suited for this environment and should be investigated for heat stress.

**Keywords:** Holstein Friesian, skin colour



## Effect of Sires and Raising Areas on Body Weight of Holstein Friesian Cows in Northern Thailand

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The government of Thailand supports dairy development in northern districts of Chaiprakan and Maeon. Chaiprakan district is a mountainous area with lower temperatures than in Maeon district. There are now around 128 smallholder dairy farms in Chaiprakan district and 120 in Maeon district of less than 10 cows and both districts are supplied with semen for artificial insemination from the same source. It is not clear however, whether the different district environments are constraining dairy production because the two areas have differences in management, feeds and temperature. Underweight dairy cows have been observed and there are allegations that sires or environment may be the cause. The objective of this research in Maeon and Chaiprakarn districts, Chiangmai Province was to evaluate the effect of raising area, sires and their interaction on body weight of 298 Holstein Friesian cows. The cows were offspring of 17 different sires and of varying age.

There were no differences ( $p > 0.05$ ) in body weights of cows bred from the different sires. The raising area (Maeon and Chaiprakan districts) affected total body weight. Cows raised in Chaiprakan district had significantly ( $p < 0.05$ ) higher body weights than cows raised in Maeon district. The mean and standard error of body weight of cows from Chaiprakan and Maeon district were  $415.65 \text{ kg} \pm 4.07$  and  $382.72 \text{ kg} \pm 4.57$  respectively. There was no interaction between sires and raising area on body weight ( $p > 0.05$ ). These observations suggest that the environmental factors in Chaiprakan district are more favourable for dairy cows than in Maeon district. Maeon district factors are constraining genetic performance.

**Keywords:** Environmental effects, Holstein Friesian

## **A Comparative Study of Thai Native Chicken and Broiler on Productive Performance, Carcass and Meat Quality**

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A study of productive performance, carcass and meat quality of Thai Native chicken (N) and Arbor Acres broiler (B) was conducted using a completely random design. The native chicken were fed ad libitum with commercial layer diet and the broiler a commercial broiler diet. All chickens were slaughtered at market size, the slaughtered weights of N and B were around 1.2 and 1.9 kg respectively. Carcass and meat quality of the two different chicken breeds were investigated. The results showed that body weight at 0–6 weeks, average daily gain and feed intake at 0–2, 2–4 and 4–6 weeks of N were less than those of B ( $p < 0.01$ ). Furthermore, feed conversion ratio at 0–2 and 2–4 weeks of N were higher than of B ( $p < 0.01$ ) but there was no significant difference at 4–6 weeks. The mortality rate of B was higher than of N ( $p < 0.05$ ) at 0–2 and 2–4 weeks, however, at 4–6 weeks there was no significant difference. The feed cost per kg gain of N was higher than of B ( $p < 0.01$ ). Among carcass characteristics the dressing percentage of N was less than of B ( $p < 0.05$ ), in contrast, the percentages of retail cuts in terms of thigh and Pectoralis Minor of N were higher compared to B ( $p < 0.05$ ) as well as wing ( $p < 0.01$ ) and drumstick ( $p < 0.05$ ). There were quite similar percentages of internal and external organ. The indirect meat quality in terms of pH value and cooking loss percentage was higher in the case of B ( $p < 0.05$ ). However, thawing loss, drip loss and nutritive value showed no significant difference between the groups. Meanwhile, L and b values of B were higher than N ( $p < 0.01$ ). The shear value of N in terms of maximum shear force (N), energy (J) and distance (mm) had higher values compared to B ( $p < 0.01$ ).

**Keywords:** Broiler, carcass, meat, native thai chicken, productive performance

# Subsession 2b: Livestock Production and Nutrition

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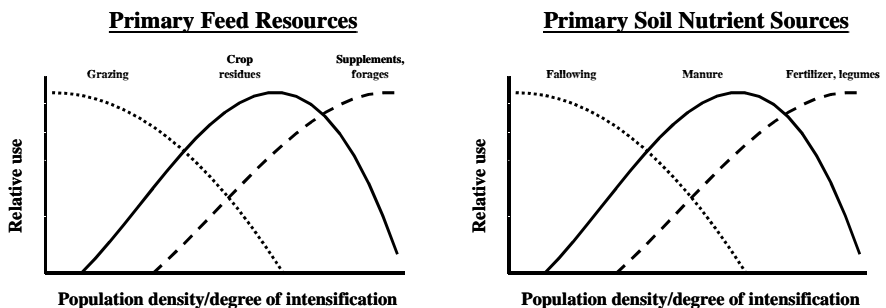
## Livestock Systems and Nutrient Cycling

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Agricultural production systems in developing countries are evolving in response to growing demographic pressure. At low population densities crop and livestock production are specialized and based on low-input, low-output strategies. As population density increases and systems intensify, rural livelihoods increasingly depend on integration of land cultivation and livestock rearing. In mixed farming systems livestock enhance food security, provide a source of cash and draught and play a key role in recycling nutrients to sustain crop production. Integration of crop and livestock production is thus a mechanism to cope with risk and to intensify agriculture through more efficient use of labor and farm organic resources. At very high population densities the systems revert back to specialization and depend more on high-input, high-output strategies. This evolution trend is driven primarily by market demand and is mediated by labor availability, use of production enhancing technologies, such as using external sources of nutrients (fertilizers, feed supplements) and more efficient nutrient management. Analysis of case studies of agro-pastoral systems in the Sahel and crop-dairy systems in Eastern Africa under different levels of intensification suggests that as population density increases and systems intensify, soil nutrient management and livestock feed use are closely related and follow the following general pattern:



In nutrient-deficient systems manure is crucial to maintenance of soil fertility and crop production. In such systems, policy, institutional and technical options are required to improve access to inputs and outputs markets, increase productivity and revert nutrient depletion trends. In systems with nutrient surplus, manure becomes a polluting factor and therefore production efficiency should be improved while decreasing the emission of nutrients to the environment.

**Keywords:** Crop-livestock systems, livestock systems, nutrient cycling

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## Characterisation of Smallholder Pig Production Systems in Mountainous Areas of North Vietnam

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Situation of farmers in Vietnam's mountainous areas is hampered by low and unsteady resource availability and less developed infrastructure. Smallholders seek to improve their livelihood by extending livestock husbandry with main focus on pig keeping. Local pig breeds are progressively replaced by genotypes with higher production potential. Keeping high-yielding genotypes may generate higher revenues from pig production but also mean an economic risk for farmers due to higher input required. This study assesses the suitability of local pig breeds/ introduced genotypes for smallholders in different production systems. Pig production intensity, farmers' production aims and management strategies are described. Reproductive/ productive performances of genotypes are recorded. Output from pig production is determined and production efficiency is calculated under different input scenarios. Data collection is carried out in two research periods (1/2001 to 7/2001; 1/2002 to 8/2002) in North Vietnam, Son La province. Four selected villages of ethnic Black Thai cover a gradient from semi-intensive pig production in the mountain valley, near-town to extensive pig production at the hillside, far from town. Research methods include structured household interviews, communication tools (from RRA methodology), recording production/ reproduction data and weighing pigs. Preliminary results show that near town farmers keep the introduced Mong Cai pig with relatively high performance ( $11.2 \pm 2.7$  piglets/litter,  $1.8 \pm 0.7$  litters/year; ADG of crossbred piglets  $190 \pm 80$  g/day). The more market-oriented pig production returns a high cash revenue ( $6.0 \pm 4.3$  million VND/year = 402 USD), but requires higher production costs. Far from town, pig production fulfils mainly social functions. Farmers keep the local Ban pig with low performance ( $7.3 \pm 1.5$  piglets/litter,  $1.2 \pm 0.3$  litters/year; ADG of purebred piglets  $70 \pm 60$  g/day) and yield a low cash revenue ( $1.6 \pm 1.1$  million VND/year = 104 USD), however, have lower production costs. Data analysis yielded factors influencing production efficiency and variation of productive/ reproductive performances on-farm. The results are prerequisites for the setup of on-farm performance testing and thereby for the determination of production efficiency of different pig genotypes in the production systems investigated.

**Keywords:** Local breed, on-farm, pig, productive performance, small holder farming

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## **Indigenous Characterization of Local Camel Populations and Breeding Methods of Pastoralists in Northern Kenya**

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Dromedaries provide nomadic livestock keepers in Northern Kenya with the mobility they need and milk for their daily diet. Because of their high adaptability, camels (*Camelus dromedarius*) are particularly suited for areas with seasonally varied forage supply and a high production risk due to recurrent droughts. In the past the characteristics of local camel breeds, which are named after the ethnic groups of their owners, were described only superficially. Knowledge on characteristics of local camel breeds and indigenous breeding methods is a prerequisite for the understanding and development of means to improve the pastoral system of camel keeping. Therefore the aim of this study was to record the indigenous characterization of local camel breeds and the breeding methods of Rendille and Gabbra pastoralists.

Both, open and structured interviews were conducted with 20 Rendille and 23 Gabbra pastoralists. The results comprised the two main areas indigenous characterization of local breeds and pastoral breeding methods and are as follows:

The Rendille and the Gabbra categorise camels of their own local breed into different types. These types are determined by a certain combination of characteristics: **a)** low drought tolerance and high milk yield but only in the rainy season and; **b)** moderate drought tolerance and moderate milk performance throughout the year; **c)** high drought tolerance and low milk yield. The categories are also reflected in the breeding concept: In view to breeding, a herd with an ideal proportion of the various types is considered more important than breeding towards one ideal camel with specific characteristics. Hence there is no single breeding aim. Combination of animals with different characteristics in the herd, and splitting up these animals to stationary and mobile camps reduces risk for the camel keepers.

The study shows that pastoralists in Northern Kenya have a comprehensive knowledge of camel breeding. The herewith recorded indigenous knowledge gives an insight in breeding-redundant concepts of pastoralists, in marginal areas under high risks. Breeding strategies that have proven to be suitable for these areas should be included in the set-up of modern breeding programs, that aim at dynamically maintain and further develop local breeds.

**Keywords:** Breeding methods, breeds, dromedary, indigenous characterization, indigenous knowledge, local camel populations, pastoralists, pastoral system

## **Lifetime Under-Nutrition and Lactation Performance of Zebu and Zebu × Holstein Cows in the Tropics**

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Insufficient feed supply is a major limiting factor for milk production in the tropics. The aim of this study was to assess the effects of feeding level on live-weight and performance of Zebu (Boran) and crossbred (Boran × Holstein, 50–75 % Holstein) lactating cows.

Twenty-four heifers of each breed 20 to 36 months of age were allocated to three feeding levels (1.0, 1.2 and 1.4 times of maintenance energy requirements) until the end of the second lactation. The results of the two lactations are reported here. The diet consisted of grass hay and wheat bran in a ratio 2:1. A mineral block and water were given ad libitum.

In both lactations, increasing feeding level resulted in higher daily milk yields by crossbred but not by Zebu cows. Milk composition was not affected by level of nutrition. However, the milk of Zebu cows contained more fat, protein and solids than that of crossbred cows. Average live-weights during lactation increased with feeding level in both breeds but the response was higher in crossbred cows. However, the effect of feeding level on weight changes during the lactation was not significant. Lactation length significantly differed between genotypes. Zebu cows ceased producing milk at less than 250 days after calving whereas crossbred cows had more than 300 days of lactation. The calving interval did not differ between genotypes. Compared to the first lactation, live-weight and milk yield were maintained and lactation length slightly decreased in the second lactation.

These results suggest that the response to increased feeding level of crossbred cows is higher than that of Zebu cows. Therefore, crossbreeds would be an appropriate option in those areas where more and better quality feed can be produced and with access to milk markets.

**Keywords:** Boran, calving interval, crossbred, dairy, Ethiopia, lactation length, lifetime, milk, performance, tropics, under-nutrition



## Intake, Digestion and Duodenal Nitrogen Flow in Sheep Fed Tropical Diets Supplemented With Fruits of *Sapindus saponaria*

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Suppression of ciliate protozoa is known to increase the flow of microbial protein from the rumen to the duodenum thus possibly improving nitrogen utilization. The incorporation of saponin-rich fruits from *Sapindus saponaria* into tropical ruminant diets may suppress rumen protozoa population. However, little information is available on its effects on nitrogen utilization and it is unknown whether these effects are depending on the quality of the basal diet or not. Thus an experiment was carried out to study the influence of *S. saponaria* on intake, digestion and duodenal N-flow in sheep fed two diets of contrasting quality (a grass-only and a grass-legume diet) using *Brachiaria dictyoneura* and *Cratylia argentea*. Both diets were fed either without supplementation or with fruits of *S. saponaria* (8 g/kg BW<sup>0.75</sup> per day) directly introduced into the rumen through fistula.

Intake was higher with the grass-legume diet than with the grass-only diet ( $p < 0.001$ ). The administration of *S. saponaria* had no effect on forage intake, and interactions of basal diet and *S. saponaria* on intake were insignificant. Interactions ( $p < 0.05$ ) were observed with digestibility. *S. saponaria* reduced DM and NDF digestibility in the grass-only diet but not in the grass-legume diet. Ciliate protozoa were not affected by the diet type and were increased by *S. saponaria* ( $p < 0.01$ ). Higher amounts of total N (+55 %,  $p < 0.001$ ) and bacterial N (+30 %,  $p < 0.05$ ) reached the duodenum when the legume was fed. The supplementation with *S. saponaria* tended to increase total N flow (+18 %,  $p < 0.1$ ) and significantly increased bacterial N flow (+36 %,  $p < 0.01$ ) to the duodenum. Apparent N absorption was increased when the legume was fed (+48 %,  $p < 0.05$ ) but was unaffected by the supplementation with *S. saponaria* ( $p > 0.05$ ). Interactions of forage quality and *S. saponaria* on nitrogen intake, digestibility and duodenal N-flow were insignificant.

These results indicate that the supplementation with fruits of *Sapindus saponaria* increases bacterial nitrogen flow to the duodenum independent of the quality of the basal diet. It is interesting to note that this was occurring even though the rumen protozoa counts per ml of rumen fluid were not suppressed.

**Keywords:** Duodenal nitrogen flow, rumen protozoa, *Sapindus saponaria*, saponins

## Use of Lemon Grass Oil as Feed Additive in Weanling Pigs Diets

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The experiment was conducted at Chiang Mai University to determine the use of lemon grass oil as additive in weanling pigs. Piglets after weaning at the age of 28 days were randomly selected and distributed into 5 groups of 6, 4, 5, 4 and 4 animals. The piglets were housed in individual cages. Diet 2 (control diet) was a basal diet containing corn-soybean meal. For Diet 2 the basal diet was supplemented with 0.75 g tetracycline/kg diet. Diets 3, 4 and 5 were basal diets supplemented with lemon grass oil at 1, 2.5 and 5 ml/kg diet respectively. A completely randomised design (CRD) was used. Diets were formulated according to NRC (1998) requirements. The productive performance and faecal characteristics of the pigs were determined beginning at  $7 \pm 0.8$  kg BW until  $20 \pm 0.8$  kg BW. Average daily gain (ADG) and feed conversion ratio (FCR) of pigs fed diet 1 to 5 were 420, 390, 330, 320 and 380 g/d and 1.89, 1.88, 1.81, 1.87 and 1.73, respectively. There was no significant difference of ADG among treatments. The inclusion of lemon grass oil at 5 ml/kg diet tended to improve FCR of piglets. The pigs fed the control diet had higher average daily feed intake (ADFI) ( $p < 0.05$ ) than pigs fed diets containing 1 and 2.5 ml/kg diet of lemon grass oil (diets 3 and 4). There were no differences ( $p > 0.05$ ) in ADFI of pigs fed diets containing lemon grass oils (diet 3, 4 and 5). The faecal score (shape and colour) of the pigs fed diet 4 and 5 was better than in pigs fed other diets ( $p < 0.05$ ). It was concluded that lemon grass oil can substitute tetracycline as feed additive.

**Keywords:** Lemon grass oil, productive performance, weanling pig

## **Performance of Growing Broiler Chicks Fed Bambara Groundnuts (*Vigna subterranea*)**

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### **Introduction:**

The lack of sufficient animal protein in human diets in the tropics could be attributed to the high cost of animal production. This cost could be reduced by using unconventional plant protein sources for livestock feeding. Bambara groundnut is one of such sources. Bambara is a legume, which grows in the tropics and subtropics. Its nutrient content (CP—22 % DM, starch—30 % DM, EE—9 % DM, GE—19 MJ/kg DM) necessitates its experimentation as livestock feedstuff. Experiments were therefore designed to test its performance on growing broilers.

### **Method:**

120 12-day old broiler chicks, kept in individual metabolic cages, were used in 2 experiments. In the first experiment, 50 were equally allotted into a control (no bambara) and 4 experimental groups (about 20, 40, 60 and 80 % crushed bambara (3 mm) inclusion level diets). In the second, 70 chicks were allotted to a control and 6 experimental groups, comprising of about 20, 80 and 100 %, normal and autoclaved bambara. The control diets contained Soyabean meal, wheat and Soyabean oil, mixed in proportion conforming to the CP, EE and GE in bambara. Diets were balanced for amino acids, vitamins and minerals. All diets were isoproteinous, isoenergetic. Feed and water were provided ad libitum. Each experiment lasted 15 days. The metabolisability of energy and nutrients were determined by use of a marker (TiO<sub>2</sub>).

### **Results:**

There was no significant difference in Feed intake. There were significant drops in weight gain and FCR when the inclusion level exceeded 60 % and 80 % respectively. Birds fed bambara as sole feed performed more than 75 % of the control. Autoclaving brought no significant improvement in performance. ME showed a decreasing tendency with increasing bambara. OM retention decreased steadily with increasing bambara. Autoclaving tended to improve OM retention.

### **Conclusion:**

Bambara, up to 60 % inclusion level, shows a great potential in broiler ration and if the price of bambara is considerably lower than other organic feeding components in a feed, then bambara stands ideal to be used as a sole feed in the tropics and subtropics. It may alleviate the problems caused by the competition between man and his animals for the conventional food / feedstuff.

**Keywords:** Bambara Groundnut, broilers, FCR, livestock, nutrient retention

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## Effect of Vitamin C Supplementation on Performance of Broiler Chickens in Cambodia

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The hot and wet climatic conditions in the tropics limit the high performance and survival of broilers in these regions. In Cambodia heat stress in broiler is experienced nearly all year round, but is more pronounced in the transition period from hot to wet season. An experiment was conducted in the Animal Experimental Station of the Royal University of Agriculture, Cambodia, from June 15 to July 27, 2001, to determine the effect of Vitamin C supplementation on the productivity of broiler chickens. 270 day-old chicks of initial weight  $44.49 \pm 3.23$  under a completely randomised design were divided into 3 groups with three replications and reared on deep litter rice husks for 42 days. All birds were fed a balanced broiler diet ad libitum, however, group A (the control group) received normal drinking water while group B and C were supplemented with Vitamin C dissolved in drinking water at levels of 20 mg and 40 mg/bird and day respectively. Average weight gains of groups A, B and C of  $1281.64 \pm 47.4$ ,  $1401.18 \pm 51.7$  and  $1511.87 \pm 46.8$  respectively were significantly different ( $p < 0.01$ ). There were no significant differences in feed consumption among groups ( $p > 0.05$ ). However, feed conversion ratios of A ( $2.22 \pm 0.01$ ), B ( $2.11 \pm 0.01$ ) and C ( $2.04 \pm 0.01$ ) were significantly different ( $p < 0.01$ ). The broiler mortality was highest in A (8.9 %), followed by B (5.6 %) and lowest in C (2.2 %). It was concluded that supplementation with Vitamin C at 40 mg/bird and day in drinking water reduces the impact of heat stress and improves the productivity of broilers under the environmental conditions of Cambodia.

**Keywords:** FCR, growth rate, heat stress, mortality, supplementation, Vitamin C

## Effects of Microbial Phytase and Citric Acid on Utilization of Phytate Phosphorus and Growth of Chicken

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Improving phosphorus utilization has become increasingly important to reduce P-pollution from intensive animal production. The objective of the current experiments were to determine supplementation effects of microbial phytase in combination with citric acid in the presence of different activity of native phytase. A total of 360 day old chicks was used in growth experiments between 3–38 d (180 chicks) and 7–42 d (180 chicks), fed corn soybean meal (CSM) and wheat soybean meal (WSM) diets respectively. The corn and the wheat subjected to hydrothermal treatments with steam addition (100 °C for 10 minutes) and mixed in the diets of T<sub>1</sub> and T<sub>2</sub>. All the diets (control, T<sub>1</sub> and T<sub>2</sub>) were supplemented with 500 U/kg of microbial phytase (SP-1002ct) and applied in pelleted form. A mixture of citric acid:Na-citrate (1:1, w/w) was added (30 g/kg) to diet T<sub>2</sub>. The total phosphorus content of the diets was equal to 4.5 g P/kg and all diets were deficient in available phosphorus (1.5 g/kg).

Average daily gains were 36, 34 and 45 g/d (CSM) and 54, 46 and 55 g/d (WSM). Total phosphorus depositions were 5.75, 5.36 and 6.99 (CSM) and 8.15, 6.90 and 7.77 g (WSM) for control, T<sub>1</sub> and T<sub>2</sub> respectively. The results indicate that inclusion of citric acid in CSM-diet with a low activity of native phytase increased growth and P-deposition significantly. In WSM-diets, the heat treatment of the wheat reduced the native phytase activity dramatically. This effect was not completely compensated by phytase addition, but after application of additional microbial phytase and citric acid. It can be assumed that hydrothermal treatment of wheat resulted in a change of solubility of pentosans and antinutritive effects could influence the results.

Conclusion is that citric acid (30 g/kg) has an influence on the efficiency of microbial phytase during degradation of phytates in poultry. Further experiments are needed to clarify if these observations are effects of acidification, changes of solubility of phytates during passage of GIT and/or other conditions affecting the efficiency of supplemented microbial phytase.

**Keywords:** Citric acid, hydrothermal treatment, phosphorus pollution, phosphorus utilization, phytase, poultry

## Effect of Soybean in Milk Replacers on Veal Calf Performance

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In Thailand, feeding of veal calves with milk is expensive. The cost of production can be reduced by using milk replacers. A low cost and high quality plant protein milk replacer could be produced from soy bean which is readily available in Thailand. The objective of this study was to compare the performance of veal calves produced with three different milk replacers. 18 Holstein Friesian Crossbred (75 %) calves with an initial average weight gain of 30 kg were under a completely randomised design (CRD) allocated to 4 groups. Group 1 (control) received whole milk, group 2 milk replacer based on milk protein, and group 3 and 4 milk replacers with 5 and 10 % soybean protein respectively. The calves were fed 10 % of body weight (2 times a day). Weight was recorded every 2 weeks until 120 days of age.

There were no significant differences ( $p > 0.05$ ) among groups 1, 2, 3 and 4 in average total feed intake (789.1, 727.4, 649.5 and 636.4 kg, respectively) and feed cost per kg weight gain (111.5, 117.8, 148.2 and 97.3 bath/kg weight gains, respectively). The groups reached final weight gains of 70.3, 45.4, 31.5 and 33.7 kg respectively. Weight gain of group 1 tended to be higher ( $p > 0.05$ ) than of group 2 and was higher ( $p < 0.05$ ) than for group 3 and 4. Average daily gain (0.586, 0.388, 0.243 and 0.294 g/day), feed conversion ratio (11.94, 15.86, 17.04 and 17.98) and feed efficiency (8.76, 6.31, 5.87 and 5.60) of groups 1, 2, 3 and 4 were significantly different. Group 1 was better than the other three groups ( $p < 0.05$ ).

It was concluded that veal production with fresh milk gave better production performance than with milk replacer in terms of weight gain, ADG, FCR and FE. But feed cost per kg weight gain was not different.

**Keywords:** Milk replacers, soybean protein, veal calves

## **Growth Performance, Rumen Fermentation and Blood Constituents of Goats Fed Diets Supplemented with Bentonite**

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Fifteen male Angora goats with an average body weight of 12.9 kg were randomly assigned to three groups of five kids each in an 84 days' growth experiment. Animals were kept in semi-opened pens rations that consisted of concentrate mixture and urea treated rice straw (3 kg urea dissolved in 50 kg water and sprayed on 100 kg rice straw). Bentonite 0 (control), 2.5 and 5 % was mixed for each group with the concentrate mixture.

Results showed that inclusion of bentonite significantly ( $p < 0.05$ ) increased daily gain of kids without significant difference between the bentonite groups 2.5 and 5 % respectively.

Results also showed that addition of bentonite to the ration of kids caused a significant ( $p < 0.05$ ) improvement in feed conversion efficiency. Bentonite significantly ( $p < 0.05$ ) increased dry matter (DM), organic matter (OM) and crude protein (CD) digestibilities. The nutritive value (%) expressed as TDN showed an increase ( $p < 0.05$ ) for the treatments with bentonite. Nitrogen balance of bentonite groups was significantly ( $p < 0.05$ ) higher than the non-treated control, without significant difference between groups in this respect.

**Keywords:** Bentonite, goats, rumen, TDN, urea

## **Inclusion of Several Indonesian Medicinal Plants to *in vitro* Rumen Fermentation and Their Effects on Microbial Population Structure and Fermentation Products**

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There are thousands of native or naturalised plants in Indonesia that have been used as herbal medicine for centuries. Utilization of medicinal plants to livestock especially in villages has also been practised, but very limited information is available on the effect of these plants on rumen fermentation. The aim of this experiment was to study the effect of addition of four medicinal plants; *Morinda citrifolia* (Mengkudu) fruit, *Nothopanax scutellarium* (Mangkogan) leaves, *Melia azedarach* (Mindi) leaves and *Coleus atropurpureus* (Jawer kotok) leaves, at level of 10 % to an elephant grass basal diet, on digestibility, end products of fermentation and microbial population. The experiment was done in an *in vitro* system (Hohenheim gas test) and sampling was done at different hours of incubation. Gas production, ammonia, short chain fatty acid (SCFA), microbial population structure and microbial mass were analysed. There were no differences in total gas and SCFA production and apparent or true digestibility. Inclusion of Mengkudu and Mangkokan gave higher ammonia production whereas Jawer kotok reduced ammonia production compared to the basal although its Nitrogen content was the highest (18.6 %). Nitrogen content in the residue was lower in Mengkudu and higher in Jawer kotok than elephant grass which may be due to different crude protein content. Isovalerate production which results from degradation of leucine, was higher for Mengkudu but lower for Jawer kotok, indicating that more protein degradation occurred on Mengkudu than on Jawer kotok. Tannins in Jawer kotok may bind to protein and may, thus, be responsible for lower ammonia production and protein degradation. Bacterial population structure and microbial mass measured by <sup>15</sup>N showed similar results and none of these plants gave higher values compared to elephant grass. The eukaryotes population was very low when Mengkudu and Mangkokan were added which may be due to the presence of saponin.

**Keywords:** Fermentation end products, *in vitro* fermentation, medicinal plants, microbial population

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## **An Evaluation of Diversity in the Biochemical Composition of *Moringa oleifera* Seeds**

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*Moringa oleifera* is a pantropical multipurpose tree. It tolerates most common stress factors, propagates easily and has a very high biomass yield. The leaves are suitable for human or animal nutrition. The seeds are used for oil production and provide a flocculant applicable in water purification. The seed cake obtained after extraction of oil and flocculant has been evaluated for animal nutrition. Despite these multiple uses, little is known about the variation in composition and activity between material of different origin. We therefore analyzed different batches of *Moringa oleifera* seeds, covering three different geographical locations (Nicaragua, Indonesia, The Gambia), successive mixed harvests from the same plantation, and seeds collected at the same time from different plants in the same location. Crude nutrient composition, oil content and oil composition, and the protein pattern of the water extract were compared. Recent results indicated that the seeds also contain a component that modulates rumen fermentation *in vitro*. This component was originally detected in the water extract, but its chemical nature has not yet been identified. It effectuated a delay of ruminal protein degradation, when it was added to protein enriched substrates, such as wheat straw supplemented with soy protein or lyophilized alfalfa leaves. Selected samples were therefore incubated with rumen fluid to screen for this activity in the defatted seed cake, in the water extract, and in the corresponding extraction residue. Information about the variability of traits within the species is an important prerequisite to develop a strategy for the optimized exploitation of *Moringa oleifera*.

**Keywords:** Diversity, *in vitro* fermentation, *Moringa oleifera*, ruminant nutrition

## Comparison of Aerobic and Anaerobic Methods to Assess Quality of Tropical Multipurpose Shrub Legumes

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Legume quality is a key factor for enhancement of feed resources and contribution to soil fertility in mixed crop-livestock production systems. To compare methods used by soil and animal-nutrition researchers to assess quality of plant materials, three woody tropical legumes with contrasting quality (nil, low, high contents of condensed tannins, CT) were used: *Indigofera constricta* (Indigofera), *Cratylia argentea* (Cratylia) and *Calliandra* sp. (Calliandra). Plant material of each legume was either used fresh, freeze-dried, frozen, oven-dried (60 °C) or air-dried in order to estimate extent and rate of aerobic degradation on the soil (litterbag, 140 days) and anaerobic degradation *in vitro* with rumen microorganisms (gas production, 144 hours). Results showed that decomposition rates of leaf tissues, applied to soil surface, were very fast for *Indigofera* ( $k=1.35 \text{ day}^{-1}$ ), followed by *Cratylia* ( $k=0.33 \text{ day}^{-1}$ ) and *Calliandra* ( $k=0.19 \text{ day}^{-1}$ ). Decomposition on the soil of *Cratylia* and *Calliandra* was not affected by drying treatments whereas fresh leaves of *Indigofera* decomposed more rapidly than oven-dried leaves. Gas production rates differed significantly among species evaluated, being faster for *Indigofera* ( $k=8.57 \text{ %/hour}$ ), intermediate for *Cratylia* ( $k=6.16 \text{ %/hour}$ ) and slowest for *Calliandra* ( $k=2.51 \text{ %/hour}$ ). *Cratylia* showed no differences in digestion between treatments, whereas *Indigofera* and *Calliandra* showed significant differences between treatments. The forage quality parameters that best correlated with extent of dry matter loss under aerobic decomposition and anaerobic digestion were Lignin + CT ( $-0.90$  and  $-0.91$ ,  $p < 0.0001$  for anaerobic and aerobic, respectively) and ( $-0.92$  and  $-0.91$ ,  $p < 0.0001$  for anaerobic and aerobic, respectively). Results showed that differences in decomposition and digestibility were more related to intrinsic plant quality parameters than to changes in quality induced by drying pre-treatment. In addition, we found that rate ( $0.75$ ,  $p < 0.0001$ ) and extent ( $0.87$ ,  $p < 0.0001$ ) of aerobic decomposition of legume leaves on the soil (litterbag-technique) were highly correlated to the extent of dry matter loss using the *in vitro* dry matter methods digestibility method (IVDMD). We conclude that the aerobic and anaerobic degradation of legumes used was a function of indigestible fractions of the cell wall such as lignin alone or corrected for presence of condensed tannins.

**Keywords:** Condensed tannins, decomposition, gas production method, plant tissue quality, tropical woody legumes

## Early Adoption of *Arachis pintoi* as a Forage Legume in Huetar Norte, Costa Rica

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The legume *Arachis pintoi* has a number of characteristics which can contribute to the development of sustainable and productive pastures in the tropics. For this reason it was introduced to Costa Rica in 1987. The objective of this study was to raise information about the adoption process of *A. pintoi* as a forage legume in Huetar Norte, in the north of Costa Rica.

To raise the data 115 randomly selected livestock holders out of a frame population of 7.131 as well as an additional 34 farmers known to have planted *A. pintoi*, were interviewed.

The descriptive analysis revealed that *A. pintoi* was well known among farmers in the sample (90.4 %). However, the adoption rate was low (3.48 % of farmers or 0.0006 % of pasture land). Adopters and non-adopters faced the same problems in forage and cattle production such as excess of rainfall, low pasture quality and weeds. The introduction of more suitable forage plants was seen to be the most important tool to increase forage and cattle production. Adopters and non-adopters showed clear differences in socio-economical factors (e.g. age, educational level). An econometric analysis revealed that some of these factors had a significant influence on adoption (e.g. information acquirement). The majority of adopters saw the legume's advantage in its good quality as a feed and thus in increased cattle production. Adopters found the legume's establishment to be difficult, slow and expensive, and its maintenance complicated when mixed with taller grasses. Nevertheless, on nearly all farms where farmers were interviewed the maintenance of a pasture with *A. pintoi* was less cost intensive than that of other improved pastures.

There is a need for suitable forage plants in the region. Farmers are well aware of the advantages of *A. pintoi* and acknowledge its advantages. However, difficulties in establishment and maintenance as well as lacking acquirement of information hinder major adoption.

In order to support the adoption process it is recommended to more actively provide suitable information, especially about less costly and success ensuring establishment as well as maintenance techniques.

**Keywords:** Adoption, *Arachis pintoi*, Costa Rica, forage, Huetar Norte, legume, pasture, pasture degradation, soil conservation



# Subsession 2c: Disease Control and Hygienics

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## Implications of Globalisation on Hygienic Measures in Animal Disease Control

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A new political and economic paradigm has emerged with the turn of the century which also profoundly affects ways of animal disease control. With production of animal-products worldwide rapidly changing from traditional to intensive/industrial, the spectrum of diseases changes from mono-causal to multifactorial. The concurrent development of a global rules-based production and trading environment under WTO-SPS additionally introduces vital food safety concerns which regulate/limit the kind and extent of disease control measures.

The political dimension of animal disease control is indicated as measure aiming at controlling and eradicating diseases is in conflict with the idea of free international trade as being continuously discussed within e.g. the EU and WTO. If these problems are not solved, the free international trade tends to result in a situation where ambitions to improve animal health are discouraged and instead one may end up in a situation where the lowest disease status of a participating country will be considered as the standard.

Production management aspects of disease control, summarized under the term 'hygiene', both in regards to the "livestock revolution" geared towards production intensification, as well as regarding food safety issues, gain in importance and are at the forefront of animal infectious disease control or prevention programs. These management measures cover the multitude of man-derived factors which essentially focus on altering the susceptibility of host animals to disease agents and on agent's ability to survive and transmit. The hygienic measures include structural, zootechnical and production-organisational elements or combinations of them.

The concept of the epidemiological triad is used to illustrate the role of hygienic factors for disease occurrence. It outlines the spectrum of possible hygienic interventions, ranging from single major techniques against mortalities and morbidities of 'simple' epidemic diseases to solving complex herd problems of suboptimal production or reproduction; the type of livestock system and available infrastructure essentially determines the scale and economic justification of hygienic measures. A hygiene concept has to be an integral part of an encompassing production and business management process. An appreciation of the relationship of the most important determinants for disease disorders can be gained by epidemiological-statistical methods.

With the current process of intensification of production, demands for measures to ensure production efficiency and increasingly also product quality are growing. Not all farmers will be able to follow these demands. While livestock is one of the fastest growing parts of developing country agriculture, it paradoxically is becoming less of a viable development path for many of the rural poor. The market for disease control, as that of food products, consequently will split up into a premium and a 'discount' segment. Even further pressure on disease control techniques will be exerted when, additionally to product standards, also mandatory process standards of production are asked for.

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**Keywords:** Disease control, food safety, globalisation, hygienic measures, production intensification



## **Botulism of Cattle in Brazil, Diagnosis and Vaccination.**

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Botulism as a Cattle disease in Brazil was first diagnosed in 1969 in the federal state of Piauí. Nowadays the disease can be seen in almost every part of Brazil and occurs mostly in phosphorus deficient areas. The losses can be numerated to a total of 1.5 Billions US Dollar during the last 10 years. The outbreaks accumulate temporally in the rainy season (October to March). During this period the fast-growing and widely used pasture species *Brachiaria* contains very low amounts of phosphorus. Unsupplemented mineral deficiency is followed by osteophagia on carcasses which are not eliminated and therefore serve as a permanent source of intoxication. Other sources for intoxication can be contaminated feeding stuffs such as silage or chicken litter.

Aim of this research work was to determine the predominant type of *Cl. botulinum* and to test three vaccines against the toxin types C and D.

64 samples mainly carcass material and soil on farms where botulism recently occurred and 16 samples of carcasses of no known history of botulism were collected. Diagnosis was realised by mouse neutralisation test. 25 of the collected samples were positive for the presence of *Cl. botulinum*, 24 of the CD toxin complex group and one of type A toxin. Two samples of no known botulism history were positive for *Cl. botulinum* type C.

Vaccination was carried out in 60 animals out of which 15 animals each received the same type of vaccine and 15 served as the negative control. Blood was taken over a period of one year once a month at the beginning and then every second month. The immunologic titre of the vaccinated animals was determined in an ELISA using the toxin of *Cl. botulinum* reference strains as the antigen. Two of the tested vaccines produced a good antibody titre, the third had no measurable response compared to the control group.

The results lead to the assumption that the types C and D are playing a major role in causing botulism in Brazil and that only using an effective vaccine in combination with a good pasture management is helpful to prevent Botulism.

**Keywords:** Botulism, Brazil

## **Main Problems of Brucellosis in Zambia**

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Bovine brucellosis is one of the most important reproductive diseases of cattle in Zambia, having been recognized as early as 1915, but the overall incidence and distribution was not known. The results and conclusions of the survey into the incidence of *Brucella abortus* in traditional cattle and goats conducted in the major cattle areas of Zambia, viz Western, Central, Southern, Eastern and Northern Provinces are prevented. Field survey with abattoir survey is compared. The results revealed that except for the Northern Province the prevalence of the disease in Zambia is significant. Economic impact of the disease was studied. Incidence of the disease in various age categories together with the role of the traditional management in epizootology of the disease are discussed. Other ways of disease possible spreading are discussed. As the home made sour milk is popular in the regions of Zambia with the highest incidence of cattle brucellosis, the study on the survival of brucella germs in home made sour milk was done and the results of study are discussed.

The incidence of genital tracts' abnormalities in brucella reactors and comparison among field and abattoir findings are discussed. The influence of the regional macroclimate and microclimate factors on the incidence of brucellosis were confirmed. In the areas of similar climatical conditions the most important factors influencing the prevalence of brucellosis are herd size and the form of herd management, especially as regards to the time of kraaling. Problems of randomly performed service together with *abortus* detection are presented. Rural farmers are not educated as to prevention of disease spreading. The role of veterinary services network both private and state one in the disease spreading and prevention is discussed.

**Keywords:** *Brucella* germs, brucellosis, milk, Zambia

## Effect of Milking Strategies on Milk Yield and Udder Health of Crossbred Dairy Cattle in Thailand

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The Thai dairy industrie meets only about 30–40 % of the domestic demand. Milk production in Thailand based on crossbred dairy cattle using methods developed in industrialized countries. Yield per cow is low amounting to 8–10 kg/day. Furthermore, the mastitis incidence is high (56 %) under smallholder management and became a more serious problem in herds with machine milking than in hand milking herds.

This study aimed to evaluate the effect of milking method and calf rearing management on milk production and udder health of the cows.

Fourty crossbred (75–87.5 % HF) dairy cows were included in two × two factorial experiment. The milking managment was: hand milking (HM) and machine milking (MM), and the calf rearing management was: artificial rearing (bucket feeding, AR) and restricted suckling (RS). The calf suckling period in RS treatment was ended at 84 days postpartum. Milking treatment was continued until the end of lactation. MM cows had a significantly ( $p < 0.05$ ) higher daily total milk production (TMP) (7.49 vs. 6.97 kg/day) and total lactation milk yield (TLMY) (2297.72 vs. 2137.41 kg) than HM cows. The RS cows produced significantly ( $p < 0.001$ ) more TLMY (2455.46 vs. 1979.68 kg), annual total milk yield (ATMY) (2277.23 vs. 1970.73 kg), lactation saleable milk production (LSMP) (1724.64 vs. 2165.90 kg), annual saleable milk production (ASMP) (2035.21 vs. 1721.17 kg) and daily saleable milk production (SMP) (7.98 vs. 6.47 kg/day) than the AR cows. The MM cows showed significantly ( $p < 0.001$ ) higher somatic cell score (SCS) than their HM herdmates throughout the study period. The AR cows exhibited a significantly ( $p < 0.001$ ) higher SCS than RS cows.

**Keywords:** Annual/daily saleable milk production, annual/daily total milk yield, artificial rearing, crossbred, lactation saleable milk production, restricted suckling, somatic cell score, total lactation milk yield

## ***Salmonella* Infection in Calves: Virulence Proteins and its Immunogenic Properties**

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Faecal samples collected from calves suffering from diarrhoea revealed the isolation of *Salmonella* in 17.5 % of the cases, while in the contact apparently healthy calves the incidence was 3.4 %. Four *Salmonella* serovars were elucidated namely, *S. typhimurium* (7.3 % and 1.7 %), *S. dublin* (5.1 % and 0.8 %), *S. enteritidis* (2.9 % and 0.8 %) and *S. anatum* (2.2 % and 0 %) from diarrhoic and apparently healthy calves respectively. SDS-electrophoretic analysis of the outer membrane protein (OMP) revealed common antigen protein bands especially between *S. dublin* and *S. enteritidis*, due to the greater similarity in their antigen structure. All serovars showed intense protein bands in the range from 20K to 45K. In the Western blot analysis, serum antibodies from calves infected with *S. typhimurium* (serogroup B) reacted with protein bands at the range of 17K, 24K, and 31K. The OMP of the two serovars *S. dublin* and *S. enteritidis* (both serogroup D1) reacted relatively similar in Western blot with the antisera collected from calves infected with their corresponding serovars. Two protein bands were characteristic for *S. dublin* and *S. enteritidis*, 14.4K and 24K. Only one protein band, 24K from the blotted OMP of *S. anatum* (serogroup E1) reacted with serum from infected calves infected with that serovar. Using the heterologous serum in the Western blot analysis gave weaker results than the homologous serum.

ELISA results detected the presence of serovar specific antibodies, *S. typhimurium* ELISA detected 10.9 % and 4.3 %, *S. dublin* ELISA detected 7.3 % and 2.6 %, *S. enteritidis* ELISA detected 5.1 % and 1.7 %, while *S. anatum* ELISA detected 2.9 % and 0.9 % of the serum samples collected from diarrhoic and apparently healthy calves respectively. It could be concluded that *Salmonella* OMP were major immunogenic antigens that could be used in ELSA or Western blot to detect and monitor *Salmonella* infection in calves.

**Keywords:** Calves, ELISA, outer membrane proteins, *Salmonella*, Western blot

## Influencing Factors of Infestation With Endo and Ectoparasites on Hair Sheep in Tropical Ecuador

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The Department of International Animal Husbandry's project funded by GTZ examined the parasite condition of hair sheep in Sucumbios, Ecuador. Parasites can impair the health of an animal causing high economic losses. As the problem has not yet been tackled by a government institution in Ecuador, the project carried out various parasite tests. According to the parasitologists factors like farming systems, source of water, salt additive as well as sex, age and breed of the animal play an important role. In this report the farming system, sex, breed and age are to be analysed.

120 hair sheep of the breeds Barbados Blackbelly, Pelibuey and the Ethiopian breed were tested for faecal, skin and blood parasites. For the faecal tests flotation, sediment and migration methods were used to test for gastro-intestinal, liver and lung parasites. The WOO and IFAT tests were used to test for blood parasites. Skin specimens were microscopied directly after removal to test for ectoparasites. The above mentioned factors were analysed statistically for significance of parasites.

The first season, July to September, was dry with relatively high humidity. The endoparasite infestation was classified as light. None of the parasites was significant as far as the influencing factors were concerned. In contrast two ectoparasites *Boophilus spp.* and *Chorioptes spp.* were classified as significant. Correlations and t-test were carried out at random in pairs. The farming system, sex and breed had no connection with the *Boophilus* infestation, the same for *Chorioptes*.

In the second season, October to December, temperature and humidity remained constant, rainfall increased later. Parasite infestation was classified as light. Apart from the ectoparasites *Boophilus spp.* and *Chorioptes spp.* the lung parasite *Dictyocaulus spp.* was classified as significant. The breed played an important role in the infestation of *Dictyocaulus*, *Boophilus* and *Chorioptes*.

In the third season parasite infestation with *Chabertia*, *Bunostomum*, *Ostertagia*, *Dictyocaulus* and *Boophilus* was significant with regard to the surveyed influencing factors. *Trichostrongylus* and *Psoroptes* parasite infestation was directly influenced by breed and age. Between February and April due to high rainfall the development and reproduction of parasites was high.

**Keywords:** Ectoparasite, Ecuador, Endoparasite, hair sheep

## Investigation of Cameline Trypanosomiasis in Mid-Eastern Sudan Using AgELISA in Conjunction with Parasitological Examination

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The major constraint to camel productivity in the Sudan is trypanosomiasis caused by *Trypanosoma evansi*. Currently, diagnosis is based on clinical signs and/or parasitological confirmation, but clinical signs are not pathognomonic and detection of trypanosomes in the blood is frequently difficult. In this study, the antigen detection enzyme-linked immunosorbent assay (AgELISA) in conjunction with parasitological examination of blood (buffy coat technique (BCT) and packed cell volume (PCV)) were used to study the enzootic situation of trypanosomiasis in camels in Butana plains, mid-Eastern Sudan. Over a one year survey (from November 1989 to October 1990), a total of 1738 randomly selected camels were sampled. The survey showed that the infection is endemic among pastoral camels with a prevalence of 5.4 % based on parasitological examination and 31.3 % based on AgELISA. The infection rate was significantly ( $p < 0.05$ ) higher during the dry period (November to May) than the wet season (June to October) based on BCT and it was slightly higher with AgELISA. Young camels had a much lower infection rate based on parasitological techniques, but they had a higher infection rate with AgELISA. A higher prevalence of infection was detected by BCT in herds of camels raised by nomads compared with those kept by agropastoralists and in camels located in the southern than those located in the northern districts of Butana plains. AgELISA compared to BCT was 68.8 % sensitive and 70.2 % specific.

The AgELISA test system was developed by the joint Food and Agriculture Organization and International Atomic Energy Agency (FAO/IAEA) division, Austria, in collaboration with the Centre for Tropical Veterinary Medicine (CTVM), Scotland.

**Keywords:** Camel, *Trypanosoma evansi*

## **Effect of Gender on Nutritive Value and Sensory Evaluation of Bacon of Pigs Slaughtered at 110 Kilogram**

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Entire male pigs production is not popular in Thailand because of the long time notion about boar taint. The source of boar taint as faecal-like (skatole) is attributable to the residual tryptophan (BURGOON et al., 1992) and fibre (JENSEN et al., 1992) in the colon. Boar taint accumulates in fatty tissue and the consumers can detect it when cooking (CLAUS et al., 2000). Therefore, boar meat products like bacon made from fatty tissues are a major concern for meat producers. This study investigated the chemical composition and sensory score in relationship to gender of bacon from boars, barrows and gilts fed diets with 0.22–0.56 % tryptophan and 3.6–3.7 % fibre and slaughtered at market weight (110 kg). Twenty-four bacons from crossbred (Large White × Landrace × Seghers) boars, barrows and gilts (8 bacons from each group) were investigated in a completely randomised design experiment.

Protein content was higher in bacon from gilts than from barrows (16.16 vs 14.58 %,  $p < 0.05$ ) but not different ( $p > 0.05$ ) from that of the boars (15.70 %). Bacon from boars had lower nitrite content than that of barrows and gilts (1.97 vs 3.09 and 4.16 ppm:  $p < 0.05$ ). No differences were found for phosphate and nitrate contents. Sensory evaluation revealed a higher preference score for bacons from barrows and gilts than from boars. The overall acceptability of bacon from gilts was greater compared to barrows (3.75 vs. 3.52;  $p < 0.05$ ) but not different ( $p > 0.05$ ) from that of boars (3.56). Bacon from gilts had better flavour than that of boar (3.76 vs 3.51;  $p < 0.05$ ) but not different ( $p > 0.05$ ) from that of barrows (3.59).

## Ketonuria in Holstein Friesian Milking Cows in Chiang Mai, Thailand

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Ketonuria tests on Holstein Friesian milking cows were performed at a farm in Chiangmai, Thailand.

**Test 1:** 20 cows were tested for ketonuria at 2, 4, 6, 8, 10, 12 and 14 weeks postpartum. 45 % of the cows showed negative results and 78 % of these were low milkers (cumulative 14-week milk production, < 2000 kg). Cows testing positive for ketonuria were more at week 2 and 4 than at week 6, 8, 10 and 12 postpartum (30, 30, 5, 10, 10 and 15 % respectively). There was no ketonuria detected at 14 weeks postpartum. Fifty percent of ketonuria cows at weeks 2 and 4 postpartum were high milkers (cumulative 14-week milk production, 3001–4000 kg). Variations in the number of ketonuria cows from week 2 to 14 postpartum among low, moderate (cumulative 14-week milk production, 2001–3000 kg) and high milkers were not significant ( $\chi^2 = 7.57$ ,  $p > 0.05$ ). There was no correlation between ketonuria cows and milk production (contingency coefficient:  $C = 0.78$ ,  $p > 0.05$ ).

**Test 2:** 24 cows were tested monthly for ketonuria at 3 periods postpartum: 0–4, 5–8 and 9–12 weeks. 62.5 % of the cows were negative at all testing periods. There were more cows with ketonuria at 0–4 weeks than at 5–8 and 9–12 weeks postpartum (21, 17 and 17 % respectively). The correlation between ketonuria occurrence and milk production at 0–4 and 9–12 weeks sampling period were significant ( $p < 0.05$ ,  $r = 0.41$  and  $0.44$  respectively) but not at 5–8 weeks postpartum ( $r = 0.39$ ,  $p > 0.05$ ).



## Subsession 2d: Aquaculture Systems

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## Perspectives in the Search for Future Fish Feed Ingredients

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Aquaculture is an important weapon in the global fight against malnutrition and poverty, particularly in the developing countries (TACON, 2001). Increase in human population in these countries, along with changing perceptions of healthy food in affluent regions, are set to increase the demand for food fish. The total fish catch from the world's fishing grounds have levelled off in the last decade with the majority of wild stocks being fully exploited. Aquaculture production seems to be responding to the increased fish demand and have exclusively increased the world fish production by 20 million tonnes (mt) in the past decade. By the year 2010 the world food fish production is set to increase to about 105 mt and the approximately 20 mt increase from the current levels would again have to come from aquaculture. In addition to being the fastest growing food production sector of the world aquaculture activities currently employ about 9 million people (FAO 2000).

The projected high growth in fish culture would demand a concomitant growth in the production of feeds. One projection puts the total production of aquafeeds in the year 2010 at 37 mt, which would further increase to about 68 mt in 2025, against an approximate production estimate of 13 mt in the year 2000 (see HASAN 2001). Fish meal is a favourite source of high quality protein in feeds. The proportion of global fish meal production used for fish feeds has increased from 10 to 35 % in the last fifteen years (HARDY, 2000). Predictions of fishmeal needs for aquaculture feeds in 2010 are 2.8 mt, approximately 44 % of the ten-year average global fishmeal production of 6.5 mt. This is in spite of the predicted decrease from current levels of the percentage of fish meal included in feeds of all major aquaculture species. Considering an average feed crude protein content of nearly 48 % for cold water fish and 30 % for warm water fish, high protein ingredients would have to contribute substantially to the rest of the quantity.

Two factors deserve consideration while discussing the question of future fish feed ingredients. The first is that approximately 90 % and 82.2 % of the total world aquaculture production in 1998 was produced within the developing countries (35.5 mt) and, in particular, within the low income food deficit countries or LIFDCs (32.4 mt; TACON 2001). The second involves the spread of 'mad-cow' disease (BSE), and the resultant ban on the use of meat and bone meal in animal feeds. This induces a short to medium term uncertainty regarding the availability of these two animal by-product meals widely used as fishmeal substitutes in different parts of the world and its effects on prices of other viable ingredients.

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The need for looking at new possible aqua-feed ingredients of the required high nutritional quality is therefore imperative. The importance of the development of non-human-food grade feed resources whose production growth can cope up with the projected and desired fast growth of the sector has been stressed (TACON and FORSTER, 2001). Since the largest potential for aquaculture expansion is in the LIFDCs, capital inputs for feed-ingredient production may be limited. Given this scenario, coupling with remedial measures for other problems where international attention is focussed, to exploit synergies might have higher chances of success. Multifunctional plants that require low inputs and that are capable of surviving under poor soil conditions offer viable solutions to multiple problems. Products from these plants, taking their availability and potential for growth into account, could be considered as protein sources in feeds. Alongside potential production of feed ingredients, these can help in reclamation of degraded areas and therefore profit from national, international and private funding that is being channelled into wasteland reclamation. According to UN figures, more than 2 billion hectares of land are affected by degradation and loss of productivity. The largest area affected, about 550 million hectares, is in Asia and the Pacific, where over 90 % of the current aquaculture production occurs. In Africa (having potential for expansion of aquaculture), an estimated 500 million hectares of land have been affected by soil degradation since about 1950 (UNEP/ISRIC 1991). China and India that together account for about 75 % of the total aquaculture production, have 180 million ha and 110 million ha of degraded land respectively (UNEP 1997). There exist therefore, possibilities for regional and local integration of feed ingredient production from wasteland and their use in fish feeds.

Plant species promoted internationally for multiple purposes include *Jatropha curcas*, *Moringa oleifera*, *Mucuna pruriens*, *Leucaena leucocephala*, *Sesbania aculeata*, *Sesbania bispinosa* and *Stylosanthes hamata* to name a few. These plants are capable of resisting adverse soil and climatic conditions and still sustain a reasonably high primary and secondary production. Research reports available on some of them indicate the potential to develop products of high nutritional quality (FRANCIS et al. 2002). These products, however, also contain high levels of antinutritional, toxic principles that keep herbivores at bay. Utilisation of these plants as animal or fish feeds would therefore not only depend on their nutritional content, but also on the presence and level of various toxic principles and methods of detoxification. A challenge for tropical aquaculture research is therefore to identify products from these plants having the required nutritional quality and to develop viable treatment methods to make them suitable for addition to fish feeds (plant genetic improvement alone may not provide an adequate solution). This, along with improvement of the culture species and optimisation of semi-intensive culture techniques would provide the fuel for the sustainable growth of this important food production sector in LIFDCs.

## **Preliminary Evaluation of Jackbean (*Canavalia ensiformis* L. DC) Seed Meal as a Substitute for Fishmeal in Diets for *Clarias gariepinus* (BURCHELL, 1822)**

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Jackbean (*Canavalia ensiformis*) is an underutilised novel legume with crude protein content and amino acid profile that make it a potential candidate as substitute for fish meal in fish diets in the tropics. This study is aimed at assessing the potentials of Jackbean seed meal (JSM) for partial replacement of fish meal in diets of *Clarias gariepinus*. Ten fingerlings of *C. gariepinus* (average weight 1.87 g) were introduced into 26 plastic tanks containing twenty liters of freshwater respectively. Thirteen isonitrogenous (30 % protein) and isocaloric (ME 12.2 kcal/kg) diets were formulated for the trials. Fishmeal in the control diet was replaced progressively (10 %, 20 %, 40 % and 60 %) by raw JSM as well as JSM that was bioled for 30- and 60-minutes. Test fish in each tank were fed 3 % of their biomass twice daily for 56 days. At the end of the experiment, weight measurements of fish from the feeding groups were taken. Fish carcasses collected at the end of the study as well as samples frozen at the beginning were homogenized and subjected to proximate analysis. Fish fed control diets had the best SGR (1.61) and feed efficiencies (FCR 1.88, PER 1.74). SGR and PER of fish groups fed test diets were inversely related to the dietary levels of JSM. The same trend applied to protein and fat contents of the fish carcass. FCR however had the reverse trend. Fish fed diets with up to 20 % fishmeal substituted by 60 minute boiled JSM had a protein content similar to those fed the control diets ( $p < 0.05$ ). Fish fed diets with fishmeal substituted by 10 % raw JSM, up to 20 % JSM boiled for 30 and 60 minutes, had similar fat levels in the fish muscular tissue as those fed the controlled diets ( $p < 0.05$ ). The poor performance observed in fish fed diets containing increasing levels of boiled JSM suggests the probable presence of thermostable antinutritional factors in processed JSM as well as an imbalance in the nutrient profile which may be corrected by supplementation. However, the study shows that 20 % of fish meal in the diet can be replaced with JSM previously boiled for 60 minutes without any adverse effect on the growth performance.

**Keywords:** *Clarias gariepinus*, fishmeal substitute, Jackbeans

## **Quantitative Estimates of Ecological Sustainability in Upland Integrated Agriculture-Aquaculture Systems in the Philippines**

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To meet the increasing demand for food, there is a need to intensify agricultural production in rural areas of developing countries without negative social and environmental impacts. Sustainable intensification can be achieved when innovative technology is adopted by farmers who are supported by appropriate government policies and institutions. To allow system comparison and decision-making, quantitative estimates of the sustainability of technological innovations are needed. Sustainability can be defined in economic, social and ecological terms. Aquaculture may be such a technological innovation. In this study, we estimated the ecological sustainability of aquaculture in upland farms in Quirino province in the Philippines by calculating nitrogen flows between the different farm enterprises.

Based on a two-year survey of resource flows and production, we used Ecopath to estimate static mass balance nitrogen models of farms before and after integration of aquaculture. It was shown that several indicators of ecological sustainability based on nitrogen flows in the farm were higher after integration of aquaculture into the farm system. In the discussion, we present several options for improving this methodology and for linking it to economic sustainability indicators.

## **Nutritional Quality Evaluation of Moringa (*Moringa oleifera* LAM.) Leaves as An Alternative Protein Source for Tilapia (*Oreochromis niloticus* L.)**

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According to FAO (1997) aquaculture as fastest growing sector of the world animal production has annual increase about 10 % and to sustain such high rate of increase in production, a matching increase in fish feed production is imperative. The high cost and fluctuating quality of fish meal as well as uncertain availability have led to the need to identify alternative protein sources for fish feeding formulation. Therefore, in order to attain more economically sustainable, environmentally-friendly and viable production, recently the research interest has been directed on the evaluation and use of unconventional protein sources. However, only limited informations are available on the utilisation of these resources as fish feed.

*Moringa oleifera* LAM., a member of *Moringaceae* family, is fast growing plant widely available in tropics and subtropics with several economic importance for industrial and medicinal uses. The leaves are rich in carotinoides, ascorbic acid and iron. However, there is no information regarding the utilisation of moringa leaves in fish feed. Therefore, the present study was carried out to evaluate suitability of moringa leaves as partial protein replacement for fish meal in practical diets for tilapia based on its effects on growth performance and body composition.

Three experimental diets were formulated to contain 10 %, 20 % and 30 % of total dietary protein with moringa leaves (diet 2, 3 and 4, respectively) and one diet (diet 1) as control was included only with fish meal as protein source. All diets were isonitrogenous (35 % protein) and isoenergetic (20 kJ g<sup>-1</sup>). A 7-weeks feeding trial was carried out in triplicate groups of 7 fish each (9–11 g) in 45-l aquaria connected to recirculating system. Daily fish ration was calculated based on 5 times level maintenance. Diets with higher inclusion of moringa leaves (diets 3 and 4) showed depressed growth performance. In diet 3 and 4, the relatively high total phenolics (0.7 % and 1 %), non-hemolytic saponin (1.5 % and 2.3 %) and phytic acid (0.5 % and 0.8 %) might have contributed to poorer growth performance in these groups.

**Keywords:** *Moringa oleifera* LAM., *Oreochromis niloticus* L.

## **Effects of Rearing Temperatures on Sex Ratios in Tilapia, *Oreochromis niloticus* L., Investigations on a Local Population from the Lake Victoria in Kenya**

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Due to early and uncontrolled reproduction, farming of Nile Tilapia in ponds results in overcrowding, insufficient food for the fish and thus stunting. Therefore, all male production populations are often preferred. High rearing temperatures are suspected to shift the sex ratio towards males in different strains and populations of Nile Tilapia, *Oreochromis niloticus*. To test, whether a local population of *O. niloticus* is sensible to high rearing temperatures, research trials were conducted on progenies, derived from brooders originating from the Winiam Gulf, the Kenyan part of Lake Victoria. All investigations were carried out at a testing unit, including closed recirculation systems for the rearing of brooders and artificial incubation of eggs, at Maseno University, Kenya during a research period from October 2000 till May 2001.

Eleven batches could be tested, which encompassed a 10-day temperature treatment (36°C), fry on-growing until an age of 90 days post fertilisation and final sex determination by inspection of the gonads. From these 11 batches all temperature treated progenies showed a high male tendency in their sex ratios. The overall male ratio in the treatment group was 79.1 % while for the control the male ratio was 54.1 %. This reflects a difference of 25 %. In 6 of these batches the difference regarding the sex ratio between the treatment group and their respective controls was significant (t-test). The results indicate that, the tested population of *O. niloticus* from Lake Victoria shows a response to temperature treatments by shifting the sex ratio of the temperature treated progenies towards males. The results further indicate that due to the non-homogenous reactions on sex determination, the lability of sex ratio to elevated temperatures might depend on specific breeding pairs and therefore it might be a heritable trait.

**Keywords:** Kenya, *Oreochromis niloticus* L., sex determination, temperature sensibility



## **Response of Dietary Phosphorus Concentration and Phytase Supplementation on Weight Gain and Phosphorus Utilisation in Gilthead Seabream (*Saprus aurata*)**

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In order to determine methods for maximizing growth in gilthead seabream and minimizing waste output of nutrients into the water at the same time, a series of growth experiments was carried out. Since phosphorus is largely responsible for water pollution, main targets in this study were the adjustment of dietary phosphorus and improving availability of phosphorus of plant origin by supplementing the diet with microbial phytase.

In two growth experiments with gilthead seabream the response to different levels of dietary phosphorus was examined. Each trial contained seven diets based on wheat gluten. Phosphorus sources were Dicalciumphosphate (DCP) in the first and Monocalciumphosphate (MCP) in the second trial.

Each diet was fed two times a day to triplicate groups of seabream containing 27 and 26 fish respectively. In the DCP experiment fish were fed to satiation and in the MCP experiment feed was restricted. This restriction took into account that fish fed to satiation consume less of a P-deficient diet than of diets sufficient in P. The restriction achieved that feeding intensity was the same in all groups referring to their body weights. After reaching three times the initial weight, fish were killed, homogenized and analysed.

Maximum phosphorus concentration in gain required 12.3 g DCP and 10.4 g MCP per kg diet. For maximum weight gain a concentration of 10.2 g DCP per kg diet was sufficient.

Utilization efficiency was determined at 67 % for DCP and 83 % for MCP.

To examine the possibility of improving phosphorus digestibility in seabream at diet based on rapeseed oilmeal was used. The diet comprised about 80 % rapeseed meal being the only phosphorus source in the diet. Phosphorus concentration was about 11 g per kg diet. This diet was fed with and without supplementation of 2000 FTU microbial phytase per kg diet to duplicate groups of seabream each. Digestibility was calculated using chromic oxide as a marker. Phosphorus digestibility of the control diet was determined to 50 %. With phytase supplementation phosphorus digestibility could improved up to 85 %.

## **Artificial Reproduction of Asian Green Catfish (*Mystus nemurus*): Trials to Obtain High Quality Sperm from Alive Males**

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The Asian Green Catfish (*Mystus nemurus*) is a native species to South East Asia. Due to its excellent taste and dietary merits the species represents a new aquaculture candidate with a production of about 700 t/a. Although other steps of cultivation seem to be practicable methods of getting sperm for artificial reproduction needs to be optimised. For artificial reproduction of the Asian Green Catfish ripe eggs can easily be stripped from live females, whereas sperm has to be collected from dissected testis of killed males. Getting adequate sperm from living males would be a benefit especially for selective breeding programmes, because paternal influences could be calculated and utilised to increase the breeding progress. Therefore the aim of this study was to evaluate practicable methods to obtain sperm from live male Asian Green Catfish. The male reproductive system of Asian Green Catfish was anatomically and morphologically examined. The testes and seminal vesicles were composed of numerous lobes connected to the posterior part of the vas deferens. Furthermore the testes lie deep in the body and are covered by other organs. This seems to physically inhibit the stripping of large quantities of milt. The GSI (mean: 0.44) from milt of different dissected testes, the percentage of motile sperms (mean: 98 %), the duration of motility (mean: 4 min) and the sperm density (mean:  $1.465 \times 10^{10}$  sperms/ml) were examined. To provide the best possible preconditions for artificial stripping of testes, the influence of injections with different dosages of LHRHa (15–60 µg/kg BW) in combination with domperidone (5–20 µg/kg BW) on GSI and sperm density was monitored. An upward tendency of GSI in the case of increasing hormone dosages could be shown, nevertheless this trend was not significant. No significant influence of hormone dosages on sperm density could be found. Treated males (20 µg LHRHa/kg BW and 5 µg domperidone/kg BW) where artificially stripped. In half of the males a mean of 0.5 ml milt with a mean sperm density of  $3.97 \times 10^7$  sperms/ml could be stripped whereas in the other half stripping remained unsuccessful.

**Keywords:** Aquaculture, artificial reproduction, catfish

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## Assessing the Dietary Amino Acid Requirements of Tilapia, *Oreochromis niloticus* Fingerlings

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*Oreochromis niloticus* fingerlings (initial weight,  $4.35 \pm 0.24$  g) were fed diets with dietary protein levels, ranging from 7.3 % – 44.2 % dry matter (dm) for eight weeks. Using growth performance and food conversion ratio, the dietary protein requirement of the fingerlings was estimated at 33.32% dietary protein (dm). Dietary protein: Energy (P:E) ratio of this diet was  $16.10 \text{ mg kJ}^{-1}$ . Dietary essential amino acid requirements for *O. niloticus* were expressed as the essential amino acid composition of the diet with a protein content of 33.32 % dm. This follows the concept that protein requirements is the minimum amount needed to meet amino acid requirements and ensure maximum growth. The essential amino acid requirements, as % dm are: Arginine 1.68, Histidine 0.70, Isoleucine 1.15, Leucine 2.15, Lysine 1.98, Methionine 0.10, Phenylalanine 1.13, Threonine 1.11, Tryptophan 0.84, and Valine 1.34. This result was verified by comparing the performance of fish on diets having essential amino acid profile similar to the diet containing 33.32 % dietary protein and others mirroring the recommended amino acid requirement for tilapia by SANTIAGO and LOVELL (1988). The specific growth rate among different fish groups was not significantly different. Essential amino acid requirements are therefore not absolute values but rather an indication of concentration range which must be present in fish diet to allow adequate performance of fish. The relative ease of tilapia culture as well as its rapid growth-rate under tropical and semi-tropical climates have led to its widespread distribution. Further intensification of culture methods for tilapias may be successful if perfected diets satisfying all of the nutrient requirements are formulated. This study is aimed at suggesting a simpler method to help those in developing countries determine the amino acid requirements of fish before formulating fish diets.

**Keywords:** Protein and amino acid requirements, Tilapia



## **Session 3: Farming Systems and Management, Rural Development**

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# Subsession 3a: Sustainable Use of Farm Resources

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## Challenges towards the Sustainable Use of Farm Resources

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In a world where news on decline significantly outranges positive news on the quality and quantity of farm resources, approaches for a sustainable management is an imperative in particular for people whose living standard depends immediately on the continuous and, if possible, improved performance of these resources. Problems in sustainability of farm resources are not restricted to natural resources only, but include man-made resources like infrastructure, education, gender-related competences, informal and formal institutions, too.

The necessity to satisfy essential needs in the short run may engender decisions and practices on the level of farming families that contradict the requirements of the long-term sustainable preservation and development of resources. This holds the more in cases where families live close to the minimum of existence and is the more tragic since these families are the first whose quality of life suffers from resource degradation. Farmer's knowledge and its consideration in participatory decision and implementation processes has the potential to provide solutions in a substantial number of cases, but faces limits when new situations do not correspond to the rudiments of traditional, indigenous experience. This type of situation constitutes the interface where researchers with their expert approach are demanded to provide alternative concepts and methodologies for decision makers on all levels. Coping with the challenge of a sustainable use of farm resources can thus originate only from combining both, farmer's knowledge and achievements from the expert approach, via participatory mechanisms.

The numerous contributions to this workshop, which are second in number only to the intimately related workshop 1d on resource management concerning land and crops, give an idea about the multiplicity of fields where researchers try to add knowledge to the vast field of resource use on the farm level. This multiplicity holds for the resources under research as well as for the applied methodological toolbox, which ranges from field trials and laboratory work up to social and socio-economic analyses and policy development. About half of the contributions deal with aspects of natural resources, whereby research results related to soil dominate with three oral presentations and six poster contributions. Water and forests are the subject of one poster each. The other half treats a wide array of research topics on different man-made resources, which may be roughly summarized under the key words human resources, system analysis, policies and technology.

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This diversity of topics, which found their place under the umbrella of the workshop's title emphasizes once again that farm resource use is simultaneously a part and a result of a system. Consequently, sustainability cannot be achieved by partial approaches alone, but calls for the interdisciplinary co-operation between researchers from all fields. Success in this regard is a pre-condition for the operational co-operation between farmers and researchers and might nourish the hope that we may be able to avoid a situation where the priority of sustainable resource management will have to be replaced by the priority of reconstructing resources.

## **Determinants of Farmers Use of Sustainable Conservation Practices in Osun State, Nigeria**

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Sustainability which involves the ability to use a resource in ways that ensure little or no damage to guarantee continuous use was the focus of the study. Participatory tools i.e. focus group discussion was employed using farmers to take inventory of the soil conservation practices they consider to be sustainable. Fifteen practices were validated. The practices are: slash and manual removal of biomass, zero tillage, minimum tillage, use of organic manure with inorganic fertilizer, multiple cropping, crop rotation, construction of ridges and heaps, planting nitrogen fixing legumes, use of strip cropping, planting cover crops, planting multipurpose trees, use of vetiver grass, mixed farming, fallow cropping and use of mulches

The study identified the determinants of farmers' use of the practices in the study area. Data were gathered from 112 respondents sampled through systematic technique from five (5) communities.

Results of the study show that the farmers are aware of most of the practices, while the soil conservation practices they often make use of are multiple cropping, use of cover crops, crop rotation and the use of fallow system. They also plant multipurpose tree species for erosion control and use organic manure with inorganic fertilizer at varying degrees to enhance productivity and ensure sustainability.

Correlation tests show that farm size, income, labour use, other income generation activities and level of awareness had significant relationship with respondents' use of the sustainable soil conservation practices.

Multiple regression analysis shows that factors that determine farmers' use of those soil conservation practices are level of awareness, farm size, income, labour use and other income generation activities. The factors determine 72 % of the variation in respondents' use of the conservation practices. Sustainability therefore demands that the farmers should be assisted with respect to those factors.

**Keywords:** Conservation, determinants, farmers, soil, sustainability

## **Forest Health under Institutional Development for Community-Based Upland Resource Management: Comparison of Villages in Lowland and Upland Settlement, Northern Thailand**

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This article is part of a research for a doctoral degree of the first author entitled institutional development for community-based upland resource management. The study has been carried out at Sopsai sub-watershed (in Nan Watershed), Nan province, Northern Thailand.

By comparison between Nahai, a lowland settlement village, and Huamuang, an upland settlement in terms of background, livelihood, and institutions in association with forests, it can pinpoint at critical issues in intervention to institutional development for community-based forest resource management in Northern Thailand, a part of the mountainous mainland region in Asia.

Although Huang-muang has been settled for 20 years and Hahai only for a few, there is no difference in forest health. But the greater succession in Hua-muang forest may be caused by management practices of Sopsai watershed management unit and villagers' fire protection. The forest areas in Nahai village are divided into 2 zones: conservation zone (CZ) and utilization zone (UZ). The analysis of forest resources yielded the following results: **(1)** there are no differences in forest health between UZ and CZ, **(2)** there are better regeneration and biodiversity in CZ than UZ, but **(3)** UZ showed a higher total density of preferred timber species than CZ, and **(4)** considering 5–10 major firewood species, there was a higher density and basal area (etc.) in UZ than in CZ.

These findings emphasize the importance of collective decisions with respect to rules and regulations for forest resources, health and improvement of resource management by the authorities of the communities themselves. The processes of interventions for institutional development towards community based approaches are synthesized. In addition, further research needs for supporting sustainable community-based upland resource management are identified.

**Keywords:** Biodiversity, common property, community-based approach, institutional development, livelihood, private property, tenureship, Thailand, upland resource management

## **Soil Fertility Management in Semi-Arid India: Its Role in Agricultural Systems and the Livelihoods of Poor People**

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It is commonly assumed that rainfed areas face a soil fertility crisis. While there are concerns, a research study carried out in 2001/2002 in two districts of semi-arid India by the Natural Resources Institute, the Deccan Development Society and the BAIF Institute for Rural Development challenges the view that farmers are not managing soil fertility carefully, and that simply more external inputs will improve livelihood. It offers alternatives based on consultation with farmers and analysis of a wide range of case studies. The research findings have implications on development programmes, future research and policy.

The study focused on two poor groups: small and marginal farmers and how they are managing soil fertility and the soil-related problems on their farms, and (often landless) families engaged in the trade of organic fertilisers, such as farmyard manure (FYM) and vermicompost. The research included a combination of reviews and fieldwork using both quantitative and qualitative methods, such as farm resource flow mapping. Fieldwork covered four villages each in both Andhra Pradesh (Medak District) and Karnataka (Tumkur/ Hassan Districts).

Key findings are:

1. In the study areas there is little evidence that soil productivity is in decline. In fact, yield trends and the views of farmers suggest that productivity is stable or increasing.
2. Farmers are actively managing soil fertility and other soil properties through a wide range of practices and significant inputs of labour, knowledge and capital.
3. While the overall number of livestock is decreasing in the study areas, the proportion of landless and small farmers owning livestock is increasing. Livestock ownership opens up new opportunities for the poor, including trade in FYM and compost.
4. The strong demand for organic inputs and changes in livestock ownership have led to a rapidly expanding market for organic fertilisers. With improved access to the supply of FYM, some of the poor and landless are in a strong position to benefit from this trade.
5. Farmers expressed concern about negative impacts of chemicals on soils such as hardening and compaction, and the soil becoming 'addicted' to fertiliser applications.

**Keywords:** Chemical fertilisers, farmyard manure, India, organic matter, rural livelihoods, semi-arid tropics, soil fertility management, vermicompost, video documentation

## Organic Manure Use among Smallholders in the Rainforest of Southeast Nigeria

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The interest in organic manure in African agriculture is not necessarily the same as in the developed countries, where the overwhelming issue is about environmental and health consciousness. In Africa, it is the damage to soils and scarcity of inorganic fertilizer. The problem of declining soil fertility in the crop based farming systems of sub-saharan Africa is well known. This arises because traditional soil fertility management practices, which relied on shifting cultivation and fallow periods are no longer sustainable. Those were low external inputs systems where farmers allowed soils to rest long enough to regenerate adequate organic biomass to restore acceptable levels of fertility. But farmers can no longer do this due to land use pressure as population grows. Continuous cropping without appropriate soil management leads to deterioration in soil physical, chemical and biological properties. Consequently, declining yields and low resource productivity, worsen poverty in rural agricultural areas.

So far research efforts on this matter have been restricted to on-station trials. The present research on which this paper is based was carried out in form of trials with farmers, under their own conditions and management practices. The study was carried out among crop farmers in Abia state in southeast Nigeria. Here, population density is about 598 persons per sq. km, while rainfall reaches 2257 mm per annum. Fifty farmers growing a mixture of various food crops were engaged in the trials. Organic materials were sourced from farms, households and livestock producers. Plots were demarcated for organic and inorganic fertilizer application.

Results show that output from farms using organic manure was slightly less than that from inorganic farms, though only by 5 % on the average. However, inorganic fertilizer added about 20 % to costs of production. Returns per hectare were higher on organic farms, though farmers observed additional labor demand. This required 10 % more labor in man-hours. Labour scarcity and costs are problems in the area. This can be a serious limitation to widespread recommendation of organic farming. Furthermore, farmers complained that organic materials are not easily storable, and that it was difficult to obtain organic materials in the quantity and time needed.

**Keywords:** Inorganic fertilizer, organic biomass, soil fertility

## **Study for a Sustainable Development of the Family Agriculture in the Region of Vale do Rio Pardo/RS/Brasil**

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The region of Vale do Rio Pardo, in the State of Rio Grande do Sul, presents approximately 45 % of its population living and working in the rural area, in family units of production. The main culture is tobacco, which, in its productive process, absorbs intense labor force and great quantities of agrotoxics.

It is in such context that several initiatives, concerned with the development of the region, have turned to the study of viable alternatives to the tobacco.

This text tries to evidence the insustainability of modern agriculture, and presents, as an alternative to the rural development, the agro ecological model. In such context, experiences already under development in Vale do Rio Pardo/RS were investigated, in order to analyze the agents responsible for the development of the agro ecological model in the family units of production, as well as the socio-spatial changes, in order to contribute to the sustainable rural development of the region.

The major evidences of the researches allow us to statement that one of the basic conditions feasible for agro ecological practices in family agriculture is the commitment of the community involved in the process, once their achievement demand multiple information and great determination to accomplish results. In order to reach success, the organization of associations and/or rural workers cooperatives gain special importance, once they produce, in addition to mutual support, the exchange of experiences, which consist in strategies to overcome difficulties in two phases, the phase of crop growing and the phase of commercialization.

It is also essential to identify the natural environment where the agro ecological practice is developed, such as: climate, soil, landscape, flora, fauna, and others, once ecological control of illnesses and plagues is extremely vulnerable to these conditions.

It is also necessary to stimulate and prize the use of fertilizers produced in the property, in order to minimize the external dependence, reflecting in a reduction of the production cost.

**Keywords:** Agro ecology, family agriculture, sustainable agricultural development



## **Differential Productivity and Economic Performances: Experiences from Two Rural Communities in South-Western Nigeria**

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As rural policy evolves in response to the changing demands placed on rural and traditional communities by most African governments, agricultural technologies and innovations that can be sustained, it is becoming increasingly necessary that we understand the underlying cultural practices that generate community and local disparities in terms of subsistence.

This paper reports findings on productivity and, in effect economic performances from two settlements which are typical for rural south-western NIGERIA. One a migrant “Cattle Fulani” settlement (mainly cattle rearers) and two, a “peasant farmers” settlement. In addition to rearing cattle, the cattle Fulani grow few food crops to meet subsistence needs. The “land owners” on the other hand are essentially peasants whose means of livelihood rests entirely on scattered plots of cultivated lands.

A controlled and monitored survey was carried out to, among other things, assess the subsistence productivity levels of the two settlements which make use of organic manure, composed mainly of cattle, goat and sheep dung and droppings from fowls. The survey was then extended to dig deeper into the farm level economic implications of this soil fertility improvement practice and its impact on household livelihood. The authors explore the results of the interim analysis to determine model structures that define sustainable indigenous land management practices emanating from consistent and adaptive use of organic fertilisers.

**Keywords:** Cattle Fulani, landowners, organic fertilizers, organic manure, peasant farmers, South Western Nigeria

## **Land Use and Household Economy in H'mong Mountainous Farming Systems in Vietnam — the Case of Mai Son District**

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The development of farming and forestry based systems in the mountainous regions of Northern Vietnam lead to an extension of the agricultural land to the detriment of forest area and the environment (DOPPLER, 1999). In addition, increasing population pressure and non-adapted land use practices lead to land degradation, which threatens the future food and income security of the population in this area. To overcome these problems, a shift towards more sustainable land use and stable living standards is required. A representative sample of 50 H'mong families and 25 black Thai families builds the basis for analysis designed to: investigate land resource availability under its capacity and the potential of management and exposure to resource overuse and its specific features; understand and explain the relationship between availability and utility of land, compare living standards of families; develop and simulate future development of sustainable land use in the mountainous farming systems. There are significant differences of the total average area per farm between H'mong villages (ranges from 2.09 ha to 2.88 ha) and black Thai village (3.65 ha). Most of H'mong land is sloping (250 to 450). Thus, easily eroded and degraded. Typical features of H'mong farming systems are: Mono culture with short fallow even without fallow or crop rotations; only maize, cassava and upland rice are grown; low input and land use efficiency. Family income/year of H'mong farmer (from 80 to 125 US\$) is nearly half of that of black Thai farmers. Most of this income comes from farm activities. It is still less than income of the farmers in red river delta from the year 1998. The H'mong farmers start from very difficult conditions (little land, degradation problems, poor infrastructure, far away from the market) than the black Thai, therefore their living standard is still lower than the other in this mountainous area, and an optimal strategy for sustainable management and use of land to improve farmers' living standard on the level of farming systems is expected to be identified.

**Keywords:** Farming system, land use, Vietnam

## **Women's Role in Iran's Rural Development**

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Most development planners believe that the human resources of a country are the major factors in social change and economic growth. As about half of the human resources are women, they are an essential goal and issue of development policy. The increasing cooperation of women in production of agricultural products, for example, is one of the indicators of social development. Since most of the population of Iran inhabit rural areas, the importance of the rural women's role as half of the rural population of the country can be considered effective in the process of agricultural production which leads to economic development of rural areas. It is observed that rural women present in the socio-economic scene of society, by performing their different roles, including management of home economy, educating children, working on the farm, etc. function as an always active element of society. Although, having a multi-aspectual role, they are not given the proper recognition they deserve. Their role in economic development is left unconsidered. In Iran, in the agricultural field, in many cases, the women's role is more difficult than men's. Such as transplanting, weeding, and carpet weaving ... etc. Their status is lower than that of men. The productive role of rural women is not visible and is rarely recognised economically and socially. The contribution of female labour is estimated at 40 % of the agricultural labour. They have no rights of access to resources. The above mentioned activities are not even considered in the official statistical records of the country as a business or productive activity. Unfortunately up to now Iranian rural women have not been considered seriously in development programmes although they are one of the central pillars of rural families. It seems that the first step would be an accurate assesment of their situation and an indication on rural womens' abilities, limitations and deprivations in the different dimensions of life (economic, social, cultural backgrounds). The favourable and necessary background for guaranteeing their real place in the process of rural development is yet to be developed.

**Keywords:** Rural development, women

## **Socio-Economic Assessment of Farming Systems of Different Ethnic Groups — a Case of Northern Thailand**

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Rural development of Northern Thailand from both, highland and lowland sites generated different processes of natural resources degradation that question the sustainability of the rural development and security of living standard. The study aims to examine how the differentiation of resource availability, environment and ethnic groups lead to differentiation of resource use, management and living standard of farm families, and analyses the impacts of natural resource use according to differentiation of farming systems on socio-economic situation of farm families.

There are two different ethnic groups, Thai and Yao, living in different altitudes. The primary information for the analyses was collected in 1999/2000 in a socio-economic family survey in 22 Thai families, 22 Yao families at the middle altitude (Yao-mid) and 20 Yao families at the higher altitude (Yao-high).

The research is still in the process. Only preliminary results can be presented in the poster. The result shows that there is a difference in farming systems according to land and water availability. The farming system of Thai families is based on both rainfall and irrigation whereas the Yao-mid families applied mostly irrigation for fruit trees, which are the main crops. No irrigation system exists in higher altitudes. The highest of farm and family income are in the Yao-mid families due to high value lychee production with an environment favorable for lychee. According to the result of regression analysis, farm size, input intensity and access to water are the significant factors affecting the family income. In the study area, ethnic differences alone do by no means define the living standard.

**Keywords:** Ethnic differences, farming system, living standard, Thailand

## **Post-Civil War Socio-Economic Development in the Kachin State of Myanmar through Integrated Organic Rice-Based Farming Systems Using the Farmer Field School Approach**

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Over the last two years, the farmer field school (FFS) program of Metta Foundation in the Kachin State of Myanmar, in close collaboration with three local partner organisations, the KBC (Kachin Baptist Convention), KIO (Kachin Independent Organisation), and the Catholic Diocese, has achieved to lay the foundation for the development of an agricultural training and capacity building program based on the principles of the farmer field schools for organic rice-based farming systems. The three partner organisations nominated suitable persons as FFS facilitators. After the training they will conduct FFS in selected villages. Until today, two TOT (training of trainers) were conducted and a total number of 56 FFS facilitators graduated. In the rice cropping season 2001, 29 FFS have been conducted by 19 facilitators and a total number of 461 farmers of whom 86 were women, have participated in this training. In those fields, where several IPM/ICM techniques could be applied, rice yield increased more than two-fold. The economic analysis showed a net return of the IPM/ICM plots of 26.940 Ks vs. 10.300 Ks on the conventional plots. Particularly the SRI system of rice cultivation is highly productive. These first data impressed farmers and encouraged the program.

Based on an analysis of the first field FFS, it was learned that for a successful implementation of FFS a more comprehensive introduction to the community is essential. Furthermore, the senior leadership of the partner organisations has to fully support the program by linking it appropriately to the structure of their organisation, by providing the necessary staff capacity and by encouraging the local leaders in the communities to collaborate with the FFS program. Their political weight greatly supports the work of the FFS facilitators in their communities. They also play a vital role in inducing synergistic collaboration between the partner organisations in the communities. Thus the FFS are also an important contribution for the much needed peace-building process after 30 years of civil war and 8 years of cease-fire agreement during which a heavy exploitation of the rich natural resources in this mountainous state have reached a serious dimension.

**Keywords:** Farmer field school, IPM/ICM, Kachin state, Myanmar, organic rice-based farming systems, peace-building process, SRI

## Conflict Management Related to Natural Resources in South-West Burkina Faso

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Land conflicts caused by deterioration of natural resources and migration brought about by a rapidly increasing population and droughts are a rising issue in West-Africa. Areas where both pastoralism and agriculture are possible and where “modern” and “traditional” legal norms are simultaneously in use are particularly concerned. The sub-humid south-western part of Burkina Faso is such a region where violent land use conflicts between autochthonous farmers and Fulani pastoralists occur.

To investigate the conflict management strategies, a six month’s study was carried out by an interdisciplinary team in the Poni and Nounbiel Provinces. Six villages were investigated by semi-structured interviews with farmers, pastoralists and the formal institutions on district level involved in conflict management. The questionnaires covered land tenure, interethnic relations, land use systems as well as conflicts and conflict management.

Results show that the traditional land tenure system provides three ways to obtain an usufruct right to land: heritage, donation and loan. Since land is still abundant, the expansion of the crop-land area is mainly restricted by labour shortage. The population is composed of autochthonous farmers (Birifor, Dagara) and immigrating Mossi farmers as well as transhumant agro-pastoral Fulani. Social interactions among these ethnic groups vary and range from a complete lack of relations, in part due to the language barrier, to friendships across ethnic borders. There are different forms of cooperation between the ethnic groups: the farming groups (Lobi, Birifor and Mossi) often obtain cattle dung from the Fulani, sometimes in exchange for labour. The farmers work as daily labourers on the Fulanis’ fields or help them constructing houses. Commercial relations exist as well. Good farmer-herder-relations are essential for an effective conflict management and are an important possibility to increase incomes. Two thirds of the households are affected by conflicts, most of them by the farmer-pastoralist-conflict about crop damages caused by livestock. The conflicts can be managed on several institutional levels: by the concerned persons themselves, by the village’s chairman (who plays an important role in conflict management) and the traditional chief (*chef de terre*) or by the formal institutions on district level. In some districts, the inadequate and unsatisfactory way how prefectures acted in conflict cases has caused a sceptical attitude of the population. Hence, the village population does no longer involve the district administration in conflict management.

**Keywords:** Burkina Faso, conflicts, conflicts management, pastoralism

## **The Impact of Innovations and Policies Affecting Smallholder Agriculture in the Eastern Amazon: Implications for Research and Implementation**

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The semi-subsistence smallholder fallow system in the eastern Amazon is characterised by increasing intensification and market-integration. For the environment this situation results in the shortening of fallow periods and more frequent burning as part of the common slash and burn practices. For farmers, intensification and market-integration offer new opportunities but also involve additional risks.

Based on a case study analysis of the Bragantina region, located in the north-east of Brazil, this contribution first identifies the changes of the smallholder farming system and investigates their general causes. It then, specifically, considers the set of institutions that impact on smallholder agriculture, both locally and regionally. Institutions and organisations offer means for the adoption and diffusion of technical innovations, which are currently developed to secure the sustainability of the system by using fire-free, yield increasing technologies. To be attractive, those technologies must provide short-term payoffs as well as long-term sustainability of the natural resource base on which agriculture depends. Hence, private and social costs and benefits of the innovations count. The contribution also investigates the existing and emerging agricultural and environmental policies (e.g. the prohibition to burn) that affect smallholder agriculture in the study area and assesses their impact in relation to the innovations described.

While the Bragantina can be considered as a model for future developments in other forest margin areas in the Amazon region, an attempt is made to scale-up the results and draw conclusions for a broader region. Lastly, a research agenda is sketched which outlines a more profound analysis of factors that condition the dynamics of transforming smallholder fallow-based systems under different scenarios of alternative innovations and policies.

**Keywords:** Amazon, innovations, policy, research agenda, slash-and-burn

## Alternativen für eine nachhaltige Gestaltung von Agroökosystemen in Nicaragua

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Alternativen zur Gestaltung unterschiedlicher Anbausysteme mit variierten Anbauintensitäten wurden von 1997 bis 2001 in sechs Feldversuchsserien in der Pazifikzone Nicaraguas analysiert. Die Strategie beinhaltete bedeutsame Grundnahrungspflanzen wie Bohne (*Phaseolus vulgaris* L.), Mais (*Zea mays* L.), Sorghum (*Sorghum bicolor* L. MOENCH.) und Reis (*Oryza sativa* L.); sowie Sesam (*Sesamum indicum* L.) und Pitahaya (*Hylocereus undatus* BRITTON & SOSE) als Kulturen mit Exportpotenzial. In den Versuchen mit Bohnen wurde der Einfluß der Bodenbearbeitung (Tierzug, Traktoreinsatz), drei Sorten (DOR-364, Compañía, Criolla), drei Düngungsniveaus und die Inokulation mit *Rhizobium spp.* auf wachstums- und ertragsbeeinflussende Faktoren wie Pflanzenhöhe, Biomasse, Hülsenanzahl, Samenzahl je Hülse und TKG untersucht. Traktoreinsatz erbrachte 87 % Mehrertrag gegenüber der Bodenbearbeitung mit Tierzug. Die Sorten hatten mit 633, 613 und 589 kg ha<sup>-1</sup> keine signifikanten Ertragsunterschiede. Die Düngungsvariante Komplettdüngung plus Harnstoff erhöhte den Ertrag von 602 auf 887 kg ha<sup>-1</sup>. Aufgrund des Vorhandenseins von nativem *Rhizobium* erbrachte die Inokulation keine signifikante Ertragssteigerung.

Mögliche Anwendungen von Flüssigdünger aus Küchenabfällen und Schweinemist beinhalteten Versuche mit Mais und Hybrid-Sorghum. Der Vergleich zu mehrjähriger Brache und Mineraldüngung zeigte bei Mais keine signifikanten Differenzen bei wachstums- und ertragsbildenden Faktoren. Das TKG variierte zwischen 283 und 318 g und der Ertrag zwischen 4024 und 5489 kg ha<sup>-1</sup>. Sorghum konnte die Flüssigdüngung weniger gut ausnutzen, so dass der Ertrag signifikant geringer (2857...3507 kg ha<sup>-1</sup>) zu 5299 kg ha<sup>-1</sup> bei Mineraldüngung ausfiel.

Die Eignungsprüfung von 13 unterschiedlichen Reissorten beim Anbau als Trockenreis und als Wasserreis ergab für die Sorten INTA N-1, Taichung sen-10, CT 8240-1-3-5P und CT 8553-3I-MI-MC, in beiden Anbausystemen jeweils die höchsten Erträge (>4000 kg ha<sup>-1</sup> y >7000 kg ha<sup>-1</sup>).

Die Möglichkeiten des Anbaues von Sesam wurden in vier Experimenten untersucht, in welche 7 Bestandesdichten (96.150 bis 151.510 Pflanzen ha<sup>-1</sup>), die Stickstoffdüngung (64,4 bis 193,2 kg N ha<sup>-1</sup>) und die Bestimmung der kritischen Zeitspanne der Verunkrautung einbezogen wurden. Den signifikant höchsten Ertrag erbrachte mit 1100 kg ha<sup>-1</sup> eine Bestandesdichte von 119043 Pflanzen ha<sup>-1</sup>. Mit steigender N-Düngung wurde der Ertrag signifikant von 672 auf 1322 kg ha<sup>-1</sup> erhöht.

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Im Anbausystem Pitahaya erfolgte eine mehrfaktorielle Prüfung von vier verschiedenen Bodendeckern: *Mucuna pruriens* (L) DC, *Cajanus cajan* (L) MILLSP, *Canavalia ensiformis* (L) DC, *Vigna unguiculata* (L) WALP, *Dolichos lablab* (L) Sweet und die traditionelle Variante auf ihre unterdrückende Wirkung von Unkräutern, Schad- und Krankheitserregern, ihren Einfluß auf Parameter der Bodenfruchtbarkeit und auf Wachstums- und Ertragsparameter der Pitahaya. Das System mit *D. lablab* erreichte in 2 Jahren einen Ertrag von 26675 Früchten ha<sup>-1</sup>, gefolgt von *C. cajan* mit 23300–26675 Früchten ha<sup>-1</sup>. Den geringsten Ertrag erzielt mit 18525–26675 Früchten ha<sup>-1</sup> die traditionelle unkrautfreie Variante. Von den vier untersuchten Sorten (Orejona, Lisa, Cebra und San Ignacio) hatte Orejona mit 21000 Früchten ha<sup>-1</sup> den höchsten Zweijahresertrag.

**Keywords:** Agro-Ökosysteme, Ernährungssicherung, Exportkulturen, Nachhaltigkeit, Nicaragua

## **Small Credits for Rural Women: Impacts and Recommendations — a Case from Burkina Faso**

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Women in Burkina Faso contribute essentially to the living standard and food security of their families. Activities like small trade, livestock fattening, stocking, processing and commercialisation of agricultural products have the potential to increase this contribution significantly, provided that women have the required resources at their disposal. Analyses of the situation of 73 representatively selected women, who benefited from small credits that were provided in order to support these so-called remunerating activities, indicated effects, strengths and weaknesses of respective development programmes. Labour demand and parameters of economic success allowed for a significant distinction between labour-intensive and labour-extensive activities. The first type of activities yielded a high profitability already within a comparatively short period of time, while the latter required a much longer period for creating a first income. The relative competitiveness of both types of activities, however, depended crucially on the overall conditions of the women's farming systems. A successful implementation of labour-intensive activities presupposed large households with a high potential for distributing labour among the female members as well as proximity to markets for products and production means. Labour-extensive activities proved to be the better choice for women in small households with longer distances to markets. Labour-intensive activities like the production of local beer and peanut products, had much higher demands on environmental resources, such as wood and water; while gender-related reflections played a more important role in labour-extensive activities like livestock fattening. The contribution of a successful implementation of both types of activities yielded significant effects on all levels of living standard, which included income, food security and education as well as saving rates. Successful implementation, however, depended crucially on the women's freedom in choosing activities that fit into their individual situation and on an adequate set-up of the credit conditions, in particular with regard to the intended time-line of donor's engagement.

**Keywords:** Burkina Faso, credit, income generation, women

## **Resource Use Efficiency in Maize Production Under Traditional and Improved Technology in Western Ethiopia**

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In view of the growing gap between the demand for and supply of food in Ethiopia against the background of an increasing pressure on land, the efficiency with which available resources and technology are used by the farmers becomes a priority subject of investigation. It is argued that agricultural production can be increased either through an efficient use of traditional technology and practices, or through the introduction of a package of improved technologies like fertilizer, improved seeds and cultural practices provided that no production gains are possible through better use of the traditional practices. This paper uses a dual stochastic frontier efficiency decomposition methodology to derive the technical, allocative, and economic efficiency measures for a sample of 60 maize producers using improved technology, and of 35 maize producers using traditional technology in Western Ethiopia. The mean technical, allocative, and economic efficiencies under improved technology are estimated at 74 %, 82 % and 61 %, respectively, while the corresponding results under traditional technology are estimated at 92 %, 80 % and 73 %, respectively. The results thus suggest that there exists an immense potential for increasing production through efficiency improvement under improved technology as compared with that under traditional technology. By operating at full technical efficiency levels, traditional farmers gain only an 8 % increase in maize production while those operating under improved technology can gain a 26 % rise in maize output. This study, therefore, confirms that the potential for increasing production through improved performance with available resources and traditional technology is limited. Given the weak institutional support services such as extension, education and credit, the finding of considerable inefficiency in improved maize production is as expected and thus an efficient use of improved techniques of production coupled with better management of land through increased institutional and infrastructural support will help enhance maize production.

**Keywords:** Ethiopia, improved technology, production frontier, stochastic efficiency decomposition, traditional technology

## Reclamation of *Imperata cylindrica* (L.) Raeuschel Infested Land Using Cover Crops and Subsequent Maize Yields in West Africa

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Speargrass is widespread in tropical and sub-tropical zones, where land is continuously disturbed by recurrent fires, tillage, weeding, and other farm activities. Field experiments were conducted in the forest/savanna transition zone of Nigeria from 1996 to 2000 to evaluate the potential of two cover crops [velvetbean, *Mucuna cochinchinensis* (LOUR.) A. CHEV. and tropical kudzu, *Pueraria phaseoloides* (ROXB.) BENTH.] for reclaiming land that had been abandoned to speargrass. Cover crops were grown in the same plots for three consecutive years (1996 to 1998). The controls were natural fallow plots that were dominated by speargrass in 1996 to 1998. Maize (*Zea mays* L.) was planted in all treatments in 1999 and 2000. Total dry matter of speargrass before the treatments were imposed was 9 Mg ha<sup>-1</sup> and rhizomes contributed 49 % of this. At all subsequent sampling dates, plots without cover crops had higher shoot and rhizome dry matter than plots with cover crops. Dry matter of both shoots and rhizomes declined over time in plots with cover crops. Shoot dry matter was reduced to zero at 65 WAP in both cover crops; rhizome dry matter was reduced to zero after 97 wk in velvetbean plots and after 105 wk in tropical kudzu plots. At maize harvest in 1999 and 2000, there were more weed species in addition to speargrass in plots previously sown to cover crops than in plots without cover crops. Speargrass density increased from 31 shoots m<sup>-2</sup> in 1998 to 78 shoots m<sup>-2</sup> in 2000. Maize grain yield did not differ with type of cover crop ( $p > 0.05$ ). It was 60 % higher in plots with tropical kudzu ( $p < 0.0313$ ) and 102 % ( $p < 0.0013$ ) higher in plots with velvetbean than in control plots without cover crops. Maize grain yield was negatively correlated with speargrass dry matter ( $r = -0.67$ ,  $p < 0.01$ ), indicating that lower maize yield, especially in plots without cover crops, may be attributed to weed competition.

**Keywords:** Integrated weed management, planted fallow, smallscale farms

## Screening of Rice Genotypes for Early Leaf Nitrate Reductase Activity

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Previous studies have suggested that rice is ammonophilic and, as such, not capable of assimilating nitrate-N at the early seedling stage. Nitrate-N is available to rice grown under upland conditions, lowland direct seeded rainfed conditions and in the rhizosphere of flood grown or irrigated rice. Under these circumstances the nitrate reduction pathway is used which comprises a 2 step reaction involving the enzymes nitrate reductase and nitrite reductase with nitrate reductase being the most critical. The objectives of this study are: (1) to investigate, if and if yes, how early rice genotypes show nitrate reductase activity; (2) to find out if the nitrate reductase is substrate activated and/or dependent; (3) to identify rice genotypes with early nitrate reductase activity and to test them in weed-competitive environments for early vigor.

Rice genotypes have shown wide variability and considerable potential for nitrate-N assimilation. This study relates weed competitiveness to the ability of the rice plant to assimilate nitrate at early seedling stage corresponding to high nitrate reductase activity at early seedling stage.

The genotypic differences in rice cultivars representing traditional and improved glaberrima, japonica and indica groups were studied by growing the rice in culture solutions comprising of low nitrate, high nitrate, ammonium nitrate and ammonium. Leaf nitrate reductase activity was measured at 7, 14 and 21 days.

Preliminary results showed large differences in nitrate reductase activity among genotypes. Leaf nitrate reductase activity was positively correlated with the presence of ammonium in japonica and indica types but was not in traditional lowland types. Results suggest that there is a genotypic nitrate concentration threshold level that triggers nitrate reductase activity.

**Keywords:** Nitrogen management, rice, screening tools, weed competition

## GIS-Based Survey and Nutrient Fluxes in a Mountain Oasis of Oman

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Little is known about the land use system and nutrient fluxes in oases of the Arabian Peninsula. To overcome these gaps of knowledge, field surveys were conducted between 2000 and 2002 at Balad Seet, a traditional mountain oasis of Northern Oman. The oasis system investigated comprised 650 inhabitants distributed in 80 households who rent land in and out. The 386 tiny fields are divided into six terrace systems totalling 4.6 ha. Additionally about 2,800 date palms in 14 varieties cover about 8.8 ha.

Due to price/cost relationships between imported cereals and locally produced meat, the large majority of the land grown with field crops is dedicated to feeding ruminants, whereas for their own consumption farmers buy imported grain externally. The application of manure from about 200 small ruminants and 30 cattle and considerable N, P and K inputs from mineral fertilisers lead to annual nutrient inputs of up to 380 kg N, 30 kg P and 400 kg K ha<sup>-1</sup>. However, the distribution of these inputs varies greatly throughout the year and across fields and terrace systems, which is reflected in a highly heterogeneous distribution of negative versus positive nutrient budgets (–500 to 900 kg N ha<sup>-1</sup> yr<sup>-1</sup>, –66 to 140 kg P ha<sup>-1</sup> yr<sup>-1</sup> and –1000 to 850 kg K ha<sup>-1</sup> yr<sup>-1</sup>). This does not comprise the contribution of legumes to the N balance which is in the process of being quantified by <sup>15</sup>N studies.

Nutrient inputs to the palm yards as well as the usage of the harvested dates depend on the varieties grown. Typical application rates per palm tree of 1,220 g N yr<sup>-1</sup>, 142 g P yr<sup>-1</sup> and 1,848 g K yr<sup>-1</sup> to high-quality local varieties (Khasab, Khalas and Hilali) differ from nutrient inputs to low-quality varieties (e.g. Naghal and Fardh) which are around 488 g N yr<sup>-1</sup>, 57 g P yr<sup>-1</sup> and 372 g K yr<sup>-1</sup>. High quality dates are usually consumed by the farmers' families, whereas low quality dates go into feeding livestock. An overall estimate of the nutrient balance in the palm yards is subject of future investigations.

The scarcity of irrigation water in the oasis leads to its selective distribution towards the prime agricultural land in the immediate proximity of the houses. It is evident that the sustainability of the current land use system heavily depends on external incomes of the farmers' extended families.

**Keywords:** Date palm, nitrogen, nutrient fluxes, oasis system, Oman, phosphorus, potassium

## Studies on the Photosynthetic Carbon Acquisition of *Azolla-Anabaena* Symbiosis

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*Azolla* spp. is small ferns floating on water surfaces. They contain cyanobacterial microsymbionts (*Anabaena azollae*) in leaf cavity are able to fix elemental nitrogen. The combination of photosynthetic acquisition of carbon and energy and biological nitrogen fixation provides a basis for potentially high productivity of the symbiotic system. Consequently, *Azolla* have been used for centuries to fertilize rice paddies without need for supplementary manure. When combined with urea as a fertilizer, *Azolla* layers reduce the volatilization of ammonia originating from urea hydrolysis by decreasing the pH of floodwater. This effect is accomplished by reduction of algal photosynthetic activity during the day. More insight into the physiology of *Azolla* system and into the interactions between *Azolla* and *Anabaena* may increase the benefit from using *Azolla* in agriculture and in this way contribute to a sustainable land use. Photosynthesis is the ultimate source of ATP and reductant required for nitrogen fixation and there is a close relationship between both processes. Thus carbon fluxes into and out of *Azolla* and between the symbiotic partners are of interest. Studying *Azolla carolinia* and *A. pinnata* var. *imbricata* involving the measurement of <sup>14</sup>C incorporated from <sup>14</sup>CO<sub>2</sub> into symbiotic *Anabaena* filaments and *Azolla* tissues, we found that less than 15 % of the fixed carbon in the system was located in the *Anabaena*. KAPLAN and PETERS (1988), comparing net photosynthesis rates of symbiotic association and *Anabaena*-free *Azolla* plants, suggested that *Anabaena* contributes little to carbon fixation. Sucrose is assumed to be the photosynthetic product transferred from *Azolla* to *Anabaena* (KAPLAN & PETERS, l.c.). Some approaches to verify the existence of carbon metabolism in *Anabaena* symbionts are presented.

**Keywords:** *Azolla*, carbon acquisition

## **Livelihood Security and Organic Agriculture. The Case of Uganda**

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In Uganda, a high proportion of the rural population is poor or vulnerable to become poor. To them, agriculture is an important livelihood strategy. Over the years, organic agriculture has developed into a booming sub-sector and an increasing number of farmers have responded to the rising international demand for certified organic produce from less industrialised countries. Uganda is currently exporting coffee, sesame, cotton and fruits to the European Union, Asia and North America. Some of the cocoa and vanilla production is under conversion. Given the enormous drive of the organic sub-sector in a globalizing world, the question is what organic agriculture has to offer for the poor and the vulnerable segments of the Ugandan society. This paper describes the progress of a study that aims to contribute to a better understanding of **(a)** the impact of organic agriculture on livelihood security, and in particular on the asset base of farmers and **(b)** the linkages between micro-level outcomes of organic agriculture and institutional and policy factors at the macro-level. The sustainable livelihood approach is employed as an analytical framework. Disaggregated data collection will be carried out in three districts in the east and the north. Methods and tools comprise qualitative interviews with actors of the agricultural knowledge and information system of each district and participatory rural appraisal tools. Empirical data will be collected during the course of two seasons to capture seasonal variations, external shocks and response measures taken by farmers. At the macro level, secondary and primary information on policy issues such as the Plan for the Modernisation of Agriculture (PMA), certification and international markets for selected commodities will be collected and related to the outcome of organic agriculture at the micro-level to better understand macro-micro linkages. The study is being implemented in cooperation with Africa 2000 Network Uganda.

**Keywords:** Livelihood security, micro-macro linkages, organic agriculture, poverty



## **Economic Analyses of Water Quality in Farming Systems Development**

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Water scarcity in the West Bank represents a critical constraint to further expanding, or even maintaining the present irrigated areas. There is an increasing demand for agricultural water use to be restricted in favour of other water consumers, such as local communities and industry. The objective of this paper is to study the economics of different water quality reuse in agriculture in the light of the water scarcity, and whether irrigation water is being used wisely in Al Faria'a basin. Detailed analysis was conducted through farm family questionnaires, covering the various crops, different water qualities and irrigation methods commonly used. The criteria of living standard and crosses pending analysis in farming system were done according DOPPLER, 2001.

The results show that the groundwater annual abstraction was highly variable where the annual abstraction ranged from 2 MCM in the year 72/73 to 24.8 MCM in the year 99/00. The paper indicates that water use efficiency is relatively high. This is not due to good management, but mainly to the shortage of water in the irrigated areas. The analysis shows that there is a negative effect for the water quality mainly on the economics of the farm-family-household system and on crop production ( $\text{kg/m}^3$ ) and the gross margin of water ( $\text{Jd/m}^3$ ) between the three farming systems. And the analysis shows that livelihood indicators are higher where the water quality is higher than in the areas where low quality water is used to reflect the impact resulting from using different water quality in the three farming systems.

**Keywords:** Al Faria'a basin, economics, evaluation, farming system, water



# Subsession 3b: Diversity and Sustainability of Household Income

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## Diversity and Sustainability of Household Income

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Diversity and sustainability of households' income play a central role in rural households' strategies to ensure survival under difficult ecological and economic conditions. Rural households have been observed to follow a multitude of actions and practices to prepare for and cope with different kinds of risks and thus reduce their vulnerability. Those actions may be grouped into four categories: **(i)** adjusting and diversifying on-farm production activities; **(ii)** off-farm activities such as wage- and self-employment; **(iii)** capital formation; **(iv)** access to financial markets.

Actions in these different areas are interlinked in numerous ways, partly complementing and mutually reinforcing, partly competing with each other.

Strategy group **(i)** 'on-farm production diversification': farmers growing crops or raising animals under complex ecological conditions and in fragile environments have developed an amazing array of measures to cope with such vagaries as drought, differences in soil moisture and fertility, irregular rainfall, incidence of pests and diseases etc. Sequencing of planting according to rainfall, plant spacing according to soil moisture, adapting crop planting (even in a single plot) to differences in soil fertility and the selection of plant species often document a long experience and farmers' intimate knowledge of their ecological environment and highly sophisticated mechanisms to cope with its risks. Moreover, mulching, composting, using green and animal manure are other measures to improve soil conservation and fertility. Two contributions to this session, ANJA BLUME'S and AXEL DRESCHER'S papers, discuss these strategies, particularly factors of influence and successes.

Strategy group **(ii)** 'off-farm income': off-farm employment has long been found to be an important and, particularly in fragile ecological environments, an income stabilizing component of household income. STEFAN SCHWARZE'S paper discusses its importance and sources of income and analyses the determinants.

Strategy **(iii)** 'capital formation': to build up assets to provide for unforeseen events is a commonly observed human strategy to prepare for and cope with risks. Capital formation can focus on physical assets, such as trees, animals, machinery, consumer goods and jewellery. A second, important set of actions is directed to human capital formation, such as providing education for family members who, with their expected higher income, can be relied upon in times of crises. A third focus is social capital, i.e. building networks, being a member of different village groups (labour groups, credit and savings groups, women groups, etc.) and integrating oneself into family and clan networks and local organizations. CHARITY IRUNGU'S and MANFRED ZELLER'S paper analyses the factors that determine the targeting policies in poverty alleviation

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programmes of non-governmental development organizations and shows the importance of physical, human and social types of capital formation in selection.

Strategy (iv) ‘financial market access’: besides income diversification, reliance on assets and social networks, resorting to formal and informal financial services can be important strategies for rural households to address income and food security risks. The more limited the former strategies, the more important becomes the access to savings and credit markets for smoothing income and consumption. Repeated transitory food shortages tend to erode households’ income and productive base and may finally result in chronic food insecurity. Timely access to financial markets can be vital for easing transitory food shortages and can contribute to prevent chronic food insecurity. In most countries, the food insecure in need of consumption loans resort to informal financial intermediaries. The formal financial sector hardly offers this income and consumption stabilization service, in addition, it is often not easily accessible. Unfortunately, none of the papers in this session deal with this issue.

The posters grouped under this session underline the importance of plant diversity and soil fertility for food supply in home gardens (ALEXANDER WEZEL; FLORIAN WICHERN, CHRISTIAN RICHTER, RAINER GEORG JÖRGENSEN; and KATJA KEHLENBECK, NORBERT CLAASSEN, BRIGITTE MAASS). The determinants of rural households’ participation in income generation and diversification programmes are analysed and presented in SLAMET ROSYADI’s poster; and the potential of substituting synthetic insecticides by *Neem* is presented in the poster by THIES BASEDOW, MOHAMMED MUDATHIR and HAMADTTU EL SHAFIE.

In summary, the papers and posters, while not covering the entire range of issues, highlight nevertheless important research results concerning rural households’ income diversity and sustainability.

## **Managing Agrobiodiversity: Successful Farmers as Environmental Agents. A Case Study from Kenya and Tanzania**

ANJA BLUME

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Results of a study carried out between 1998 and 2002 in 18 rural, partly female-headed smallholder families in two project areas in Tanzania and one in Kenya are presented. The research focuses on sustainable livelihood strategies of successful female farmers, the role of (women's and mixed) groups, the potentials and problems of project approaches and activities, success indicators as well as field methods, paying special attention to gender aspects. A multi-method approach has been applied with main focus on participant observation.

The paper concentrates on various measures implemented as well as on trickle-down effects of the farmers and self-help groups researched on their social environment. It is demonstrated that successful female farmers and self-help groups show positive effects on their natural environment through carrying out measures like tree plantings, natural tree regeneration, organic farming, promotion of traditional medicinal and food plants, physical measures, techniques of sustainable water and energy management, zero-grazing and fodder banks, off-farm income generation, etc. Within this context, practices related to organic farming like mulching, composting, the use of green manure and animal manure are central with regard to soil conservation, soil fertility and income increase. Additionally, off-farm income seems to be crucial within the context of farm stability and livelihood improvement.

Furthermore, farmers and groups have got a decisive influence on their social environment. In fact, they function as knowledge carriers and multipliers and consequently take over the role of important mediators between projects and local people, especially marginal groups like female-headed households and resource-poor farmers in general. The findings apply to 'open-minded' men (e.g. husbands) as well.

Various closely linked success indicators have been sifted out on farm and project level, being responsible for the success or failure of project measures.

As one of the most important outcomes, the study shows that qualitative field research based on participant observation is a promising approach: it not only contributes to mutual understanding between researcher and participants as well as to intercultural exchange but it is also a valuable method for the collection of additional, complementary and specific information.

**Keywords:** East Africa, gender, natural resource management, successful farmers

## **On Targeting and Outreach of NGDO Safety Net Programmes: Evidence from Rural Kenya**

CHARITY IRUNGU, MANFRED ZELLER

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Targeting limited resources in the context of poverty alleviation to a subgroup of the population, who need them most remain a challenge to most development agencies and policy-makers. Though widely recognised as an attempt to reach the poorest of the poor, targeting is however not always straight forward to implement and a poorly targeted intervention could end up being more costly and less effective than one that is randomly allocated or made available to all households. Due to limited resources and the small scale of operations, most Non Governmental Development Organisations' (NGDOs) practice targeting to limit access to the interventions to only a select group of individuals considered to be most in need.

This paper examines the targeting performance and depth of outreach of two child-safety net programmes in rural Kenya funded by Christian Children's Fund/Kenya and Compassion International/Kenya. Targeting in both NGDOs is done at two levels. Geographical targeting is used to locate a programme area and household-level targeting is done on the basis of local community knowledge. Data for this paper were collected through a household survey of 120 randomly selected households, stratified equally into participants and non-participants, in which a detailed questionnaire was used. In addition data from in-depth studies of the two programs are also used to complement the household survey.

The paper analyses the extent to which children from 'the poorest' households are included in the programmes. Relative household poverty is assessed through use of a poverty index, developed from a set of selected poverty indicators using Principal Component Analysis (PCA). An econometric model is specified to identify the determinants of participation. Results show the importance of the human, physical and social types of capital in enhancing selection. The role of the local socio-political power structure is also evident in the selection process.

**Keywords:** Depth of outreach, NGOs, relative poverty assessment, targeting

## **Determinants of Income Generation Activities of Rural Households in Central Sulawesi, Indonesia**

STEFAN SCHWARZE

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The Lore Lindu National Park (LLNP) in Central Sulawesi, Indonesia, hosts some of the world's most unique plant and animal species, but logging as well as agricultural activities threaten its integrity. Around the national park land, which is suitable for cultivation is already scarce and the extension of commercial tree crops and slash and burn agriculture is increasingly taken place inside the LLNP. It is not a disregard for the environment that drives rural households into the forest margins, but rather the lack of other income possibilities.

Therefore alternative income sources to reduce the pressure on the national park are needed. Such an income diversification has also direct benefits for the households. It reduces risk and fluctuations and may also lead to an increase in total household income. This paper seeks to analyse the determinants of the composition of the total household income in order to better understand the constraints of higher non-agricultural income as well as the diversification of income sources.

Income from agriculture accounts for 62 % of the total household income with 96 % of all households participating. Important income sources outside agriculture are non-agricultural wage labour and self-employed income, which account for 15 % and 17 % of the total household income, but with only one-third of the households participating. By using econometric models (ordinary least squares and 2-stage least squares) the determinants of the total household income as well as the shares of different income sources will be analysed.

Data was collected in 2000 and 2001 through standardised, formal questionnaires from 292 randomly selected households out of 12 villages around the LLNP. It is part of the Collaborative Research Centre 552 "Stability of Rainforest Margins".

**Keywords:** Income generation, Indonesia, peasant households, regression models



## **Homegardens in African Spaces — Management of Sustainable Production-Systems and Strategies for Household Livelihood Security**

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This presentation emphasises the importance of home gardens for food security of the Zambian and Zimbabwean population. Home gardening is part of the entire food system, which is different in urban, peri-urban and rural areas by various reasons. In the urban context, becoming more important recently, home gardening is part of the urban micro farming system, consisting of many agricultural activities within the cities, including urban forestry, and small scale animal husbandry. The study areas were located in Lusaka as well as in the peri-urban fringe of Lusaka and rural areas of Southern and North-Western Provinces of Zambia and the Masvingo Province in Southern Zimbabwe. The “typical” home gardens (small production units near the house with subsistence oriented production) are only to be found in cities, especially near water sources.

Especially in rural areas home gardens are very often far away from the homestead, nearly invisible and overlooked components of the households strategies for sustainable food security. Therefore there is need for a new, more flexible definition of home gardens. Home gardens are considered to represent models of sustainable agricultural production systems for many different reasons. Their contribution to organic waste recycling, high soil fertility, high species diversity and manifold contributions to the social welfare of the people are some of these aspects.

A combined home garden/livelihood-model was designed which shows the inter-relationship between the political, cultural, environmental and physical environment, the household and its decision-making and the results of the household activity with respect to home gardening. This model is applicable to any environment and helps to understand why some families do home gardening while others do not. The model can assist to understand at least some of the factors influencing this activity. The household itself is based in the centre of the model. Internal and external factors, e.g. available assets like e.g. labour availability, access or “entitlement” to resources, education, occupation, etc. determine the vulnerability of the households and its decision making. Still one major component — the “black box” — needs to be more elaborated, this is the household decision making itself.

**Keywords:** Home gardens, household food security, livelihood security, Southern Africa, sustainable production systems

## Soil Fertility Breakdown in Soils of Subtropical South Africa Used as Kitchen Garden

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Cabbage plants at one plot ( $L_1$ ) showed chlorosis and necrotic parts on the leaves. At another plot ( $L_2$ ), the plants grew better and did not reveal any symptoms, but the yield was low as well. Nutrient deficiency was not confirmed by the analysis of plant material. In this study we tried to analyse whether these deficiency symptoms were related to specific soil physical, chemical or biological properties. Samples were taken from an ecological homegarden close to Pietermaritzburg, subtropical South Africa. Soil samples were taken at three depths (0–10, 10–20, 20–30 cm) from two plots that are close together. The two gardens did not differ significantly in particle size distribution at any depth. The mean contents of sand, silt and clay were 13, 42 and 45 %. The bulk density was significantly larger at site  $L_1$  at an average of  $1.25 \text{ g cm}^{-3}$  in comparison to  $1.04 \text{ g cm}^{-3}$  at site  $L_2$ . Also, the soil pH was significantly increased at site  $L_1$  with an average of 5.6 in comparison to 4.0 at site  $L_2$ . Soil organic C, microbial biomass C, ergosterol, and basal respiration all declined markedly with depth. The basal respiration rates were similar at both sites on a depth-specific level, contrasting the contents of soil organic C, microbial biomass C and ergosterol, which were significantly elevated at site  $L_2$ . If the concentrations were converted to the total amounts stored per hectare at 0 to 30 cm depth, soil organic C was only 10 % (18.9 versus 17.2 t) larger at site  $L_2$ , but microbial biomass C was 110 % (1680 versus 790 kg) and ergosterol even 220 % (5.1 versus 1.6 kg). The ergosterol-to-microbial biomass C was nearly doubled in the new garden soil at 0–10 cm depth in combination with maximum microbial biomass C content. The microbial biomass C-to-soil organic C ratio ranged from 0.25 to 1.10 %, declined markedly with depth and was almost doubled at site  $L_2$ . The metabolic quotient  $q\text{CO}_2$  revealed strong depth-specific variations of between 18 to  $38 \text{ mg CO}_2\text{-C d}^{-1} \text{ g}^{-1}$  microbial biomass C at site  $L_1$  on a two to three times larger level than at site  $L_2$ .

**Keywords:** Basal respiration, biomass N, ergosterol, microbial biomass C

## **Crop-Diversity, Soil Fertility and Management of Homegardens in Central Sulawesi, Indonesia**

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Changing primary forest to agricultural production systems frequently used in an unsustainable manner has increased in Central Sulawesi as much as in other tropical regions. Forest margins are particularly concerned. Therefore, it is urgently necessary to promote sustainable production systems. Homegardens are generally regarded as a sustainable production system that additionally contributes to biodiversity conservation.

As part of the collaborative research program SFB 552 (STORMA — Stability of Rainforest Margins in Indonesia), 30 homegardens randomly selected from three villages were investigated for their crop diversity, soil fertility, and garden management. Overall 149 crop species were determined, about 25 of which were fruit, vegetable, spice, or medicinal plants, respectively. Among others, the remainder species were used for beverages and stimulants, staple food, firewood or building timber. More than half of the about 35 weed species occurring in the homegardens were used as medicinal plants. The spectrum of species cultivated in the homegardens was different among the three villages. The Shannon-Index was used for assessing crop diversity and comparing it between the three villages.

Soil fertility of homegardens was compared with that of adjacent agricultural areas. Soil pH and other soil fertility indicators, such as plant-available P and K as well as N<sub>total</sub> and C<sub>org</sub>, were determined. Soils from homegardens as compared to adjacent, rather acid agricultural soils mostly showed higher pH values as well as markedly higher contents of P. However, mean contents of K, N or C did not differ significantly. One of the villages contrasted strongly with the other two because of particularly low soil fertility of both homegardens and agricultural areas. Also, a significantly lower number of crop species was cultivated there. However, relations between number of crop species found in homegardens were not attributed to soil quality but largely also to socio-economic conditions of garden keepers.

Because of the long time of utilization (up to 38 years), high crop species diversity and the comparatively high soil fertility, homegardens of the region investigated can be described as a sustainable agricultural production system.

**Keywords:** Biodiversity, conservation, genetic resources, home gardens, Indonesia, soil fertility

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# Subsession 3c: Strategy, Infrastructure

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## **Strategic Challenges to Higher Education in Agricultural Sciences for Sustainable Land Use Systems Development**

HARTMUT GAESE, SABINE HÖYNCK

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In response to the challenge to secure food production, with regards to the accelerated population growth in the last decades, the achievements of the various disciplines of agriculture have been impressive. Since the 1950s, the rate of agricultural production increase has always been ahead of population growth. However it has become obvious, though, that the land use in the tropics and subtropics shows a tendency of exploitative use of resources and inappropriate extension, resulting partly in irreversible damage to ecosystems.

A lack of knowledge about appropriate agriculture and forestry practices — including the extraction of natural substances or medicinal plants from non-cultivated land — and lack of understanding of the highly complex conditions of the ecosystem frequently result in the application of destructive land use practices. The increasing concern for worldwide environmental deterioration up to the destruction of sensitive ecosystems as a consequence of population growth (man/land ratio) creates a common interest of all agricultural disciplines to respond on scientific level to the complexity of human-ecological systems which requires to establish an interdisciplinary network. Solutions for land use systems to bring overexploitation to a standstill are urgently required (BMBF, 1998).

Nowadays, generally new scientific findings with a potential for practical application in land use systems can only be generated at the interfaces to other disciplines. The focusing on specialization in science has rather hampered technical progress in some areas. Lately, a change of paradigm is in progress: Until recently, the focus has been on splitting the world down to the basic components within an ordinative framework; only now are we beginning to be more concerned with the mechanisms of interaction of all components.

The following tasks should be emphasized:

- The development of concepts for sustainable land use and protection of tropical ecosystems,
- The elimination or improvements of existing environmental problem situations,
- The strengthening and further development of institutions and institution networks engaged in applied tropical ecology research,
- The education and training of scientists in new methodologies applied in joint research projects combining disciplines in a system oriented approach.

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What should appropriate land use systems look like, resp. Which characteristics should they assume to comply with the requirements for sustainability? TIMOTHY G. REEVES, Director General of CIMMYT concluded with a view to plant production systems (certainly applicable to husbandry and integrated farming systems as well): Sustainable crop production systems have to be funded in principles of economics, environmental soundness, social equality, and political feasibility. If we aim at intensifying land use systems, specifically agricultural production systems, research has to search for new holistic approaches. We have to connect new technologies and traditional knowledge more effectively and we have to better integrate farmers and community into research, development and transfer. This approach is described with the formula  $G \times E \times M \times P$ , whereas the factor G is the “Genotype”, factor E “Environment”, factor M “Management”, and factor P “People”.

Agricultural enterprises as the major basic element of land use systems are “open systems” within a flow of change caused by the above mentioned factors. Farms, clusters of farms, micro regions and macro regions — according to the scale of observation — are subject to persisting “adjustment pressure” constantly moving the “point of equilibrium”. This is commonly referred to as the “dynamic equilibrium” of economic units which has to be maintained for a sustainability status, e.g. in terms of potential productivity of soils. This dynamic equilibrium can be determined as the respective equilibrium from which an increase (aggregation) or a decrease (degradation) is possible. The emerging question is: Which reference value is useful in a long-term view, considering the continuous change of the mentioned environmental factors and thus all related production functions and their interactions?

To allow long-term assessment of the economic development potential (considering economic sustainability and carrying capacities), external factors have to be internalized by including the ecosystem as cost and yield factors in addition to the economic-technological development. Within ecosystems and economic units exploiting resources have to be recognized as one system in both, the time and the spatial dimension, and the path of change of this system as a unit has to be considered. The increasing “relative” scarcity of land — ultimately stipulated by increasing population density and growing demands for agricultural production (provision of food, but also export production to obtain foreign exchange) — leads to an intensification of cropping and husbandry systems. These intensification processes result in differing development paths, depending on the respective ecosystem: Within humid ecosystems “ambulant production systems” (shifting cultivation) are being transferred into permanent systems of soil exploitation, requiring supporting energy input different from those required by production systems evolving in the arid tropics, where, for instance, irrigation plays a major role. The higher the trade-off between land-use system and natural environmental conditions, the higher are the demands for supporting energy (in a wider sense for all inputs) and for the kind of technical progress for the farming systems in a dynamic equilibrium or even aggregation. Growing scarcity of



land requires technical progress accompanied by increasing labor and capital intensity to maintain the dynamic equilibrium. If system factors are not adapted within the dynamic equilibrium, destructive biases might evolve.

Modern agricultural research for sustainable land use in the tropics and subtropics has therefore to follow the above mentioned formula of REEVES by forcing the association of individual disciplines within a network for modeling research. The freedom of scientific reason is the freedom of critical conscience; the prerequisite for critics is always a pluralism of independent partners who are jointly able to attain a higher level of awareness. Since collective awareness is a reflection of the institutions, in which it is generated, this awareness has to be institutionalized in higher education.

## **Rural Livelihoods at Risk: Land Use and Coping Strategies of War-Affected Communities in Sri Lanka**

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Rural societies in war-affected areas can be described as ‘distressed livelihoods’: they experience a dramatic increase in risk and uncertainty. How does this affect land use and agricultural coping strategies of small-scale farm households? This was the key research question of a multi-disciplinary, comparative village study carried out in the war-torn areas of Sri Lanka, funded by GTZ. The study employed the analytical framework of rural livelihoods promoted by the Department for International Development, UK (DFID 2000). In addition, theoretical models of risk management were instrumental in illustrating behavioural patterns of households in the war zones.

The conflict in Sri Lanka is embedded in and is an expression of existing social, political, economic and cultural structures. The civil war is not a temporary crisis, but a long-enduring feature. In such a vulnerability context, farm households have to adapt to gradual deteriorating economic trends and to cope with sudden political shocks in the form of violence. Coping strategies with a focus on short-term survival become predominant and threaten sustainable resource management and utilisation. It is essential that humanitarian agencies working in such emergency situations understand how people cope with the war in order to target their interventions more prudently and efficiently.

The study shows that changed patterns of mobility are a key response of people to adjust to the risk-prone environment. These strategies place heavy demands on the extended family network. Furthermore, access to and priority claims for resources are critical in determining differences in livelihood strategies in different communities. Limited accessibility to natural resources due to war restricts the freedom of livelihood options. Many adapting strategies of farm households reflect the declining entitlements to resources due to war and violence. Households gradually deplete their capital stock after each political crisis. Investment in sustainable land management is not rational for farm households that are uncertain about future developments affecting the fundamentals of their lives. Households therefore employ risk minimisation strategies to downsize possible losses and focus on cash earning (especially from overseas employment) and/or state welfare for survival.

**Keywords:** Coping strategies, entitlements, farming systems, land use, livelihood, risk, sustainability, vulnerability

## **Farming Systems in Northeast Brazil: Threats and Chances from Globalisation**

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A worldwide trend in agricultural sector development is the deterioration of prices for agricultural products and the impressive increase of labour productivity in this sector.

Globalisation means that within a world economy productive resources are allocated where production is most efficient. Protectionism in Brazil has temporarily protected the local farming sector from the international pressure. Later, though public indebtedness and economic instability have made a cutting of public expenditure along with liberalization unavoidable: The Plano Real has been implemented in 1993/94.

The rather suddenly exposed agricultural sector has had to catch up with its international competitors in adapting productivity increasing farm technology. This has led to a biased development of the benefits generated for individuals engaged in the agricultural sector, depending on the individual assets in terms of productive resources.

A broadly accepted public perception is that big players win over-proportionally at the expense of the small players which increases the relative poverty of the disadvantaged in a dualistic development. This undoubtedly is true for part of the sector, but the potentials of the small-scale farming sectors are often underestimated. Small-scale farming systems can adopt productivity increasing innovations for their farming systems, but they often do it more slowly than agricultural enterprises with substantial productive resources. The potential to cope with risks is much lower, innovations are introduced more cautiously.

This article argues, that the stabilization of the economic environment of the farming system, an achievement often omitted in the discussion on globalisation, creates a much more sustainable basis for the economic development than possible within a protected, but fragile economic environment. Typical farming systems in Northeast Brazil are therefore being compared in a scenario approach, considering the development in a stable economic environment exposed to world market conditions on the one hand and economic conditions as prevailing before the implementation of the Plano Real on the other hand. Focus of this comparison is the long-term development, involving investments and considering the off-farm economic environment. Of special concern are the subsistence sector and its development lines.

**Keywords:** Farming systems, globalisation, Northeast Brazil, technical progress

## **Testing GIS/RS Based Approaches for Estimating Village Boundaries — the Case of a Region in North-Western Vietnam**

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Villages with predominant farming activities depend on the availability of land resources for production. In general, the area used by a community reflects the natural resource endowment that is available for agricultural production. The level of detail as offered by available maps, which are usually topographic maps at the scale of 1:50000 is often not sufficient, because administrative boundaries are only available on the scale of communal, provincial or national level. To build a spatial basis that allows the use of GIS in farming systems research, it is necessary to find a way to attribute the villages and with them the farms to the territory used for farming. Furthermore, the spatial basis is required to analyze the natural resource endowment, and to establish the link of the spatial setting with the socio- economic characteristics of villages.

In the case of 41 villages, that belong to 4 communes in Mai Son District, Son La Province, Vietnam, three methods of village territory estimation were applied and are compared in this paper. The first approach attributes land to the villages by applying a 1000 m buffer to the around each village. In the second approach, the buffer size was calculated according to the number of farms in the village. These two approaches do not consider, which type of land cover is inside the buffer, in contrary to the third approach, in which land territory polygon are built by incorporation of additional remote sensing and GIS derived information. The paper shows the differences between the approaches and outlines potentials and constraints in the use of GIS/RS in the establishment of the above mentioned linkages. Although the differences between the polygon method and the adjusted buffer method do not show significant differences, the polygon method is considered the best available choice in village territory allocation.

**Keywords:** GIS, Vietnam, village boundaries

## Strategy in Ozone Depletion Substances in Agriculture in Developing Countries (Montreal Protocol)

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In 1974, the experts of the University of California claimed that the man-made chemicals known as chlorofluorocarbons (CFCs) were damaging the stratospheric ozone layer.

Methyl bromide (MB) and Carbon Tetrachloride (CTC) 'represents' the Ozone Depletion Substances (ODS) used in agriculture. MB and CTC are the highly effective fumigants used to control insects, nematodes, weeds, and pathogens in more than 100 crops, in forest and ornamental nurseries, and in wood products. Its primary uses are for soil fumigation, post-harvest protection, and quarantine treatments.

About 2800 metric tons of methyl bromide each year is used in the world — about 75 percent to fumigate soil before planting crops, about 11 percent to fumigate harvested commodities during storage and export, and about 6 percent to fumigate structures such as food processing plants, warehouses, and museums, as well as antiques and transport vehicles. The remaining 8 percent goes to the production of other chemicals.

There is a similar situation with CTC and other OD (Ozone Depletion) substances used in agriculture.

There is some interest in recovery, reclaiming and recycling technologies to upgrade the fumigation and soil preparation methods with focus to phase out the ODS in agriculture.

The amendment of the Montreal Protocol specify precise schedules for the reduction and phase out of ODS, there are many advantages in moving straight to viable ODS alternatives rather than trying to recover, reclaim or recycle ODS.

The UNIDO Vienna together with the Institute of Tropical and Subtropical Agriculture, CUA Prague, professional supervision implemented workshop with the field trial on 'Alternatives to Methyl Bromide in Soil Disinfection' in the Dominican Republic, held in Santiago de los Caballeros in November 2000. Technicians and farmers from the Dominican R. participated in the field trial.

The UNIDO Vienna together with the Institute of Tropical and Subtropical Agriculture, CUA Prague, professional supervision prepared the project document for the UNDP Executive Committee of the MFI of the Montreal Protocol 'Phase out of the Use of Carbon Tetrachloride (CTC) as Fumigant in Grain Storage in DPR of Korea' Pyongyang, North Korea, March 2002.

The results and information of the above mentioned projects are presented.

**Keywords:** Carbon tetrachloride alternatives, developing countries, environment, field test, fumigant, Methyl bromide, Montreal Protocol, ozone depletion substances, pesticide

## **The Impact of Outmigration on the Peasants Systems of Natural Resources Use. The Case of El Parque Chaqueño Argentina**

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The consequences of rural migration on rural space are less studied than the ones on urban places, although they could be strong in many sections of the rural environment, specially in marginal regions. Frequently stated rural unemployment might turn into a problem of labour shortage, the repercussions of which are studied in El Chaco Argentina.

Small producers tend to base their production system on family labour force and they develop a diversified production strategy. The most obvious impact of outmigration on the rural space is the diminishing labour supply affecting the labour organisation patterns of the remaining peasants. The rearrangement of labour impacts through three main transformation processes on the systems of natural resources use.

Firstly, considering that the maintenance of diversified systems demands a high amount of labour, the need to economise labour diminishes the diversity of the production systems.

Strongly related is the second process, defined as the orientation towards cash production systems that in many cases also affects the self-consumption strategies. Thirdly, the appropriated technologies, also considered as demanding plenty of labour, are replaced by labour saving technologies which are less suitable for maintenance of environmental stability.

The analysis of these three transformation processes suggests that rural migration not only produces negative environmental consequences at the places of origin but promotes also the erosion of cultural patterns. The role of small farmers and peasants in maintaining diversity and extending the appropriate management knowledge to next generation should be considered as a main strategy for sustainable development support.

**Keywords:** Chaco Region, diversity and management knowledge, rural migration, systems of natural resources use

## **The Contribution of the Conjoint Analysis for the Demand Oriented Development of the Rural Financial Sector in Vietnam**

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This paper aims to develop client-oriented financial services to improve the access of rural people to credit/savings in Northern Vietnam. A broad access to appropriate financial services has been pointed out repeatedly to be important for poverty reduction. Besides, it also improves the ability of farmers to cope with external shocks. This decreases the use of marginal areas in times of shocks and therefore supports sustainable land use. Access to credit is a piece in the puzzle of raising agricultural productivity, which again supports a sustainable land use. This is of particular concern for the uplands in Northern Vietnam.

It is the outspoken objective of the Vietnamese government to reduce poverty of rural households through improved access to credits. The government uses state-owned banks and special poverty programs for this purpose. Nevertheless, the government reaches the target group, namely the rural poor only partly. The results of the Conjoint-Analysis (CA) will contribute to a better design of adapted financial services, which will improve the effect regarding poverty alleviation. The primary data were collected between March 2001 and March 2002 among 220 households in the Ba Be and Yen Chau district in Northern Vietnam.

The CA is a methodological approach to estimate consumer preferences and to design new goods/services. These goods/services are distinct in their attributes, whereby each attribute may have different levels. The attribute/levels work as decision parameters for the clients to purchase a good/service. From the perspective of the target population, the relevant attributes/levels have to be determined in a 'participatory' process because this is preeminent for getting true-life results in the statistical analysis. Engineers and/or economists assigned with developing new goods/services may have other priorities than the potential customer. With this chosen attributes/levels hypothetical goods/services will be created. Each surveyed persons gives his/her preference for these different goods/services. For this purpose a ranking technique is applied. The combination with socio-economic data allows the differentiation of the preference structure according to market segments with distinct socio-economic characteristics.

**Keywords:** Conjoint Analysis, demand oriented financial products, rural financial markets, Vietnam

## **A National Soil Profile Database Developed for Brazil: Description and Suggested Applications**

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The increasing accessibility to computational technology is improving the use of mathematical modeling in natural sciences. Several examples of this trend can also be observed in soil science. Also, large scale phenomena and impacts, discussed on a global scale under a multi-perspective analysis are increasingly on society's agenda. Examples directly related to soil science are the expansion of agriculture on tropical forest; contamination of water resources with residues of pesticides, phosphate and nitrate used in agriculture and the degradation of soils through soil erosion. Additionally, soil scientists are increasingly concerned about global climate changes, where soil organic carbon is also a key issue. To analyze global phenomena related to soil science by modeling we need comprehensive, consistent, georeferenced and quantitative databases on national or continental scales. Robust information available in a timely manner is often more important for the improvement of the decision-making process than comprehensiveness is an important aspect for discussion. The existence of complex models, quantitatively validated in controlled experimental conditions, is not a guarantee that they will be applicable in practical conditions, if the adequate input database is not available in scale and format required for the model. The objective of this research was to create and make available a quantitative georeferenced soil database covering the total Brazilian territory. Several variables reflecting soil chemical, physical, mineralogical, morphological and pedogenetic features were included, useful for a wide range of topics related to soil science. A total of 4.000 soil profile descriptions were included in this database. The analytical description of soil properties was consisted and organized in a standard format. The multi-user aspect of this database was a major concern in defining its structure, organization and format. This database is expected to improve constantly, by inclusion of new sources of surveys and is designed to have free electronic access for any external user.

**Keywords:** Brazil, georeferenced, land use planning, soil database



## **Analysis of Water Demand and Water Availability in the Catchment of the “Haute Ouémé”; Benin / West-Africa**

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In the course of two dissertations which are part of a co-operation project named “IMPETUS” between the University of Cologne and Bonn, research is done on the water demand and water availability in Benin. The average quantity of renewable fresh water per person has declined due to the increasing size of the population and on the other hand, demand of water is rising due to higher living standards, which in the end creates competition and conflicts between consumers. In the international comparison Benin, with a fresh water quantity (surface and ground water) of at present 4.770 qm per capita & year, does not belong to the “water-stressed” countries of the world. But there are serious problems in making the ground and surface water useable to the population. The aim of the investigations is to demonstrate supply deficits depending on the season of the year, the socio-economic factors and incomplete institutional framework.

### **-Methods-**

#### **Water demand:**

1. Structured Questionnaire
2. Data collection of socio-structural informations
3. Participatory observation (well observation)

The main target of the water demand investigation is to find out correlations between socio-economic factors and the development of water consumption.

There are many socio-economic factors influencing water consumption, but easy water access seems to be the most influencing factor. The different methodological approaches give insight into most of the socio-economic aspects of water demand.

#### **Water availability:**

is a combination of the amount of the existing surface and ground water and its redistribution to the people. The following investigations take place:

1. Inventory of water resources with GPS (Global positioning system) and its presentation in a map.
2. Time analysis (investigation of the distance between the settlements and the water resources / rainy and dry season.
3. Analysis of the institutions.

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The administration and melioration of the rural water supply system lies in the responsibility of the “Direction de l’Hydraulique” or their regional counterparts, the “Service de l’Hydraulique”. There are also several NGOs (national and international), which are occupied in water projects (well building etc.) in Benin. A co-ordination of their work could make the water supply system much more effective.

**Keywords:** Benin, resource management, water, water availability, water consumption, water demand, water management, water using habits, West-Africa

## Rationalities in Cavineño Economic Strategies

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The economy of the northern Bolivian Amazon region has always relied heavily on the extraction of natural resources such as skins and hides, gold, rubber, palm hearts and, more recently, brazil nuts and timber. Although today indigenous people are among the forest owners, the monetary income generated through the seasonal extraction of timber and non-timber-forest-products in many cases is not sufficient to sustain their livelihood. Oftentimes subsistence agriculture, hunting and fishing remain the primary pillars of indigenous economies. This case study presents the findings in three months of fieldwork done in Galilea, a Cavineño community about 80 km up the Beni River from the city of Riberalta. The presentation lists the various economic problems that the community is faced with and tries to show the rationalities that underlie the behavior of the community members when dealing these difficulties. Some of the most pressing issues for the people of Galilea, e.g. the lack of wage labor and distant markets, are rather typical for many rural communities in northern Bolivia. On other economic issues, e.g. influence in regional politics or access to natural resources, Galilea has managed to avoid many of the more common pitfalls. In part, this has been due to the channeling of money and expertise from the Swiss Evangelical Mission to the community and to the placing of community members in strategic positions in regional indigenous organizations. Through these actions the people of Galilea have secured for themselves a terrain rich in natural resources and large enough to be managed in a sustainable way. By trying to better understand the rationalities in Cavineño economic strategies, the case study adds to the knowledge of how indigenous communities are active stakeholders within the national economy. The data obtained in Galilea will form part of a master's thesis in Cultural Anthropology at the University of Freiburg.

**Keywords:** Cavineño, economic strategies, extractivism, non-timber forest products, Northern Bolivia

## **Stand der Nutzung und Haltung von Zugtieren in Mittelamerika**

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In diesem Beitrag werden die Ergebnisse einer Diagnose vorgestellt, die im Rahmen der Arbeit des Arbeitskreises Forschung, Entwicklung und Neuerung von RELATA (Red Latinoamericana de Tracción Animal y Tecnologías Apropriadas) im September 2001 vorgenommen wurde. Die Zugtiere bedeuten eine wichtige Energiequelle für die Landwirtschaft Mittelamerikas, besonders bei Landarbeiten und in den Städten für den Transport von Gütern und Personen. Nach Angaben des Gusano Barrenador-Programms des Agrarministeriums in Nicaragua existieren dort ca. 56.000 Ochsen in den landwirtschaftlichen Betrieben und ca. 20.000 Pferde, die in den Städten arbeiten. Die Statistik ist allerdings nicht sehr zuverlässig. Mit dem Rückgang der Traktorenanzahl in den letzten Jahren in Nicaragua haben die Zugtiere eine zunehmende Bedeutung in der landwirtschaftlichen Produktion erhalten. Die Ergebnisse dieser Diagnose sind sehr wichtig für die weitere Forschung über die Gesundheit, Ernährung, Haltung und das Management der Tiere. Bis jetzt hatten alle Forschungsarbeiten als Ziel die Verbesserung und Anpassungen von Maschinen und Geräten für die Arbeit mit Zugtieren, aber die Tiere selbst wurden als Energiequelle vernachlässigt.

Die Zugtiere arbeiten im Durchschnitt zwischen fünf und sechs Stunden pro Tag und sechs Tage in der Woche. Mehr als 80 % haben einen schlechten Ernährungszustand und Mängel bei der Körperbildung. Sie erhalten kaum Zusatzernährung. 60 % der Betriebe haben keinen Zugang zu veterinärmedizinischen Dienstleistungen. Alle Tiere leiden unter irgendwelchen Krankheiten.

Die Situation in den anderen Ländern Mittelamerikas Honduras und El Salvador, wo auch eine Diagnose der Situation vorgenommen wurde, ist ähnlich wie in Nicaragua. RELATA steht damit vor der großen Herausforderung, die Lebensbedingungen der Zugtiere zu verbessern.

**Keywords:** Animal traction, Nicaragua

# Subsession 3d: Forestry, Agroforestry

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## **Co-evolution between Ecological and Social Systems in Tropical Forest Management. Elements of an Action-oriented Theoretical Approach**

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### **Introduction**

Tropical forest ecosystems are subject to a continuous dynamic force, which is due to natural influences or — with a rapidly increasing speed — is directly affected or induced by human activities. Existing monitoring instruments facilitate gaining rough data on changing land cover and land use patterns on a macro-level (FAO 2002). More profound insight in the effects of these changes is based on basic-sciences oriented case studies which cover a local or a regional area on a micro level.

The description and theoretical explanation of human interference underlies a similar differentiation: The macro level is related to global perspectives and national development policies. Emphasis is put on the contribution of forest ecosystems to national and global development. Large scale forest destruction and degradation fits in this category. Meanwhile the micro approach focuses on the analysis of the very specific local situation. Stakeholders' attitudes, behaviour and power relations have an influence on forest ecosystem management. All approaches are valuable and necessary, but there is a lack of linkages between the different concepts and strategies.

### **Methodological approaches**

Recent methodological developments permit the elaboration of a theoretical framework for the integration of the above mentioned levels. Components are Cultural ecology (BENNET 1976, BARGATZKY 1986), Political ecology (ESCOBAR 1996, BRYANT 1992), Hermeneutic methods (SEELAND 1997), Constructivism (BERGER & LUCKMANN 1967), the Critical theory (HABERMAS 1965, 1988), Institutional economics (OSTROM 1990) and the Advocacy coalition approach (SABATIER & SMITH 1993).

### **The macro level**

Management concepts for forestry and the respective policies were to a high degree subordinated to general socio-economic development. This can be demonstrated in a diagnosis of changes over time, which is categorised in six stages (PRETZSCH 1995). Due to the failure of technocrat large-scale colonisation and forest projects, a revival of local strategies and local stakeholder involvement occurred in recent times. Noticeable is the strong feed back to forest management related local knowledge, which in many tropical countries reaches back to pre-colonial times, sometimes even more than 2000 years. The actual development stage may be characterized by decentralisation

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of bureaucracies and devolution of forest management rights to the local population. There is also a tendency towards privatisation and rational choice-based-thinking in forest management. This is reflected by changes in institutional rules and organisation structures. Strong dependency of forest management on external influences has to be understood, which makes a continuous monitoring of determining political influences necessary.

### **The micro level**

In the current development stage much preference is given to grassroot experiences and local development. The research community responds to this with an increase in case study-based investigations. Many of the results of these studies are fragmented, not much linked to theory and to the above described macro level. Their relevance for the implementation of a better forest management often is limited.

### **Intermediate approaches, based on case studies**

Action-oriented approaches, which combine to some extent ecological and social sciences and which are linked to a macro level, permit the construction of an intermediate theoretical framework, which opens consistent new perspectives and strategies. Based on five case studies, some elements of an intermediate framework are presented. The case studies are based on PhD and MSc dissertations, which were elaborated in recent times or are being finished in the Institute of International Forestry and Forest Products in Tharandt. They deal with the economics and marketing of Gum Arabic tapping and the behaviour of involved stakeholders in Sudan (TAHA 1999), the shift of administrative power in the forestry sector of Tripura/India (SHRIVASTAVA 1999), the Khor Jor Kor movement as counter strategic forestry in Thailand (PYE 2002), Ejido community forestry in Quintana Roo/Mexico (HESS 1996) and forest enterprise analysis and development in the Amazonia (PRETZSCH et al. 2001). Each case study is linked to meta-theoretical constructs. In all cases ecological and social systems changed over time and were strongly interrelated.

The results show, that the combination between the above mentioned levels is necessary for a better understanding of the co-evolution between ecological and social systems in forest management. Further case study research should be less descriptive and more oriented towards overall theory development and action orientation. This is the platform for learning, strategy development and intervention. The case studies underline the hypotheses, that the attitude of many foresters is internally focused, passive and hierarchy linked, that there is a dominance of conventional forestry systems and a lack of inter-sector and multi-stakeholder integration.

### **Outlook**

By the implementation of more integrated and action-oriented research projects the elaboration of pro-active visions, concepts and strategies in forest management may be supported. The above mentioned theory framework, which is still fragmented, can contribute in this direction.



## Sustainability of Forest Product Use in Zimbabwe

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Forests provide a wide variety of commodities which are used by rural dwellers in tropical countries and contribute to their welfare. During the 1990s Zimbabwe experienced an upsurge in the marketing of forest products, in particular woodcarvings. The potential social and ecological impacts on forests originating from this commerce are alarming. To quantify the impacts of the woodcarving sector on the forest and to identify sustainable extraction rates, a simple growth model was developed and tested. The model was used to analyse the development of growing stock, increment, and the annual allowable cut in a miombo woodland in southern Zimbabwe. Based on an inventory and on the assessment of growth rates, various extraction scenarios for two land tenure classes (communal and private) were modelled. The optimal growing stock (where the increment reaches its maximum) of the nine tree species which are preferred for carving is approximately  $7.3 \text{ m}^3 \text{ ha}^{-1}$  and the highest potential increment at this point is about  $0.11 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$  under a 'current demand' scenario. The consumption of carving wood in the study area is around 2 trees with a dbh  $>50 \text{ cm}$  per 100 ha and year (or  $0.034 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$  of carveable wood). At present, considering the growing stock ( $8.1 \text{ m}^3 \text{ ha}^{-1}$ ) and annual increment ( $0.10 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ ), sustainable harvesting is only feasible on land under private tenure. The growing stock ( $2.7 \text{ m}^3 \text{ ha}^{-1}$ ) and annual increment ( $0.01 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ ) conditions on communal land do not allow sustainable harvests. Due to the degraded forest structure under this land tenure a decline of the species used for carving is likely to occur even if harvesting is abandoned immediately. Resource regeneration would be feasible if stands are artificially regenerated by e.g. enrichment planting. The model shows that two trees  $\text{ha}^{-1} \text{ yr}^{-1}$  in-growth in the 15 cm diameter class on communal land would be sufficient to elevate the current (low) growing stock levels over the no-use scenario. Alternatively, if the current demand of wood is maintained and if two trees  $\text{ha}^{-1} \text{ yr}^{-1}$  in-growth in the 15 cm diameter class are obtained, the current growing stock could be maintained.

**Keywords:** Forest products, growth and yield, woodcarvings, Zimbabwe

## Natural Regeneration of *Boswellia papyrifera* (DEL.) HOCHST. A Key Dryland Tropical Species in Northern Ethiopia

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*Boswellia papyrifera* (DEL.) HOCHST belongs to a tropical family called *Bruceraceae*, which contains up to 600 species in 17 genera. The family is characterized by the production of aromatic oil or resins. The resin from *B. papyrifera* is used as frankincense, which has been burning in the Roman Catholic, Greek Orthodox, and Coptic Churches throughout the world. Moreover, it has also numerous environmental, socio-economic, traditional and industrial benefits. Frankincense is a raw material in perfume, paint, paper-making and pharmaceutical industries. Hence, it is one of export earning commodities for Ethiopia and other countries. Nevertheless, the species is on the verge of extinction. It has been categorised as a species which needs priority in the conservation of medicinal and wildlife resources in east and southern Africa by various international organisations. This paper reviews the biology, ecology, methods of harvesting, and uses of the species both at national and international levels. It also depicts the plight conditions of the species through the results of a research work aiming at monitoring natural regeneration under two management situations in northern Ethiopia. The two management strategies are either to enclose *Boswellia* stands from livestock grazing and cutting, or allow free grazing but no cutting of trees. 64 plots with a size of 20 m × 20 m (32 in each management) have been located randomly in *Boswellia* growing sites in Tigray, northern Ethiopia. These plots have been assessed four times during 2000–2001. In all plots, newly emerging saplings have been counted and all species were identified. Moreover, diameter, height and frequency of trees have been recorded. Results of vegetation analysis are presented using species diversity, density, frequency and important value index. Other ecological indices are also computed. The study highlights management options to replenish this economically and ecologically important species.

**Keywords:** Area enclosure, *Boswellia papyrifera*, natural regeneration, vegetation analysis

## **Traditional Rubber Agroforests in Amazonia — a Model for Sustainability and Forest Conservation in an Ancient Frontier Region**

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The agricultural use of Amazonian uplands is characterized by the dualism of small-scale slash-and-burn agriculture of small farmers and large-scale extensive pastures of large land owners. Recently, the highly mechanized cultivation of rice and soybean has also begun to expand into some regions. Neither of these land use systems generates much income for the rural population, while the extensive land use forms, especially cattle pastures, are a major cause of deforestation and global concern. In the search for land use options for small farmers that combine sustainability, profitability and forest conservation, scientists have focused on agroforestry and tree crop agriculture, but cases of wide-spread adoption of “improved” land use methods are still rare. In the lower Tapajós region of central Amazonia, in a priority area for biodiversity conservation where agricultural land use is intensifying rapidly, small farmers have developed a land use system that could serve as a model for the sustainable use of a tropical forest landscape. In a region where the Ford Motorcompany failed with its attempt to grow rubber in high-tech plantations in the 1920s to 40s, partly due to an endemic fungal disease, small farmers have long sown rubber seeds into their slash-and-burn plots and cultivated the trees successfully in a secondary forest environment. In contrast to their much better documented Indonesian equivalent, the “jungle rubber” systems, these Amazonian agroforests remain productive for many decades, and century-old trees may still be tapped. A farm survey on the right bank of the Tapajós river, carried out in 2001–2, documented for the first time the present distribution and management of this promising land use practice. The results, some of which will be presented in this contribution, showed not only its importance for the local communities, where the rubber tree is widely seen as “the only thing that has ever brought money” to the farmers, but also threats to its persistence and opportunities for improvements and perhaps for a south-south technology exchange between Amazonian and Indonesian rubber agroforesters.

**Keywords:** Agroforestry, Amazonia, forest conservation, rubber tree, sustainability

## Doubling Returns to Land and Labour? The Potential of Improved Tree Fallow in the Humid Highlands of Southwestern Uganda

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Decreasing per capita food production and insufficient wood availability affect the livelihood of smallholder farmers in highlands of Southwestern Uganda. Fields on bench terraces are under intensive continuous cultivation without any soil amendment leading to nitrogen deficiency and a degraded soil structure. The study explored the potential of tree improved fallows in overcoming wood deficits and soil limitations.

The potential of indigenous (*Sesbania sesban*, *Acanthus pubescens*) and exotic (*Calliandra calothyrsus*, *Alnus acuminata*, *Tephrosia vogelii*) tree species as improved fallow on previously degraded land was compared to natural fallow and continuous cropping in a randomized block design with 3 replications. After a fallow phase of two years, trees were harvested, wood removed while leaves and twigs were incorporated before crops were grown. Performance of *Triticum aestivum* and *Zea mays* was assessed for four seasons. The effect of fallows on water conductivity and weed biomass and its composition was assessed.

Soils sampled showed significant ( $p < 0.05$ ) differences between treatments in their nitrogen ( $\text{NH}_4^+$  and  $\text{NO}_3^-$ ) levels, especially on the less fertile upper parts of the terrace with highest levels for *Sesbania* followed by *Calliandra*. In both the fallow and cropping phases, weed biomass was lowest in the plots with leguminous tree fallows.

*Sesbania*, *Calliandra* and *Alnus* produced over 24 tones  $\text{ha}^{-1}$  of sun-dried firewood, respectively. Farmers preferred *Alnus* and *Calliandra* for their firewood qualities and higher farm gate prices. Green manure production from tree fallows ranged from 5.4 to 1.8  $\text{t ha}^{-1}$ .

Crop performance after the fallow phase followed the trends in mineral nitrogen levels. *Sesbania* and *Calliandra* plots had significantly higher wheat and maize yield across all the four seasons. The levels of mineral nitrogen explain only 42 % of the yield differences while differences in soil physical properties are thought to be reason for much of the remaining differences as evidenced by doubled water conductivity in the fallow plots.

The yield advantage due to fallows declined over time as nutrients continue to be removed through crop harvest and soil structure deteriorated with continued cropping.

The system shows potential to double returns to land and labour and is currently under wide on-farm testing.

**Keywords:** Agroforestry, improved fallows, Uganda

## Organisational Efficiency of Water Users' Associations in Uzbekistan

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For decades the collective use of natural resources in Uzbekistan was centrally controlled. In 2000, irrigation systems were handed over to farmers during an extensive structural adjustment leading to the founding of Water Users' Associations (WUA) as means of self-organisation in several regions of Uzbekistan. In the framework of the ZEF — Uzbekistan project the administrative and organisational structure of these WUAs was studied. In order to assess the organisational structure and efficiency of the WUA's one WUA in the Region of Khorezm was investigated using the institutional criteria set by Ostrom. Those criteria define self organised associations as having clear boundaries & members, congruent rules, collective-choice arenas, monitoring etc. For the WUA in Khorezm those criteria were assessed using questionnaires, expert (7), and focus-group interviews with 37 water users between November 2001 and January 2002. The study showed an ambivalent evaluation of the situation. It was evident from the interviews that the criteria set by Ostrom for an efficiently working self-organised group of water users were only partly fulfilled. However, structure and efficiency of the organisation were positively assessed by the WUA members. The study concludes, that the criteria designed from a western viewpoint possibly are not generally applicable in a Central Asian connection. The criteria would have to be adapted to the socio-cultural environment to take into account historic facts as for example the clan-system in Uzbekistan. Thus, a new tool would be created better adjusted to evaluate and analyse the efficiency of self-organised groups in the regional context.

**Keywords:** Central Asia, institutional analyse, self organised association, use of natural resources, water management

## **Use of Forest Resources by People in Protected Areas and its Implications for Biodiversity Conservation**

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The importance of wildlife conservation cannot be argued against. However dependence of local people, mostly marginalized and tribals, on forests cannot be overlooked either. Protected Areas (PAs), specially in the tropics, coincide with areas of human habitation with a heavy reliance on the PAs resources for subsistence and economic use. Lack of viable alternatives compels people to continue relying heavily on the Park resources which has brought many problems in its wake for the people, the forest department and most of all for the wildlife.

This paper looks at resource use by the resident human population in one of the PAs in India, the Bandhavgarh National Park, and assesses its implications for the PA. The paper is divided into three parts. The first part assesses the reliance of the resident human population on the Park resources for subsistence as well as economic use. The second part assesses the impact of this resource use on the Park; the third part focuses on possible solutions for lessening the dependence of people on Park resources and strategies for involving people in Park management.

Use of the Park resources has implications for the PA in the long run as well as for the resident people themselves. People's use of the Park resources is in direct conflict with the use of Park resources by the wildlife and in blatant flaunting of Park rules and regulations.

Continued resource use by people may prove to be detrimental for the wildlife in the long run. The point to be kept in mind though, is that this resource extraction by the resident human population within the Park is not as big a threat as resource extraction and utilization by the peripheral villages. Education, awareness generation, benefit sharing, provision of better irrigation facilities for improved productivity, increased land efficiency provide some answers for protection and conservation of the wildlife in the long run.

**Keywords:** India, resident human population, resource utilization, wildlife conservation

## **Forest Utilization and Conversion in Lore Lindu National Park, Central Sulawesi, Indonesia: Challenges to Community-Based Conservation Strategies**

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The designation of protected areas is a central policy means to conserve the high biodiversity of tropical rainforests in South-East Asia. Recent studies hold that this is a viable strategy only if local forest dependent communities are actively involved in the designation and management of these areas.

This study explores the interplay of the implementation of national law and local regulations for forest utilization in four villages in the vicinity of Lore Lindu National Park, Central Sulawesi, Indonesia.

It is shown that the local population depends on a relatively small number of forest products (mainly timber, rattan and firewood). This is mirrored in an equally small number of local rules for forest utilization. While the access to forest produce is important, a by far greater value is assigned to having sufficient areas of forest left that can be transformed into arable land. This perception of forest as a land reserve is especially prominent in communities that have faced a rapid population increase due to migration. As the demand for agricultural land and its price increase, some autochthon families are prompted to open more forest and thereby establish ownership rights. In these villages (two out of four research sites) arable land and forest outside the protected area has become already scarce in the perception of the local community.

It is concluded that in these villages community based management might not be a promising option. Clearly conflicting priorities of forest conservation (by the state) and conversion (by local communities) call for the provision of bigger financial resources, if the objective of long term conservation of biodiversity is upheld. The latter might be achieved only if the people bearing the costs of nature protection are compensated and are provided with better extension services and income opportunities outside agriculture.

**Keywords:** Community-based management, deforestation, Indonesia tropical rainforest, national parks

## Comparison of Flora Development of Area Enclosures and 'Undisturbed' Forest in Tigray, Ethiopia

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The environmental degradation in the Northern part of Ethiopia, Tigray is a well-established fact. To tackle this problem several interventions have been tried, one of which is the area enclosure. Area enclosure is a method, by which an area is protected from human and livestock interference. This methodology of environmental improvement appears to be successful, but no substantive investigation to quantify the improvement has been attempted. This study tries to quantify the improvement of the vegetation in the degraded sites of a Juniper-Olea afro-mountain forest. This is done by comparing the vegetation of different aged area enclosures, of 25 years, 5 years, 0 years, and a forest that has not been disturbed for at least 500 years. To achieve the intended objective, samples of 0.19635 ha were taken from the above four sites. In the samples the number of trees, shrubs, grasses and herbs was counted, and their species was identified. Based on the information gathered the following will be presented: a species area curve; mean and standard deviation of the basal area for trees, in the different area and for the different species; number of species and species diversity for the different areas; frequency of trees, shrubs, grass or herbs per hectare, based on area and species. Based on these, the natural progress of development can be determined. This will help in developing a strategy towards managing and improving the productivity of the enclosed areas in such a way, that the conservation of biodiversity, environmental sustainability, and some of the demands of the local people can be met.

**Keywords:** Area enclosure, Ethiopia, forest



## Effects of *Pinus caribaea* L. Plantation on Fractions of Soil Organic Matter in Savannah Soil from Venezuela

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*Trachipogon* sp. dominated savannahs cover a high percentage of territory in Venezuela. This kind of savannah developed on well drained soils characterised by poor nutrient status, low pH (pH < 5), and low content of soil organic matter (SOM). The savannahs are used as pasture land. In the Uverito zone, Monagas state, the National Government by the Corporacion Venezolana de Guayana (C.V.G) (Venezuelan Corporation of Guayana) and the Compañia Nacional de Reforestacion (CONARE) (National Company of Reforestation), decided in 1969, to reafforest the savannah with pine trees.

Earlier studies of the plantation have shown that the forest stand has induced important ecological changes in the microclimate and soil fauna. However, it was unknown how SOM has changed. SOM is the main important pool for the turnover of nitrogen and carbon in the soil. The objective of the present study was to evaluate the impact of the pine forest stand on the quality of SOM. The study compared SOM in a savannah ecosystem and a pine forest ecosystem with 24 years old trees at two depths (0–5 cm and 5–10 cm) during the rainy season (August). Microbial biomass C and N, soil organic carbon and total nitrogen as well as the carbon and nitrogen in the “Light Fraction” and the “Heavy Fraction” of SOM have been investigated.

Microbial C and N are not affected by the plantation. Soil organic carbon and carbon and nitrogen in the “Light Fraction” increased at the forest site. However, total nitrogen and nitrogen of the “Heavy Fraction” decreased significantly. The nitrogen in the “Light fraction” was about 15.5 % of total nitrogen and 71.6 % in the “Heavy fraction”, respectively. In this context it is discussed if plant N demands and lower mineralization rates in the pinus stand might be reasons for decreased total and mineral nitrogen content in the soil.

**Keywords:** Fractions of soil, microbial biomass C and N, organic matter

## **Simulation of Agroforestry Using SCUAF Model in Czech Republic Condition**

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Agroforestry may be one of a few realistic ways of sustaining forestry production on agriculturally pressured forest land. Agroforestry is a collective name for land-use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit. Agroforestry has attracted lately great attention, verging almost to become a panacea for many tropical lands, particularly for marginal areas.

SCUAF (Soil Changes Under AgroForestry) is a computer model which predicts the effects upon soils of specific land-use systems under given environmental conditions. It is designed to include the distinctive features of agroforestry. The model simulates, on an annual basis: changes in soil condition and the effects of soil changes upon plant growth and harvest. SCUAF represents a tool for tracing the linkages between soil processes (including erosion) and physical outputs.

SCUAF is not a plant growth simulation model. The user enters the initial rates of plant growth (trees, crops, and their component parts) as biomass increase per year. The model then estimates the effects of changes in soil properties upon subsequent rates of plant growth. The soil conditions and processes covered are: soil erosion, its rate and effects; soil organic matter, represented as carbon; plant nutrients: nitrogen and phosphorus; tree/crop competition for nutrients.

SCUAF is primarily intended to simulate agroforestry systems in tropics and subtropics. The previous applications of SCUAF give confidence in the model. They were done in South-east Asia and Africa. The last version 4.0 includes also default values for temperate zone. I used this computer programme to simulate an agroforestry system under the condition of Czech Republic to prove its reliability in the temperate condition. The final results will be published in autumn 2002.

**Keywords:** Agroforestry, SCUAF

## Effects of Slash & Burn Agriculture and Cocoa Plantation on the Water Chemistry of a Small Rainforest Catchment on Central Sulawesi, Indonesia

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The interdisciplinary German-Indonesian research project “Stability of rainforest margins in Indonesia” concentrates on processes and principles which facilitate the maintenance of stability at the Central Sulawesi Province (Indonesia) with the protected area “Lore Lindu National Park” in the centre of the study area. Especially the borderline of the National Park is underlying manifold stresses caused by migration, illegal logging and forest conversion with its influence on the available water resources. The effects of forest conversion, slash&burn agriculture and cocoa plantation on the hydrological cycle and the water chemistry is monitored in the Nopu catchment (2.5 km<sup>2</sup>), which is considered as representative for the borderline of the National Park.

Since September 2001 meteorological measurements and hydrological measurements of runoff and runoff chemistry at three different river sections are continuously recorded. Due to the specific land use distribution each of the measured river sections is mainly representative for one predominant land use type. To investigate the impact of forest conversion on soil and stream water chemistry, soil water samples are weekly taken using 36 suction cups at the three different land use systems. Stream water samples and precipitation samples are collected daily. The following parameters are analysed: Na, K, Ca, Mg, P, N, NO<sub>3</sub>, Al, NH<sub>4</sub>, SiO<sub>2</sub>, EC, pH, DOC.

Preliminary results show that forest conversion with clear cut and burning leads to high element losses, which are enriching the associated slash & burn river section. The natural forest section in general has lower nutrient concentrations than the slash & burn section. Element concentrations of cocoa plantation section are in between. The perkolation of the elements at plot scale and element concentration in stream water also depend on rain intensity and are therefore temporal very variable. A vertical chemical zonation can also be measured at all plots with steepest gradients at the slash & burn area. In conclusion our preliminary results show that slash & burn practice has an adverse outcome on stream water chemistry and water balance.

**Keywords:** Slash-and-burn agriculture, stream water chemistry, Sulawesi, tropical rainforest catchment

## **From Technology Transfer to Innovation Development — Experiences in Scaling up the Use of Agroforestry in Southern Africa**

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Increasing levels of poverty, food insecurity and degradation of natural resources currently characterize development in southern Africa, with land and agricultural production being a particular concern to the majority of the population who are smallholder farmers. Agroforestry plays a critical role in the development of sustainable farming systems, but access to technologies is currently limited to only tens of thousands of smallholder farmers who now use a number of agroforestry options in Tanzania, Malawi, Mozambique, Zambia and Zimbabwe. The challenge over the next years is to scale-up this use to hundreds of thousands of farming families in order that significant impact on people's livelihoods can be achieved. The objective of this paper is to review and synthesize scaling-up approaches that have been used in the region since 1997 and to draw lessons that can guide efficient scaling-up in the region over the next five years. ICRAF's goal in southern Africa is to reach 400.000 farmers with agroforestry by 2006. The effectiveness of a number of approaches that were used to address the two biggest constraints to wider agroforestry use, i.e. lack of awareness and grass-root level capacities, are analyzed. Other strategies used, such as scaling-up agroforestry through partnerships and networking and the direct implementation of pilot development projects are discussed.

Some generic issues for scaling-up innovations in rural development are distilled from these experiences and the future challenges are outlined for reaching critical thresholds in agroforestry use in the region.

**Keywords:** Development, impact, scaling-up, smallholder farmers, sustainable agriculture, technology

## **Status, Constraints and Sustainability Issues in the Agricultural Intensification of Humid Forest Inland Valley Ecosystems in Southern Nigeria**

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The inland valleys of the humid forest ecology show a considerable potential for intensified land use because of a higher rainfall regime, better water availability, higher soil fertility and lower erosion risks compared to uplands. But they are presently under utilised. The current challenge facing inland valley development is how to break the poverty cycle of rural farmers, initiate an intensification process and simultaneously maintain a sustainable land use system especially in densely populated humid forest ecologies. Various analytical techniques, (eg valley bottom ratio, land use ratio, actual production ratio, fallow index, soil preparation index, total and actual land use intensity, and cropping intensity) were used to evaluate the land use systems in a selected inland valley. The constraints to intensified (double rice crop) production given the present capacity of the resource poor farmer in the humid forest ecology were identified following an on-farm experiment. Results indicate that three arable crop enterprises; namely yam, cassava, and rice, were cultivated by farmers based on cultural prestige, food security, and commercial reasons respectively. Gross margins and returns per naira invested were highest for the rice enterprise followed by cassava and yam enterprises. But net farm income is highest for the cassava enterprise and least for the rice enterprise. Intensification of rice production in humid forest ecological zone is feasible and can increase farmer income by 74 percent. Labour costs for rice production will reduce by nine percent while capital operating costs will double with the use of improved inputs. Labour bottlenecks due to competition with upland crops, absence of mechanized dryers and storage facilities may limit the adoption of double rice cropping. Recommendations on the intensification and diversification of production in humid forest inland valleys were made based on various sustainability issues with respect to the peculiar production environment of the smallholder farmer in southern Nigeria.

**Keywords:** Humid forest, inland valley, intensification, Nigeria, sustainability



## **Session 4: Post Harvest Technology, Marketing and Policy**

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# Subsession 4a: Post Harvest Technology, Food Quality and Food Certification

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## Niche Markets: an Opportunity for Developing Countries

FRANÇOIS MAZAUD

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In the last year FAO has organized in collaboration with the GFAR (Global Forum for Agricultural Research), several regional workshops in 5 regions of the world (Asia, Africa, Near East, Central Asia and South America). The outlook of the exercise was to generate an international focus and awareness concerning the breadth of the post harvest sector and to request funds to support a global initiative for the development of the post harvest system and technologies (GIPH).

Different documents and procedures were prepared for these workshops in which a certain number of elements were highlighted, such as niche-markets.

Even if food security remains an essential consideration for most of the developing countries, exportations are seen as a major source of possible income for the producers.

For the man crops, small producers can't compete with large exporting countries, however there are some existing opportunities which are for non-traditional products. In addition, food consumption pattern is in permanent change, consumers are looking for new flavours or to discover products in their own countries that they have tasted during travel. Another factor is immigrant population that look after traditional products, or industrialists are looking for new flavours or new raw materials. The biggest markets for these products worldwide are in the USA, Europe and Japan. In this group, the Market Volume was 11 billions US-Dollars in 1997, 13 billion US-Dollars in 1998 and it was expected to reach 20 billion in 2002.

These new products could be classified as follow:

- Organic (spices and aromatic plants, fruit and vegetable)
- Ethnic (breadfruit, tamarind)
- Functional (quinoa)
- Orphan crops (quinoa, fonio, amaranth...)
- New (dragon fruit, Andean tubers, cut flower...)

Even when the importance of these cases is growing, a few is known on the specific conditions of handling, conservation and requirements. This situation could have negative impacts such as problems with the products that can be often refused in developed countries because of their own rules and regulations on food safety or quality.

There are some needs on research and analysis regarding new equipment, economical considerations, guidelines and recommendations that could help the producers

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from developing countries to fit with the requirements for exports. From the conclusions of the regional workshops post harvest stakeholders who were invited have highlighted the following weaknesses:

- limited information on the 'new products'
- limited research and development,
- lack of trained personal,
- lack of marketing intelligence

These points among others will be part of the Global Initiative on Post Harvest that FAO, in collaboration with the other institutions working on the same area is willing to design and present to an international expert consultation in 2004 for a future implementation

## **Development of a Methodology to Analyse the Post Harvest Systems**

MAURICE SCHILL

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The Post Harvest System (PHS) is including all activities, which are necessary to supply food to the consumer, e.g. harvesting, transport, storage, processing, and marketing. In addition, the PHS includes all stakeholders from the farm level to the consumer and all decision-makers. It is considered as one integrated function rather than a sequence of separate entities and as such by definition achieves an effective and efficient food supply. Moreover, the PHS is interrelated with the agricultural production as losses in PHS need to be compensated by an increase in production, with compensation increasing exponentially as the losses rise.

Most of the international donor and research institutions are focusing on the development of the production sector, whereas post harvest investments are still at an initial stage. This tendency is still valid even though development agencies increasingly recognise the important role of the PHS in the overall goals of food security, poverty alleviation, and sustainable agriculture. In the last decade, donors have placed greater emphasis on potential returns of their investments and on the efficacy of project implementation, whereby post harvest research rates of return on average are comparable to those from the production sector.

Although the system approach in agriculture was long recognized, only until the late 1990s research and development agencies started to consider it.

The present study, in the context of the PHS in Ghana, aims at developing a methodology to assess the economic impact of PHS interventions on the pre- and postproduction sector. The study deals with small-scale farmers and traders in the Sub-Saharan African (SSA) context with case study evidences from three different ecological zones. Preliminary results of the study will be discussed.

**Keywords:** Agriculture marketing, Ghana, post harvest systems, processing, storage, transport, West Africa

## **The Traditional Use of Uncultivated Plants. Does Certification Increase the Utilisation of Local Plant Resources?**

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People in Ladakh / India have always used wild plants, in their traditional diet as well as for their material and spiritual needs.

The field studies were carried out in summer 1999 and collected as much data as possible on the availability and use of wild plants in Ladakh. Interviews formed the basic information for the collection of 62 plant species in the village areas as well as at their high pastures and resulted in an extensive documentation of their traditional use in Ladakhi households. 64 % of the documented plant species are used for food, which corroborates that the intensifying cultivation of crops has increased the quantity of vegetable consumption but not the diversity.

The massive social change in Ladakh over a short space of time has influenced the utilisation and knowledge of local plant resources in the region massively. Thus cultural erosion, along with loss of diversity is a global phenomenon, the traditional knowledge and collection of wild food plants suffers of depreciation, even in marginal areas like Ladakh.

In July 1991, the EU Council Regulation No.2092/91 entered into force. Since that time uniform EU stipulations apply to production, wild crafting and processing of organic foodstuffs. The type of plant we find to be certifiable as “Wild Plant” is applicable, when there is no other human influence but harvesting.

The steps fulfilled for carrying out inspection and certification are the following ones:

- Definition of sites/zones/regions
- Definition of the normal quantities of an average harvest, with a confirmation that the habitat will not be damaged by overuse
- Collector’s list including all necessary elements

Certification and marketing may increase the value of such wild crafted plants and may be beneficial for the cultural knowledge, but the advantages and disadvantages of certification must be critically evaluated.

**Keywords:** Certification, Ladakh, wild plants

## Developing Country Requirements for the Improvement of Food Quality and Safety

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The importance of food quality and safety for developing countries is not only due to its implications for domestic public health, but also due to the need to meet the continuing challenge of international market access and competitiveness. Key areas of particular concern to developing countries are the improvement of food safety and quality for:

- **locally produced agricultural goods**, an area which is of growing importance because of changing food consumption patterns as well as the ever more complex and long distance agricultural-food supply and distribution systems, both related to increased urbanization in many developing countries.
- **imported products**. Triggered by the liberalization of international agricultural trade and WTO negotiations on reduction of tariffs, developing country markets might become the dump for poor quality agricultural products. Unless they have internationally recognized quality control mechanisms in place, they have no means of protecting consumers from food born hazards or inferior products.
- **export products** in order to comply with import country standards both official and private. Rejection rates for products originating from developing countries are unproportionally high, which has vital economic implications for many developing countries, where the share of agricultural products can make up 70–90 % of the total exports.

In order for developing countries to cope with with these new challenges, they need to participate more actively in the international standard setting bodies, adapt their regulatory framework and norms to the international standard, increase the effectiveness of government quality control systems, enhance communication and co-ordination between the different actors in the supply chain, introduce in house food quality systems at primary production and food industry level, and increase awareness of civil society on food quality and safety issues.

GTZ experiences in supporting developing countries in fulfilling these requirements will be discussed.

## Certification of Organic Foodstuffs in Developing Countries

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In the EU and USA, organic products are obtaining an increasing share in the market. The necessary inspection of farms and foodstuffs industries shall be carried out by independent institutions, so called certification bodies, which can be state-run or private.

In developing countries, still today the necessary inspections are mainly carried out by European and North American certification bodies. The high costs however, limit the market access for small producers. This kind of inspection and certification system may lead to new dependencies which is undesirable from the point of view of development policy.

The inspection and certification of organically produced goods in third countries can be carried out through:

1. Direct Certification — farms or small scale farming cooperatives, as well as processors and exporters of organic products are to be inspected by supervisors from certification bodies of the EU or the U.S.A.
2. Co-Certification — a certification body not recognized at the importers location comes into action in a third country and conducts the on-site inspection and makes a certification decision but it is finally the international certification body that issues the certificate.
3. Local Certification — inspections and certifications in third countries can also be carried out by recognized local certification bodies.

Establishing such institutions and developing legal regulations for organic agriculture in developing countries is also being promoted in the framework of the GTZ — development cooperation projects.

There are 3 options in the EU for the recognition of control bodies:

1. the supervision can be carried out by accreditation bodies,
2. the supervision can be carried out by qualified authorities in third-countries,
3. the supervision can be carried out by experts recognized by the EU inspection authorities.

The inspection and certification of organically grown products must be, in the long run, undertaken by local certification bodies in developing countries. Only this way there can be a guarantee for a cheaper and long-term secure market access for small producers. Like this, new undesired dependence can be avoided.

The GTZ has supported different local certification bodies in developing countries like Peru, Nicaragua, Bolivia, Mexico, Chile and Costa Rica, among others.

**Keywords:** Certification in developing countries

## **Post Harvest Compositional Changes of Yacon Roots (*Smallanthus sonchifolius* POEPP & ENDL.) as Affected by Storage Conditions and Cultivar**

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Yacon (*Smallanthus sonchifolius* POEPP. & ENDL.) is an under-exploited native root crop of the Andes, growing mainly in warm temperate valleys at altitudes up to 3200 m. It has sweet roots, which are low in calories as they contain oligofructans as the main component of dry matter, a carbohydrate the human body has no enzyme to hydrolyse. Rural farmer communities are beginning to extend the cultivation and processing of yacon roots into syrup, which is a source of alternative sweetener for the booming health food market. As oligofructans in Yacon tend to depolymerize into reducing sugars fairly quickly during storage, post harvest compositional changes of the root are a concern to producers and processors.

To gain more knowledge about the physiological processes during storage, two experiments with three local Peruvian varieties were conducted. The first experiment aimed at determining the influence of temperature under farmers' conditions between harvest and processing. Therefore the effect of short-term storage at different altitudes with the traditional exposure to sunlight to increase sweetness of roots was examined. The second experiment under controlled conditions addressed the long-term storability of yacon roots for potential export. Carbohydrate composition of different treatments has been determined through enzymatic analysis.

Results indicate that partial hydrolysis of oligofructans takes place shortly after harvest, leading to larger amounts of reducing sugars (fructose, glucose, sucrose). The greatest sugar conversion was reached under high temperatures and strong solar radiation, resulting in sweet, dried fruit like roots. At constant low temperatures on the other hand, a good storability and decelerated oligofructan turnover took place. To obtain a fructan rich syrup roots should be processed as soon as possible after harvest. This requires adequate community-based processing facilities in rural areas, allowing farmers to add value to agricultural output. Ecological cultivation and processing of yacon has a promising potential to increase farmers' income in low input small-scale Andean cropping systems in the near future.

**Keywords:** Alternative sweetener, marginal Andean root crop, oligofructans, sugars, Yacon



## The Vitamin C (Ascorbic Acid) Contents of Some Tropical Fruits

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### Introduction:

Fruits are very useful to man due to their nutritive value, which essentially circles around their vitamin content. One of such vitamins is vitamin C (ascorbic acid). Vitamin C is very unstable in air and is acquired mostly from unprocessed fruits. In West Africa there are so many fruits, with very little or no information about their vitamin C content. Most of the values used are estimates from values determined in other locations, most especially in Europe. Here, the ascorbic acid content of some fruits, common in West Africa, were determined.

### Materials and Methods:

27 West African tropical fresh fruits acquired around Ibadan in Nigeria were used. A titrimetric method based on the redox reaction of ascorbic acid and 2, 6 dichlorophenol-indophenol (DCPIP). DCPIP is a blue dye that changes to permanent pale pink colour when reduced by ascorbic acid. The determination is thus based on colorimetric change caused by oxidation of ascorbic acid. From each fruit species, 5 fruits were taken with 2 replications of each.

### Results:

The results obtained from this analysis show large variations of the ascorbic acid content. The results are summarised here in mg/100g of edible portions: almond nuts — 0.38; garden eggplant — 0.50; coconut pulp — 0.66; walnut — 0.82; almond fruit — 1.20; banana-Omini (round) — 1.99; coconut water — 2.48; tomato — 4.21; avocado — 4.47; banana (long) — 4.63; apple (jambo) — 7.29; water melon — 10.43; spondias (Iyeye) — 15.70; pineapple — 19.25; cocoa pulp — 22.53; lime — 23.52; bread fruit — 26.15; juju plump — 27.83; mango-onishu — 28.98; mango-olomi — 30.48; tangerine — 0.32; mango-sheri — 33.29; grape — 38.69; orange — 40.73; lemon — 40.88; pawpaw — 68.90; guava — 300.27.

### Conclusion:

The ascorbic acid content of the fruits varied very remarkably from traces in the nuts to 300 mg/100 g of the edible portion of Guava. Most commonly consumed fruits in West Africa are seen to be rich in vitamin C.

**Keywords:** Ascorbic acid, titrimetric, tropical fruits, vitamin C



# Subsession 4b: Market Structures and Fair Trade

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## **The Impact of Microenterprises on Poverty Reduction: the Case of El Quiché — Guatemala**

NICOLAS GENNRICH

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There is mounting evidence that non-agricultural revenues are an important source of income for rural households in poor regions. The returns achieved out of agricultural production are often not sufficient to guarantee sustainable livelihoods. The province “El Quiché” in Guatemala has for several decades been facing extreme poverty, malnutrition, and disruption of civil organisations due to the 36 years civil war, raising the question to what extent non-agricultural micro-enterprises (MEs) may help to reduce poverty. The main objective of this study is to identify factors influencing the adoption and performance of MEs to supplement farm income; and to assess the role of a rural development project in promoting the success of entrepreneurial activities reducing poverty of rural households. There is a broad variety of ME-branches in the study area. The main handicraft activities are weaving and embroidery. The annual income generated by weaving and embroidery is close to the mean generated by all ME-activities (US \$ 754). A relatively constant demand without seasonal fluctuations implies a great extent of income stability generated by these activities. Determinants identified with a significant impact on the adoption of ME-activities are related to education, social capital, farm characteristics, and the access to markets. Social capital plays an important role in both ME-adoption and the performance of ME-activities. The implementation of a handicraft shop co-operative supported by the project contributes considerably to reduce transaction costs and to increase profits. The allocation of responsibilities among the group members for the collective commercialisation of products and purchase of raw materials reduces transaction costs. An increasing production capacity to accomplish orders on a large scale and an improvement in the quality standard are important preconditions for rising profits. The adoption of an ME-activity is the factor with the strongest impact on the total monetary household income. Against the expectations, the results suggest that ME-adoption has no significant effect on housing and nutrition. By contrast, participation in the project is the most significant determinant with a positive impact on an improvement in the conditions of housing. The project has successfully targeted the poor regarding their nutritional status.

**Keywords:** Guatemala, microenterprise, poverty

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## **Agricultural Development in Zacatecas, Mexico**

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Agriculture still plays an important role in the Mexican economy and it has undergone a significant number of changes during the last 15 years, which have important impacts on the life in Mexican towns and villages.

After the Mexican revolution the new constitution of 1917 (article 27) aimed at distributing the large landed properties of the haciendas to the multitude of landless peones, forming the so called Ejidos, where the land belongs to the community, but each peasant works his share under his own responsibility. This agrarian reform and the formation of Ejidos was seen as a constant process. Most land redistributions were carried out in the 1930s and 1940s, however still in the beginning of the 80s some Ejidos were established. The Mexican agricultural sector was also strongly supported by subsidies and protected by taxes and tariffs almost prohibiting the import of foreign agricultural products.

During the government of president Carlos Salinas de Gortari (1988–1994) it was officially declared that the land reform was concluded, article 27 was significantly changed, now allowing the privatisation and sale of Ejido land. On the 1<sup>st</sup> January of 1994 when the NAFTA-treaty entered into operation this also meant the reduction of subsidies and opening borders for imports.

In my paper I will analyse the impact of these changes on the structure of agricultural production in Zacatecas, which is one of the Mexican states that still depend heavily on agricultural production. Special attention shall be drawn to the decay of agricultural prices in Mexico since 1994. In this analysis I will also distinguish between small and large scale farmers and have a look at the changes of the agricultural surface and the crops in the time span from 1970 to 2000.

**Keywords:** Agriculture, development, land reform, Mexico, NAFTA

## **Determinants of Urban Household Demand for Cassava and Cassava Products in Kaduna, Northern Nigeria**

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Cassava is one of the most important root and tuber crops grown for food in West and Central Africa. It is the chief source of dietary food energy for the majority of the people living in the lowland tropics, and much of the sub-humid tropics of West and Central Africa. The objective of this study is to ascertain the future of cassava in northern Nigeria by estimating and comparing the elasticities (expenditure and price) of demand for cassava with those of the other root and tuber crops.

The analyses were based on data collected by IITA/RCMD in two rounds (stanzas), between October 1999 and January 2000. Kaduna is situated in the north-central Nigeria. Three different levels of stratification were made to select respondent households. The income status (inferred from residential area and type of house) made the first level. The households were stratified into low, medium, and high-income groups. The second level was selecting randomly the enumeration areas (EAs). EAs were already designated by the National Population Commission (NPC). Then a random sample of households was selected. In view of the model, the AIDS methodology was used to estimate the parameters of the regression, as this model has a functional form which is consistent with known household budget data and satisfies the requirements of demand theory.

Results indicate that cassava is a price inelastic food and the expenditure elasticity is positive, though inelastic. This indicates that it is fast changing from an inferior food to a necessity. Gari is the most popular form in which cassava is consumed and it is becoming a highly preferred food among the relatively rich households too. This is because of its storability and ease of processing. Cassava tuber, gari, and yam are found to be strong substitutes. Cassava is often regarded as a poor mans food with low nutritional value that is only consumed by subsistence farmers who have little else to eat. Actually, cassava is an excellent source of dietary energy, and it is shortsighted to consider cassava solely a subsistence crop.

**Keywords:** Cassava, demand, elasticity

## **The Nuts and Bolts of a Theory on NTFP Trade and Marketing — The Case of Shea (*Vitellaria paradoxa*) Products from Sub-Saharan Africa**

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As part of an EU/INCO funded cross-disciplinary research project on “Improved Management of Agroforestry Parkland Systems in Sub-Saharan Africa”, trade and marketing practices of products from the shea butter tree (*Vitellaria paradoxa*) have been analysed over the last three-years. The study has been carried out in Africa (Mali, Burkina Faso, Nigeria and Uganda) and Europe (Germany, France, the Netherlands, United Kingdom).

Shea (French: karité) provides an annual bounty of nutritious fruit to rural communities esp. during the agricultural off-season. Seeds of the fruit contain a high percentage of edible oil: the shea butter. This vegetable fat is an important nutritional and economic resource for households of Western African parklands. In traditional societies throughout the zone, it is the women who are primarily responsible for collection of shea nut, as well as its processing and marketing. Exports of shea nut from West Africa constitute a significant proportion of export earnings for some countries.

The majority of exported shea is exported as raw nut though, and processed industrially for subsequent use in the food industry, mainly as a cocoa butter equivalent (CBE) in European chocolate production. A recent EU regulation allows that up to 5 % of the cocoa butter content in chocolate can be replaced by CBEs. Contrary to widespread expectations this has not led to an increased demand for shea butter. Marketing constraints have inhibited the expected boost in shea export from West Africa: unsteady supplies, poor quality of semi-finished products, low prices of alternative vegetable fats originating from South-East Asian plantations to name just the most prominent factors. Yet, growing neglect of shea tree stands causes not only an economic damage, but threatens the conservation of the parklands so typical to West Africa.

The results give insights into social and economic aspects of current shea use and trade. Together with results of the biological research carried out under the same project, they facilitate any attempts to improve marketing strategies of shea products that are not only economically viable but also socially adequate. European niche markets for biological and fair trade products appear to hold the highest potential in this respect.

**Keywords:** Burkina Faso, fair trade, Mali, marketing, Nigeria, non-timber forest products (NTFP), trade, Uganda, *Vitellaria paradoxa*

## **Participatory Learning for Agricultural Extension and Development in Future Myanmar**

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Myanmar is one of the least developing countries in South-East Asia and agriculture is the basic economy of the country. Agricultural extension approaches and methods have been changing in a number of developing countries in recent years to reflect a new development paradigm that emphasizes sustainability, institutional change, and a participatory learning process leading to local capacity building and empowerment. The purpose of this paper is to describe the agricultural extension approaches and methods that have been introduced and practiced by United Nations Organizations and international Non-governmental Organizations in Myanmar through decentralized participatory manner and to suggest the participatory extension approaches and methods for the future agricultural development in Myanmar. The main directions of reform in international agricultural extension approaches and methods for a new development paradigm and the potential of Participatory Extension Approaches (PEA) for moving the extension profession towards a development paradigm that embraces learning rather than teaching processes were focused. The nature of the PEA process is increasing awareness between all participants of each person's unique knowledge and contributing to "laying the playing field" between outside professionals and local expertise. Although the United Nations organizations and Non-governmental Organizations in Myanmar have been introduced and implemented some participatory extension, none of the government extension services in Myanmar practice participatory methods still now. The governmental staffs that are working in agricultural extension and development are used to centralized and top-down management in technology transfer processes and this is the serious obstacle for the sustainable agricultural development. The governmental and non-governmental staff working in agricultural extension and development should begin integrating the PEA methods and activities for the future agricultural extension and development in Myanmar.

**Keywords:** Agricultural extension, Myanmar, participatory learning



# Subsession 4c: Research, Extension, Training

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## **Stakeholder Involvement in Research, Extension, and Training: Option or Necessity**

HEIKE MICHELSEN

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The term stakeholder dates back to the early 1700. These were persons entrusted with the stakes of bettors. Nowadays, the term stakeholder and attention to their participation in research, extension and training (RET) are very popular. Most development agencies, research organizations, NGOs, and government departments declare that stakeholder involvement is part of their work. However, stakeholders and participation, that are addressed in the papers and posters prepared for this thematic group, are very general terms, nebulous and fuzzy, with varying meanings. This keynote paper provides an overview of stakeholder involvement in RET, presents major methods, tools and techniques and discusses key challenges.

The rapid evolution of stakeholder involvement in research and extension in the 1980s and 1990s resulted from the critique of the linear innovation model as the dominant research and extension paradigm (CHAMBERS and JIGGENS 1987). Weak linkages between agricultural research and technology transfer as a major bottleneck in agricultural technology systems resulted in the development of a knowledge system perspective. Consequently, farmers, farmers' organizations, extension organizations, non-governmental organizations (NGOs), educational institutions, research institutions, private companies, markets, and policymakers are now seen as (active) participants in a single agricultural knowledge and information system (AKIS) (ROELING 1990).

Participatory approaches or so-called learner-centered approaches in adult training developed in parallel to the evolution towards a knowledge system perspective. While traditional teaching methods, e.g., didactic teaching, emphasized the transfer of knowledge, messages or content-pre-selected by outside specialists, participatory training focuses more on the development of the human capacities to assess, choose, plan, create, organize and take initiative (SRINIVASAN 1993).

To get specific on the term participation the multi-dimensional conceptual model developed by COHEN and UPHOFF (1980) is used to describe and analyze stakeholder participation. It is based on three basic questions. (1) What kind of participation takes place? There are different stages and levels of a project or program such as decision-making, implementation, consequences, and evaluation. (2) Who participates in them? (3) How does the process of participation take place? The basis, form, extent, and effects of participation add a qualitative dimension to the evaluation of participation. As a result, participation can have a broad range of meaning. Nine main

forms of participation, from passive participation to self-mobilization, are presented (PRETTY 1995).

Who participates is closely related to the question of who are the stakeholders. According to BAWDEN (2002) four types can be distinguished. (1) Owners — who represent the powerful in the sense that they have considerable influence on the situation? (2) Community of beneficiaries — who are the community of beneficiaries who are the assumed ‘focus’ of the intended transformation? (3) Actors — who are the actors that need to be involved in the actions for change? And (4) Guardians — who speaks as guardians of the interests of those who cannot speak for themselves?

Stakeholder participation has many advantages but also some limitations. Theoretically, participation is about greater effectiveness and improves sustainability of development projects and programs. The impact on the efficiency due to higher transaction costs is less clear. Examining analytical studies on the role of ‘participation’ for development, PRETTY (1995) concluded that participation is one of the critical components of success in irrigation, livestock, water and agricultural projects. However, the literature also identifies many physical, social, political, and economical conditions that can limit or hinder success (DEARDEN et al. 1999).

Based on a literature review, a study of experiences of the Cornell International Institute for Food, Agriculture and Development (CIIFAD) that focused on stakeholder participation and the authors’ personal experiences in a multi-stakeholder project in sub-Saharan Africa, the paper highlights and focuses on ten key challenges of stakeholder involvement.

1. Relationships are not static. They evolve over time or change, as do the expectations of individuals and institutions involved.
2. Get the science right. Participatory methods, tools and approaches can be high-quality social science research and there are ways to prove the trustworthiness of findings. Using participatory methods also requires highly skilled persons to implement the approaches appropriately.
3. Find the optimal — not maximal — level of participation of stakeholders. Clearly determine who participates and who not and on which levels and at which stages. The key criteria should be that it is useful and beneficial to all stakeholders involved.
4. Involve key stakeholders. What is required to motivate all key stakeholders to actively participate?
5. Address conflict situations. A win-win situation is less likely than competing or conflicting interests. Decisions have to be made and someone has to take responsibility. But roles and responsibilities should be clear.

6. Limit complexity. There is a certain level of complexity at which projects can become counterproductive. Projects should be kept simple and remain realistic in what can be achieved.
7. Keep transaction costs low. Participatory approaches entail the danger of high transaction costs for stakeholders as well as project management and control, which may not result in greater benefits for the participants.
8. Scale-up to regional and national levels. Success (long-term) of participation will depend on the ability of scaling-up rather local successes.
9. Institutionalize participatory approaches. What is required to institutionalize participation to make changes sustainable?
10. Implement what you preach. How participatory are institutions (i.e., donor organizations, international centers, international universities) themselves that promote participatory approaches?

Stakeholder participation in RET is a very convincing concept for the success of local development projects, but very complex and difficult to implement. Stakeholder involvement is a necessity but how much participation in what aspects of a project depends on whether or not it is important, useful and beneficial.

## A Participatory Appraisal of *Imperata* Management Strategies for Sustainable Land Use in the Sub-Humid Savannah of Nigeria

PATRICK KORMAWA<sup>1</sup>, JIM ELLIS-JONES<sup>2</sup>, SIMON IBANA<sup>3</sup>, DAVID CHIKOYE<sup>1</sup>, S. SCHULTZ<sup>1</sup>, O. K. NIELSEN<sup>1</sup>, B. DOUTHWAITE<sup>1</sup>, U. UDENSI<sup>1</sup>

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Increasing spread of *Imperata* in the sub-humid Savannah of Nigeria has had many negative results threatening the sustainability of the natural resource base and livelihood of farmers. A community-based participatory approach (PA) was conducted to identify current and alternative technologies for controlling *Imperata*, which support sustainable land use. The PA involved *Imperata* infestation mapping, livelihood analysis, wealth ranking, crops and constraint prioritisation as well as farmers' evaluation of control methods.

Results of the PA showed that farmers commonly used hand weeding and herbicides as well as fallow and burning. High crop yield, income, type of crop(s) grown, capital, chemical, knapsack and labour availability, knowledge and sustainability criteria were the major determinants for the choice of control technique among different wealth (or resource) categories of farmers. Ensuring household food security and prevailing land ownership rights governed the choice of crops grown as well as investment in land management technologies for sustainable *Imperata* control. Farmers' evaluation of weed management techniques ranked herbicide as the most effective method of controlling *Imperata* particularly in maize, cassava and cowpea rotation cropping systems. The combination of *Mucuna* and hand weeding was second and third was the combination of *Mucuna* and herbicides. Other methods favoured by farmers included the use of improved cassava that shaded the *Imperata*, fallow and burning as an emergency control method. These methods reduce labour requirements, may increase costs but can contribute to higher income, food availability, and land sustainability. These control methods were the most preferred by resource-poor farmers, but are least likely to be adopted. It will be important to increase local awareness about problems associated with bush burning, ensure ready availability of materials, increase farmer knowledge of alternative control options, and increase access to credit. These will enhance improved management of *Imperata*, providing options for all categories of farmer.

**Keywords:** *Imperata*, participatory approaches, alternative technologies, sustainability criteria, herbicides, *Mucuna*, resource-poor farmers

## **Institutionalizing Demand-Driven Agricultural Research: Experiences with the Management Cycle of Agricultural Research in Benin**

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In the framework of the master plan of agricultural research, a management cycle at eco-regional level is implemented since 2001 covering one agricultural year and being the main instrument for implementation of regional research programs with a medium term horizon. These have been conceived with the involvement of numerous stakeholders and users of research results in 2000.

The cycle comprises the following elements:

- During the annual meeting of the regional committee for research and development research (CRRD) results are evaluated by users and decisions on their use in extension or further research are made. New potentials and/or constraints are identified and constitute the framework for research in the following year.
- Implementation of research according to the decisions of CRRD is steered by a competitive fund. Researchers of the NARS submit proposals following standard structure and criteria which then are reviewed by peers from INRAB, university, NGOs, extension and peasant organizations. The ranking of proposals is based on strategic, scientific and methodological relevance and on competitiveness. Funding is allocated to about 60 % (66 of 133 in 2001, 71 of 108 in 2002) of submitted proposals. Significant improvements in demand orientation and scientific quality have been achieved during the first two years.
- M&E during implementation is focussed on methodological and organizational advice to participatory OFR and helps to identify needs of complementary training.
- For exchange of experiences and to prepare the subsequent meeting of CRRD, a scientific workshop is organized. Proceedings of the workshop help to capitalize results.
- The cycle is completed with the next meeting of CRRD which initiates the new cycle.

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The management cycle has stimulated interdisciplinary and inter-institutional collaboration focussed on articulated demand for technologies. Perspectives are

- Improvement of representativeness of users
- Strengthening of local committees on village level for priority setting and evaluation of results
- Raising of funds for increased sustainability of the competitive fund
- Transfer of the cycle to other research programs and application of the cycle management to contractual research (ongoing)



## **Wildlife Co-Management in Kenya: an Empirical Analysis of Landowners' Incentives for Participation**

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Collaborative management (in short co-management) has increasingly become important because it seeks to create negotiated agreements between state and local communities (other stakeholder groups may also be included) and, therefore, offers a possibility to overcome conflicts over natural resource exploitation. However, achieving successful co-management is confronted with many challenges, one of the most pressing being achievement of effective participation of the landowners or resource users in the management process. Moreover, it has remained unclear as to what kinds of incentives would motivate landowners to become stakeholders of co-management arrangements in nature conservation and maintain their participation throughout the process.

Taking two wildlife conservancies in Kenya as an example, this paper analyses the kinds of incentives that make landowners participate in collaborative management arrangements. The fieldwork for the results presented in this paper was conducted in the wildlife dispersal areas of Shimba Hills National Reserve and Amboseli National Park in Kenya, where a total of 136 households, based on two stratified random samples, were interviewed.

To assess the economic incentive for participation, a financial benefit-cost analysis is performed. For both study areas, this analysis shows that investing in wildlife conservation is not financially viable to the landowners. In order to study other incentives, a two-stage least squares econometric model is applied. The results show that — under conditions where cash benefits are fairly distributed to the landowners — receiving benefits from nature conservation is a strong incentive for participation. Landowners are also motivated to participate because their involvement in the co-management arrangements enables them to protect their own property rights, reduce losses from other economic activities (e.g. livestock farming), safeguard human life, and derive non-cash benefits from infrastructural developments by the state and conservation non-governmental organisations.

**Keywords:** Benefit-cost analysis, biodiversity management, co-management, incentives for participation, wildlife conservation

## **Agroindustry R&D Partnerships in Chile and Uruguay: Cases of Public-Private Partnerships for Agroindustrial Development**

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This paper explores existing and emerging patterns of institutional innovation in agroindustry research and development (R&D) in Latin America. It elaborates on examples for public-private partnerships for agroindustrial R&D in Chile and Uruguay. This is done at a time when many small to large private companies around the world but also government institutions involve in various kinds of partnerships, for strategic reasons motivated by the aim to increase their innovative potential on more complex and more competitive global markets.

Though there has been a lot of thinking about the objectives and expectations regarding partnerships in R&D, little attention has so far been paid to the empirical question how partnerships actually function and what the effects of those partnerships are. In particular, there is no formal and accepted way of evaluating the value of partnerships, be it to the private agroindustry company, the research organization, and the society as a whole. Our study aims to contribute to the understanding of how public-private partnerships in agro (industry) research create and evolve and which factors lead to their success. The study describes examples of successful agroindustrial research partnerships in Chile and Uruguay and analyzes their contribution to agroindustrial development.

We suggest that public private partnerships for agroindustrial research develop in a cycle in which we see five subsequent steps. We then highlight the difficulties of evaluating R&D partnership and in response to those we suggest a holistic partnership evaluation approach which includes three evaluatory dimensions: (i) output evaluation, (ii) process evaluation, and (iii) evolutionary evaluation.

Having set this methodological framework for partnership evaluation we present two case studies, which support our position that institution issues warrant much greater attention if productive partnerships and successful technology development from R&D are going to take place. Main success factors for partnerships are identified. On a whole the case studies presented suggest that the partnership approach for agroindustry research is a means of development that can be used by governments and donors who focus on development of the agricultural sector with widespread impact on the actors in agrichains.

**Keywords:** Agrichain, agroindustry, Chile, Latin America, partnerships, public-private, research, Uruguay

## **The Efficiency of the Extension Workers in Improving the Adoption of the Environmental Friendly Methods by Small Scale Farmers**

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Over the last twenty years, the environmental approach has been growing in the whole world considering many sectors of production. Mainly, the agricultural and food sectors focus on improving the level of quality while keeping the level of production.

The main objective of this study is to analyse the efficiency of the agricultural extension system in supporting, improving and developing the level of adoption by small scale farmers in the field of environmental friendly methods of production in Egypt.

To measure the efficiency of the extension system, a sample has been taken from the governmental extension institution (GEI), non-governmental institutions (NGEI) and farmers in the valley area of the Nile. The extension workers' levels as a connection and change agents between the extension system (GEI and NGEI) and farmers has been considered. Surveys and Focus Group Discussion were the main methods of collecting the data.

Quantitative and qualitative methods of analysis have been used to measure the success of the extension system and the main problems faced in their work. Mainly, there is a shortage and misunderstanding of the role of extension on this level by extension workers themselves.

The level of education of the extension workers has a significant effect on the communication channels and the adoption level of farmers under 0.01 according to t-test value. On the other hand it has a great effect on the participation of the extension workers in the training courses to improve their own level of efficiency, under the level 0.05 of the t-test value. Problems are mainly focused on the shortage of the needed materials; locations for meeting and advising; and the non effective co-operation between the farmers and the extension system.

## **Documenting Water and Soil Conservation Techniques in Niger to Better Target Extension Activities**

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Intensive agriculture in dryland regions containing marginal lands and high population is leading to degradation of the available resources. The three most important agriculturally induced degradation processes are erosion, nutrient mining and organic matter decline.

Development programs dealing with the management of natural resources have often given disappointing results for various reasons. The most important and often cited reason is the lack of attractive direct or indirect monetary returns and the farmers' inability to perceive the long-term problems associated with land degradation. Therefore, training of the people involved in such programs is an essential component to better focus the technologies and to demonstrate the potential benefits. This also includes the development of efficient extension materials such as posters and leaflets.

To better target the technologies, existing soil and water conservation technologies used by farmers, development projects and non-governmental organisations (NGO) have been documented in a detailed database in Niger using the WOCAT (World Overview of Conservation Approaches and Technologies) methodology. The approaches used by the development projects and NGOs to introduce these technologies were documented as well. Further, the survey elicited farmers' perceptions of the effectiveness of the different conservation technologies.

The database, which at present describes 31 technologies and 9 approaches, was established by a Nigerien soil and water conservation association (ANCES). This association was created in order to establish an exchange of knowledge and technologies on soil and water conservation between research and development organisations.

On the basis of this database, appropriate technologies that are currently available and which have the potential to ameliorate degraded lands or prevent further degradation are identified with the participation of researchers, development workers and NGO representatives. For these technologies, special training programs as well as extension materials are developed and presently tested in several resource management projects in Niger. In a next phase, the technologies will be vulgarised involving other NGOs and farmers.

**Keywords:** Extension, water and soil conservation, West-Africa, WOCAT

## **Food Security through Seed Security: Experiences from the Integrated Food Security Programme — Eastern Kenya**

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Mwingi District located in the semi-arid lands of Eastern Kenya with bimodal but erratic/ unreliable rainfall, experiences frequent and recurrent droughts and subsequently food crop failures that result into food and seed shortage with its consequences on food security for the majority the resource poor farmers. Seed scarcity occurs in terms of quantity, quality and timely accessibility to the farming community. However, over time farmers in the district have developed some ecological, cultural and socio-economic coping mechanisms and strategies availing and accessing seeds. Nevertheless, more often these mechanisms have limitations. The application of participatory approaches and stakeholders' collaboration processes have been confirmed effective and efficient in strengthening the farmers' capacities in seed production and/or accessibility, subsequently enhancing food security in the target communities and creating more opportunities for other stakeholders in the sector e.g. commercial seed companies, local seed stockists and agricultural research institutions.

**Keywords:** Community participation and linkages, food security, formal and informal seed sector, seed security, stakeholders

## **Das “Projet Agricole et Social Interuniversitaire”. Agrar- und Geoökologisch Orientierte Hochschulkooperation in Forschung und Lehre zwischen den Universitäten Mainz und Butare (Rwanda)**

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Zwischen der Johannes Gutenberg-Universität Mainz und der Université Nationale du Rwanda in Butare (UNR) besteht eine Universitätspartnerschaft, die mit der Einrichtung des Projet Agricole et Social Interuniversitaire (PASI) 1985 begründet wurde. Im Rahmen dieses Projektes arbeiten Mitarbeiter beider Hochschulen gemeinsam an der Optimierung ökologisch angepasster Landnutzungsmethoden.

Anhaltend hohes Bevölkerungswachstum und nachlassende Flächenproduktivität sind Gründe für die Krise der kleinbäuerlich strukturierten rwandischen Landwirtschaft. Um die Produktion zu erhöhen, wurde jahrzehntelang lediglich die Anbaufläche vergrößert, es erfolgte jedoch keine Steigerung der Flächenerträge. Aufgrund verkürzter Brachezeiten und ungeeigneter Anbautechniken an steilen Hängen wird die Degradation und Erosion der Böden immer mehr zu einem limitierenden Faktor für den Anbau. Zentraler Gegenstand der Forschung des PASI ist daher die Entwicklung ertragssteigernder und bodenschonender Anbauverfahren als Grundlage einer nachhaltigen Wirtschaftsweise.

Auf den seit 1985 eingerichteten, projekteigenen Versuchsfeldern werden insbesondere agroforstliche Techniken erprobt und weiterentwickelt. Sie ermöglichen eine Steigerung der Biomasseproduktion und die Gewinnung von Kompost, dessen Einsatz die Bodenfruchtbarkeit erhöht. Diese und weitere biologische Maßnahmen sowie eine Terrassierung der am Hang gelegenen Felder bewirken einen dauerhaften Erosionsschutz.

Neben dem u.a. mit Erosionsmessparzellen versehenen Versuchsgelände zählt ein für physikalische und chemische Analytik gut ausgestattetes, vom PASI ab 1986 eingerichtetes bodenkundliches Labor zu den zentralen Einrichtungen des Projektes in Butare. Diese Einrichtungen dienen sowohl Forschungszwecken, als auch der Ausbildung rwandischer Studenten. Die angebotenen Kurse werden betreut vom Projekt-Verwalter vor Ort, dem Projektkoordinator der UNR sowie Professoren und Mitarbeitern der Universität Mainz, die regelmäßig in Butare lehren.

Vorgestellt werden die in den vergangenen 17 Jahren geschaffene Projekt-Infrastruktur, die Inhalte der bisherigen Forschungsarbeiten sowie eine Reihe neuer Arbeits- und Forschungsschwerpunkte, die die Arbeit des PASI in den kommenden Jahren ergänzen werden.

**Keywords:** Agroforestry, research cooperation, soil degradation, sustainable land use, training cooperation

## **Impact of Organic Farming Courses for Small-Holder Farmers at Bakara Farmer's Training Centre on their Agricultural and Socio-Economic Development in Lake Nakuru Catchment Area, Kenya**

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In a survey carried out in the year 2000 the situation of organic farming in Lake Nakuru Catchment area in Kenya was analysed. Basic information concerning the role of agriculture in general and organic farming in Kenya in particular were studied by literature. Based on this review three topics were formulated:

1. To explore factors for the spread of organic farming or reasons for farmers to use organic farming techniques
2. To find out the importance of organic farming techniques as a solution for production problems
3. To assess the impacts of organic farming on nutrition, household economy, employment, plants and soil

Seven experts, involved in organic farming in research and extension were interviewed and 33 small-holder farmers (22 men and 11 women), who had attended at least one one-week course on sustainable agriculture at Baraka Farmer's Training College, Molo, between 1994 and 1999.

The most important factors for the spread of organic farming were: **experts:** good and suitable education, governmental support; **farmers:** economic motives (self-sufficiency in food, monetary income), production factors (soil fertility, higher yields).

The most important problems that influence not only organic farming but agriculture as a whole were: water scarcity, transport possibilities (streets in bad condition, no motorised means of transport), collection of firewood.

The most important techniques found were: soil conservation techniques (terracing, agroforestry), crop rotation and intercropping, composting, double digging. Agroforestry shortens the time that is needed for wood collection, which creates free capacities for other tasks and innovations.

The economic situation of farmers, who had practised organic farming techniques for at least 4 years (17 of 33), had increased. In this group also self-sufficiency in staple food had increased from 23 % to 71 %, self-sufficiency in vegetables from 12 % to 94 %, as well as food diversity and the use of firewood from on-farm agroforestry trees, while labour did not increase. Eight of nine farmer families, who had no other

source of income, belonged to the group of farmers experienced with organic farming techniques. In 5 of 33 cases adult children had found full-time employment on their parents' farms.

**Keywords:** Economy, experts, interviews, Kenya, labour, motivation, nutrition, organic farming, production, small holder farmer, training center



## Contribution to the Sustainable Rural Development. Case Studies

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The sustainable development of rural areas depends, inter alia, on know-how transfer and adequate training/education of land-user that assures the rural economy. No doubt that the agricultural extension plays a very important role in promoting peasant's knowledge and improving his technologic thinking whereby putting it on more economic base. It is a continued process that extends the former basic education level (given by school or courses) for, mainly, rural population employed within the agricultural sector. Namely in developing countries it plays a very important role in the rural development. The extension work is mostly technologically-oriented and effective with regard to farming improvements. However, correct approach of extension workers gets sometimes difficult because they very often miss a necessary professional background and appropriate methods and tools. Institutional building also usually lag behind which does not permit a proper extension service development. The extension worker is mostly on lower level of his professional education.

A methodological approach represented by introduction of technological and managerial programs can be of great assistance to the extension workers in this respect. Institutional building properly prepared by respective authorities and professionally provided with know-how is also of extreme importance as the base of the whole process. The paper refers on the approach that has been undertaken at the ITSA Prague to strengthen advisory activities in selected developing countries.

Agricultural Technology Management Program was conceived and built by ITSA researchers to help extension workers in the developing countries. Projects of Advisory Centers in Mali and Jordan have been worked out to conduct advisory activities among agricultural producers focusing especially on the small-scale farmers. The paper explains philosophy and approach of both of two directions and gives details on the Program as well as Centers. It supplies more information about the first part of the Program that has been completed. Projects of Education&Experimental Center in Kayes (Mali) and Advisory Center in Jordan are described and discussed. The economic and social environment in both localities are characterized, too.

**Keywords:** Advisory center, Agricultural Technology Management Program, extension service, institutional building



# Subsession 4d: Global Policy and Economy

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## Global Policy and Economy

CHRISTOPH KOHLMEYER

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Globalisation has become a key term of present days. This process of accelerated global integration is characterised by rapidly increasing international trade, flows of capital, and technological change. Markets, societies, cultures are growing more and more together. Almost without any exception, all countries in this world have a share of these changes.

Hardly any term is more controversial. People relate globalisation to the fear of loss of familiar values, of social disintegration, of levelling of cultural diversity, the destruction of the natural resource base, unlimited transactions by world-wide active enterprises and speculators. Others perceive globalisation as advantageous and as the greatest opportunity for increased welfare. Quite a number of countries has significantly gained from economic integration. When corrupt one-party systems vanished, this brought gains in democracy and individual opportunities. The fact that all over the world women are breaking the bondage of patriarchal dominance is also the result of the fact, that the idea of the universal validity of human rights has reached the last hidden corner of the world. Literature, arts, cinema and theatre are inspired by ideas from different and far distant cultures. Undoubtedly: globalisation carries opportunities as well as risks.

Today, the risks seem to prevail: At global level, one fifth of the population earns eighty six times the income of the poorest fifth — and the gap is widening dramatically. Global public goods are dilapidating — and thereby the basis for the livelihood of future generations. The stability of international markets — especially financial markets — is deteriorating. The respect of human rights and social justice are increasingly under pressure. Violent conflicts spill over local and national borders — equally reaching global dimensions. This is unacceptable according to the standards of a civilised world — and even less for the people directly involved.

When we speak today about global policy — the political shaping of globalisation — then we speak in the first order about a normative and structural political framework. We speak about political land marks, which direct globalisation processes towards social justice and sustainable development. In order to make sure that these landmarks will guide us towards a world which creates life-worthy conditions for all its people, political decision makers have to rely on profound analysis. The political vision of a world of justice and ecological sustainable, in which all people share fair opportunities to participate in the benefits of development has to meet profound scientific analysis. This is the major challenge for politicians and scientists as well.

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The ultimate and most urgent issue is the question of a rational steering of globalisation processes, in order to maximise advantages and to minimise disadvantages. As globalisation encompasses a wide scope of manifold and inter-linked processes, which deal with international financial markets as well as with the international trade of goods and services, global natural resources, and global knowledge systems, the complexity of the task is further increased. One dimensional concepts and approaches, recipes, which set apart human behaviour, the power factor or inequality within society often create more problems than solutions. Similarly, many scientific models based on simplified assumptions may be useful for the advancement of theory, but they seldom provide direct answers to emerging political issues. Much too often politicians and scientists have not yet met in this point.

In the past decade under the so-called neo-liberal paradigm, the world market was considered as the dominant institution — uncontrollable and unpredictable. The only solution for states and enterprises was to strive for a maximum of competitiveness. The point of orientation for political decisions was the power game in the world market, co-ordinated by the “invisible hand” with international finance brokers and global players in the main roles. National governments were disciplined by market requirements in order to avoid that investments and employment shift to more attractive and more profitable locations. This logic reacts allergically to any political measure with the aim of safeguarding social balance or to protect the environment, especially when they cut on short term returns and profit. National policy making became more and more similar to business policy.

However, it is a fact, that the scope of action for purely self determined national policy making has narrowed down. Therefore international governing bodies become more important and necessary to co-ordinate actors in society and economy and to set required land marks. But this does not mean that national decisions depend entirely on international frame conditions. Also in times of globalisation, genuine forms of social and political systems will persist. Most successful development strategies continue to be based on historically evolved political, cultural and institutional particularities. With the evolution of Global Governance, national policy making receives a renewed quality by taking into account the political and social dimensions of economic development. Global policies such as the HIPC-initiative, WTO and others can only create a climate for fair and just competition. But national and even local policy making according to the principles of good governance and participation are the key to mobilise the potential, which results from opportunities at the global level.

## **Modelling the Individual and Collective Aspects of Migrants' Decisions in Pakistan**

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Migratory movements are complex processes, which are difficult to understand and to describe in models as they usually do not follow a central planning or organisation. The structure of migratory movements and the group behaviours of migrants rather emerge from the local interaction of decisions, characteristics and rules of behaviour of a large number of autonomous individuals. Usually, highly aggregated mathematical models are used to describe the process of migration. These classic models assume that migrants are a homogeneous group of individuals who are behaving rationally. They do not describe complex group behaviour, such as the formation of networks, cultural transmission, trade, etc. arising from the interaction of the individuals in a heterogeneous group of migrants or in a heterogeneous society.

The paper describes the concept of an individual-based model to analyse spatial aspects of decision-making of migrants in Pakistan. This model will allow to assess migration dynamics based on the interactions of decisions and behaviour of the individuals and to delineate the decision-making process of labour migrants. We know that the behavior characteristics of human beings are rather qualitative, and the rules which an individual applies before taking a decision are complex and frequently even contradictory. Under this assumption, an expert system approach is applied to transparently describe the decision-making process of the migrants. The expert systems will be used to develop the rules of behaviour to be implemented in an individual-based model. The potential of this innovative approach will be shown taking the example of villagers in Pakistan who decide to migrate abroad, to some urban centre, or to refrain from migration.

**Keywords:** Agent-based, expert system, migration, modelling, Pakistan

## **Opium at the Interface. Global and Local Interactions in the Golden Triangle**

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Opium links global and local levels in several respects. Firstly, opium is probably the crop with the longest history of international trade (dating back several thousand years), which was not only a natural product but closely intertwined with the rise of colonialism and the modern world economy. Secondly, opium is the object of several international treaties and of international agencies. Thirdly, through development projects aiming at crop substitution and drug control, the local level at which opium is produced is connected to national and global development organisation which requires the creation of “interfaces” as NORMAN LONG (2002) points out.

The focus of the presentation is on the local level of the Golden triangle, still the major Opium producing region, and how the local dynamics (separatist movements, war-lordism, role of the hilltribes in the respective states etc.) are intertwined with global processes (war in Vietnam, war on drugs, containment of China, illegal world economy etc.). In particular, the interface is analysed between the meaning of Opium in global discourse as a dangerous drug and cash crop, and the local reality, where Opium plays a multidimensional role as means of exchange, strategic resource, medication, status indicator etc. The development projects aiming at the reduction of opium production are integrated into the global dynamics in terms of project aims, organisation and techniques, which do not always relate to the local meaning (and understanding) of opium. The conclusion is that technically oriented crop substitution projects fail, as they are not compatible with the local context. In contrast, projects facilitating local self-organisation are presented as a promising alternative.

## **Agricultural Mechanisation in Ghana. The Challenge to Combine the Need for Increased Productivity with Sustainable Land Management.**

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In line with the Poverty Reduction Strategy of Ghana the development of the agricultural sector is a key element. In Ghana agriculture contributes 60 % to domestic product, 65 % to employment and 50 % to exports. Increase in agricultural production and productivity, and the subsequent introduction of agrobased industries are seen as the motor for economic growth, of income generation and creation of job opportunities.

However, the majority of Ghanaian farmers still work at a very low level of mechanisation, tilling the land with hand tools such as cutlasses and hoes and transporting their produce by headload. These labour intensive production methods limit the area under cultivation and are responsible for severe yield losses due to untimely-performed operations such as planting, weeding, harvesting, transport and storage. Furthermore, the tedious fieldwork and low returns to labour make agriculture increasingly unattractive for the youth.

Mechanisation of agricultural production is seen as the missing link to agro-processing and the development of agrobased industries. Tractor services are available in some parts of the country, mainly for soil tillage and transport of produce. However, the exclusive use of disc implements has resulted in soil degradation and has increased the dependancy on mineral fertilisers.

A concept is needed that is agronomically sustainable and economically affordable, that produces sufficient quantities and quality of produce, and that provides efficient postharvest services.

Therefore, the concept of conservation farming should be promoted for most conditions in Ghana in order to arrest soil erosion, sustain soil fertility, reduce production costs and make services affordable to small-scale farmers. A systems model for conservation farming is being presented.

Different organisational models are being discussed to assure efficient services. The establishment of Private Mechanisation Service Centres (Model of the German Maschinenring) that receive some support through Government is being favoured as an option, because it involves the private and the public sector, but maintains private entrepreneurship and assures organised service delivery.

**Keywords:** Conservation tillage, mechanisation

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## The Impact of the Uruguay Round Agreement on Agriculture on Sudan's Agricultural Trade

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The major objective of this paper is to assess and to quantify the consequences of the Uruguay Round Agreement on Agriculture (URAA) on the agricultural trade of Sudan.

Agriculture is the main sector of Sudan's economy. Sudan is characterized by its small-open economy, and is classified as one of the least developed countries. Given these facts, Sudan becomes more vulnerable to any changes in international agricultural markets. The URAA establishes a new regime for international agricultural trade. This new international agricultural trade environment is expected to have a great influence on Sudan's agricultural trade and on the whole economy. World price changes are the anticipated direct impact of the URAA, beside other indirect impacts like a higher cost of production arising from the implementation of the Sanitary and Phyto-sanitary Agreement.

To achieve the paper's objectives, an extended form of a multi-market model for Sudan is developed. The model embodies important characteristics of agriculture in Sudan like substitution effects and stages of production. As agriculture is the main sector of Sudan's economy, the model is extended to explicitly integrate some of the key important macro-economic linkages, and to establish certain feedback effects between agriculture and the macro-economy.

The model simulations reveal that the direct impact of the URAA would overall lead to measurable gains in Sudan's agricultural trade and for Sudan's economy as a whole. However, when the indirect impact of the URAA represented by a higher cost of production is considered, the positive results are reversed. The results of model simulations show that the domestic policy environment matters very much with respect to the potential impact of the URAA.

The following conclusions are derived: Sudan should reorientate its national policies towards export promotion in order to benefit from the new emerging trading opportunities in world markets opened by the URAA. However, to capture a greater benefit from the new environment in the international markets, Sudan should consider and manage carefully all factors, domestically or internationally — e.g. quality standards, loss of preference, dumping effects — that hinder its economic and trade growth.

**Keywords:** Agricultural trade, Sudan, URAA

## Why It Is so Difficult to Change Land for Peace? Experience from the Land Transfer Program in El Salvador

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It is widely acknowledged that the agrarian question led to the civil war and remained a central issue during the twelve years. In this form the Land Transfer Program (PTT of its words in Spanish) was a central element of the peace agreements. This program aimed to incorporate the former guerrilla and army into civil life through the provision of land. The land was transferred per market prices to the former combatants and rural dwellers of the conflict areas. Due to limitations in time and organization, the land was transferred in collective form. There is wide evidence that the land transferred is not being used for agricultural purposes, but it either lies unused or it is being sold even without land titles with a clearly lower price as a result. This apparent sign of a market failure has been attributed to the poor definition of property rights on land and as a solution a titling program has been prescribed by international donor organizations.

The paper presents results from empirical research work from August 2000 to April 2001 in rural areas of El Salvador and compiles information from a census household information of six randomly selected villages of PTT Beneficiaries, 86 structured interviews of randomly selected households and groups and expert interviews. The data have been analyzed with a regression of type Logit to prove the probability of the several determinants influencing the outcome of credit, investment and income on single households. Further analysis comprises frequency analysis to sort out the most relevant characteristics of the households.

The analysis of the data shows that while assessing the results of land titling programs, the results do not meet the expectations, hence many of the expected benefits have not occurred. The reasons vary, among them we found: **(a)** the granting of land titles proceeded in some cases slowly and in others has not even been completed; **(b)** land titling did not lead to the reallocation of land to the “most efficient”; and **(c)** no direct relationship exists or can be observed between ownership of land and productivity and or conservation goals.

**Keywords:** Agrarian reform, credit, institutional change, property rights reform

## **What Does WTO Mean for Organic Farming in the Tropical Region of China**

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Since the 1980s of last century, the role of organic farming is world widely recognized because of environmental problems caused by chemicals used in modern agriculture. Compared with the developed countries (like EU, USA), the development of organic farming in developing countries is very slow. What is the major reason for that? Could the economic globalization stimulate organic farming development in the developing countries?

This study is going to find major problems and stimulation of organic farming development in China, and to analyze the impact of China's entry to WTO on organic farming based on a case study in Hainan Province of China.

In order to fit the WTO agreements and to meet increased requirements on technical and hygienic standards as well as to increase competitiveness of the Chinese agricultural products on the world market, the Chinese government has paid much more attention to produce low-chemical or non-chemical polluted agricultural products. Hainan province is located in the tropical region of Southern China. The major goal of the province is to construct an "Ecological Province" (that means very good in ecological environment). Agricultural GDP accounted for over 40 % of the total GDP in Hainan. That makes agriculture play a very important role in Hainan's economy. The major export of agricultural products are vegetables, fruits and fishes. Would WTO be a new stimulation for organic farming development in Hainan? The investigation will be conducted on the producers, consumers and governors in Hainan province. Based on the analyzed results, future prospects of organic farming in China will be forecasted.

**Keywords:** China, organic farming, WTO



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