

Volkswagen**Stiftung**

# Natural Resources Research in Africa

## Book of abstracts

of the 2010 grantees meeting within the  
Volkswagen Foundation Africa Initiative

September 20 - 24, 2010  
Witzenhausen, Germany



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held Monday 20th – Friday 24th September 2010  
in Witzenhausen/Germany

## **Bibliografische Information der Deutschen Nationalbibliothek**

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über <http://dnb.d-nb.de> abrufbar.

1. Aufl. - Göttingen : Cuvillier, 2010

978-3-86955-490-7

## **Imprint**

DITSL GmbH, Witzenhausen

Natural Resources Research in Africa, Book of Abstracts of the  
2010 Grantees Meeting within the Volkswagen Foundation Africa Initiative

**Publisher:** DITSL GmbH, Witzenhausen

Dr. Christian Hülsebusch, Witzenhausen

- Managing Director -

© DITSL GmbH, Witzenhausen, Germany

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web: <http://www.ditsl.org>

**Typesetting:** Eric Tielkes using  $\text{\LaTeX} 2_{\epsilon}$

**Druck:** Cuvillier Verlag, Göttingen 2010

**Publication date:** September 2010

**N<sup>o</sup> of copies:** 250

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# Words of Welcome

To support communication and cooperation among researchers from different disciplines, institutions, and countries, to facilitate international exchanges and the creation of efficient, effective, and sustainable collaborations, and to enable African researchers, in particular the young generation of doctoral and postdoctoral fellows, to participate in internationally competitive research endeavours, and to make European academies more aware of intercultural differences and pressing issues their colleagues in sub-Saharan Africa are faced with – these are the prime objectives of the Volkswagen Foundation’s funding initiative “Knowledge for Tomorrow”, which started in 2003 and has been opening up opportunities for research projects and partnerships in seven topically defined areas ranging from Tropical Medicine to African Culture in the context of globalization.

At this conference in Kassel/Witzenhausen, about 130 scholars involved in projects resulting from two calls for proposals will present their work: “Resources, their Dynamics and Sustainability – Capacity Development in Comparative and Integrated Approaches” (R+S), and “Resources, Livelihood Management, Reforms, and Processes of Structural Change” (RLRP). Thematically, these two calls are related to each other since they are both dealing with natural resources, but the call ‘RLRP’ has a much stronger emphasis on the social sciences aspects of the use of natural resources. It will be very interesting to discuss the different approaches used in the natural and social sciences and to strengthen the networks between both calls. Finally, it is clear that options or solutions for a sustainable use of natural resources in Sub-Saharan Africa can only be developed in interdisciplinary approaches.

We are very happy and proud to meet especially the young researchers from altogether 20 African countries. I am confident that this meeting will provide a good opportunity to demonstrate some of the outstanding results achieved so far, but I am even more looking forward to an open exchange of experiences and ideas with respect to the overall development of our funding initiative, and in particular its future directions when it comes to ensuring ownership on the side of the African scholars through truly symmetric partnerships. More and more these will have to rest on strong inner-African networks. They will become a crucial factor in order to enable African scholars to perform independently top notch research.

On behalf of the Volkswagen Foundation I do thank all of you for coming here. My special thanks are due to the organizers, Dr. Christian Hülsebusch and Mrs Christina Ripken from DITSL at the University of Kassel, who did a marvellous job in preparing the conference. I wish us all an inspiring meeting, full of illuminating presentations and interesting debates, a lot of new ideas and acquaintances. Although we like to be complemented for our achievements, I do think that it is necessary to also look at those things which need to be improved. Therefore, I should like to encourage you to openly address whatever point you consider to be necessary in making the Africa initiative of the Volkswagen Foundation a sustainable success. By pointing at mistakes made in the past as well as by addressing the challenges and opportunities of future funding you will help us to jointly prepare the initiative for the way ahead.

With best wishes and kind regards.

Yours,

A handwritten signature in blue ink, reading "Wilhelm Krull". The signature is written in a cursive style with a long, sweeping underline.

Dr. Wilhelm Krull  
Secretary General of the  
Volkswagen Foundation

## Programme Grantees Meeting 20. – 24.09.2010

<b>Date</b>	<b>Begin - End</b>	<b>Subject</b>
20.09.2010	15.00 - 18.00	Arrival, Registration (individual E-Mail or internet activities possible via internet access at the venue)
	19.00	Welcome to Participants by the Secretary General of the Volkswagen Foundation (Dr. Willms-Hoff) Reception, Presentation of the Natural Resources Research for Africa Calendar 2011
21.09.2010	09.00 - 09.15	Welcome to Participants by Organizers (Dr. Willms-Hoff and Dr. Hülsebusch, DITSL)
	09.15 - 09.45	Introduction to the Africa-Initiative (Dr. Willms-Hoff)
	09.45 - 10.00	Aims and Program of the Grantees Meeting (Dr. Wessler)
	10.00 - 10.45	Keynote: Prof. Herbert Prins The Ecosystem Approach and One Health.
	10.45 - 11.15	Coffee Break
	11.15 - 12.00	Keynote: Prof. Abdel Ghaffar M.Ahmed The socio-economic aspects of natural resources management with special reference to the African perspective.
	12.00 - 12.30	Discussion
	12.30 - 14.00	Lunch break (individual E-Mail or internet activities possible via internet access at the venue)
	14.00 - 15.00	Project 1 R+S: Challenges and Opportunities for Nutrient Efficient Agriculture in West African Cities ('UrbanFood')
	15.00 - 16.00	Project 2 RLRP: Mobility, networks and institutions in the management of natural resources in contemporary Africa
	16.00 - 16.30	Coffee Break
	16.30 - 17.30	Project 3 RLRP: Managing forest wildlife for human livelihoods in the Korup-Oban Hills region, West-Central Africa. A multi-agent systems model to assess socio-economic and ecological sustainability

<b>Date</b>	<b>Begin - End</b>	<b>Subject</b>
21.09.2010	17.30 - 18.30	Project 4 R+S: Urbanisation and its Impact on the Use of Natural Resources in Africa
	19.00	Individual Dinner
22.09.2010	08.30 - 09.00	Individual E-Mail or internet activities possible via internet access at the venue
	09.00 - 10.00	Project 5 RLRP: The role of institutions for forest resource and livelihood management in East African forest landscapes
	10.00 - 11.00	Project 6 R+S: Agricultural use and vulnerability of small wetlands in East Africa
	11.00 - 11.30	Coffee Break
	11.30 - 12.00	Project 7 RLRP: Semi-arid areas in transition: Livelihood security, socio-ecological variability and the role of development interventions in East Africa
	12.30 - 14.00	Lunch break (individual E-Mail or internet activities possible via internet access at the venue)
	14.00 - 15.00	Project 8 R+S: Modelling of the domestic energy system based on biomass energy in rural areas in southern Africa - BioModels
	15.00 - 16.00	Project 9 RLRP: An integrated research approach to develop adaptive management strategies by small scale farmers in semi-arid South Africa and Ethiopia under changing climatic and policy conditions
	16.00 - 16.30	Coffee Break
	16.30 - 17.30	Guided Poster Session on Resources, Livelihood Management, Reforms, and Processes of Structural Change (RLRP)
	17.30 - 18.30	Guided Poster Session on Resources, their Dynamics, and Sustainability – Capacity-Development in Comparative and Integrated Approaches (R+S)
	19.00	Individual Dinner
	20.30	Kilimanjaro and Mount Kenya: Colonized mountains and their rediscovery as Icons of global climate change (Professor Dr. Marcus Nüsser)



<b>Date</b>	<b>Begin - End</b>	<b>Subject</b>
23.09.2010	08.30 - 09.00	Individual E-Mail or internet activities possible via internet access at the venue
	09.00 - 10.00	Project 10 R+S: The advancement of Malagasy biologists: Capacity building for the next generation of conservation leaders in collaboration with South African scientists
	10.00 - 11.00	Project 11 R+S: Conservation and Sustainable Use of Amphibians in Madagascar: Integrating Species and Area Priority Assessments with a Standardization of Monitoring Techniques
	11.00 - 11.30	Coffee Break
	11.30 - 12.30	Project 12 R+S: Sustainable Restitution / Recultivation of Artisanal Tantalum Mining Wasteland in Central Africa
	12.30 - 14.00	Lunch break (individual E-Mail or internet activities possible via internet access at the venue)
	14.00 - 18.30	<p>Field trip 1: Sababurg Domestic Animal Diversity and Wildlife Conservation Programmes in Germany's oldest animal park - founded in 1571. Sababurg Tierpark is partner in international conservation breeding programmes for wisent, wild horse, wolves, deer and a number of old livestock breeds. Also belonging to Sababurg is Germany's oldest nature conservancy - an old oak forest with 800 - 1000 year old oak trees and fern undergrowth, being the relict of a former silvo-pastoral ecosystem.</p> <p>Field trip 2: Hainich National Park Hainich is a large deciduous wooded area in Thuringia and is situated in central Germany not far from the town of Eisenach with the famous Wartburg Castle. With a total area of ca. 16,000 ha (13,000 ha of which is forest), Hainich is the largest continuous area of deciduous woodland in Germany. On the 31.12.1997 the southern part of Hainich, with an area of 7,500 ha, was declared Germany's 13th National Park. Since then it has been seen as a place of relaxation close to nature that is open to sustainable tourism. The area has gone through an amazing development which is quite unique.</p>

<b>Date</b>	<b>Begin - End</b>	<b>Subject</b>
23.09.2010	14.00 - 18.30	Field trip 3: Bioenergy Village Jühnde The vil- lage of Jühnde near Göttingen is Germany's first bioen- ergy village. The concept goes back to the year 2001, when the Interdisciplinary Centre for Sustainable Devel- opment of the University of Göttingen started the project "The bio energy village – conditions and consequences of independent heat and power supply through biomass for agriculture, the ecosystem and life culture in the rural area" in Jühnde. A biogas plant and a biomass heating station use agricultural raw materials to produce electric- ity and heat for the entire village. Because of the large international public interest in the project the Center for Renewable Energies was created to better inform visitors about the history, advantages and consequences of using renewable energy sources.
	19.00	Individual Dinner
24.09.2010	08.30 - 09.00	Individual E-Mail or internet activities possible via internet access at the venue
	09.00 - 11.00	Workshops
	11.00 - 11.30	Coffee Break
	11.30 - 12.00	Presentation of Workshop results and plenary discussion
	12.00 - 13.00	Summary of the Grantees Meeting and Outlook on Future of the Africa-Initiative (Dr. Willms-Hoff) End of Conference
	13.00 - 14.00	Lunch

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## **The Ecosystem Approach and One Health**

PRINS, H.H.T.

*Wageningen University, The Netherlands*

The Ecosystem Approach under the Convention on Biological Diversity is defined as “a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way”. Decision V/6 then states “Thus, the application of the Ecosystem Approach will help to reach a balance of the three objectives of the Convention: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources”. Yet, increasingly there is awareness arising that poverty and inequitable are strongly linked to health and disease load. Not only the health of people is linked to poverty – likely causally so – but also lack of productivity of livestock can be linked to health. Health of people, livestock and wildlife are all linked together – hence the recent concept of One Health.

Where the Ecosystem Approach thus aims at increasing the fairness in the sharing of nature’s resources, it now is time to think about whether the same set of Principles (see Decision V/6 of the COP of the CBD) can be applied to reducing the costs of nature or spreading those costs in a fairer way.

In my presentation I will thus explore the usefulness of these Principles for reducing sickness and disease. Indeed, it is one the fundamental Human Rights that all people have the inalienable rights (see Articles 12 and 25 of the U.N. Universal Declaration of Human Rights 1948).

Herbert Prins is full professor in Resource Ecology at Wageningen since 1991 and is Chairman of the Graduate School ‘Production Ecology & Resource Conservation’. He has represented The Netherlands and the European Union at meetings of the Convention on Biological Diversity, is board member of the European Tropical Biology Association, Netherlands Nature Conservancy, the Van Tienhoven Foundation, the Netherlands Committee for International Nature Conservation and others. He previously held positions as research fellow of the Royal Netherlands Academy of Arts and Sciences in Tanzania, as parks research management specialist for the World Bank in Indonesia, and as research fellow for the Netherlands Foundation for the Advancement of Tropical research in Tanzania. He is member of several IUCN Commissions and committees, and of the Machakos Wildlife Forum in Kenya. He is Officer in the Order of the Golden Ark and in the Order of Oranje Nassau.

## **The socio-economic aspects of natural resources management with special reference to the African perspective**

ABDEL GHAFFAR M. AHMED

*University of Khartoum / Ahfad University for Women, Sudan*

This address aims to provide a brief overview of some of the ways in which natural resources are managed and indicates their relevance to development and the socio-cultural; economic and political context of some African societies that suffer from civil strifes and chronic poverty. A brief exploration of the extent to which policies for managing natural resources situated within certain socio-cultural and political contexts shall be attempted. Development interventions have to take in consideration experiences, potentialities and constrains in utilizing natural resources and the optimum way for their management. Indigenous knowledge, be it technical or otherwise, and its impact on natural resource management shall be visited. Land issues, such as land appropriation, oil exploration and the expanding process of commercialization of land are significant instruments in the process of degradation of land and other natural resources. Pastoralists, farmers and other users of natural resources and their relation to the state policies and the socio-economic impact of such policies on their systems of livelihoods shall be addressed. Gender roles and other socio-cultural related issue shall be briefly considered in order to show how natural resources can be critical for people's survival and how they contribute to communities' safety-nets. Reference shall be made to cases from the East African region with special focus on conflicts related to natural resource management in West Sudan.

Abdel Ghaffar M. Ahmed is research professor of Development Studies at the Ahfad University for Women since 2006 and - together with Dr. Gunnar Sorbo (Director CMI, Bergen, Norway) - coordinates the micro-macro issues in peace building in Sudan. He previously held the position of a professor in the Department of Social Anthropology at University of Bergen, Norway and worked as consultant to national and international organizations such as UNESCO, ISNAR, UNFPA, UNDP, NORAD, IDRC, UNOPS and AADO. Recently he carried out an evaluation of centers such as Armauer Hansen Research Institute (AHRI, 2000), Ethiopia and the Research School for Resource Studies for Development (CERES), the Netherlands. Prof. Abdel Ghaffar M. Ahmed served on the scientific committee of the UNESCO initiated Comparative Research on Poverty (CROP) and the Advisory Committee of the MEAward of the Population Council, Cairo, Egypt. He is a member of the UNESCO team of the Initiative for the Horn of Africa 2015.

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## **Challenges and opportunities for nutrient efficient agriculture in West African cities ('UrbanFood')**

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## Challenges and opportunities for nutrient efficient agriculture in West African Cities

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SCHLECHT, E.<sup>12</sup> AND BUERKERT, A.<sup>1</sup>

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<sup>3</sup>*DITSL, Germany*

<sup>4</sup>*AGRA, Ghana*

**Problem statement and objectives.** Urban and peri-urban agriculture (UPA) increasingly supplies food and non food commodities to the rapidly growing West African cities. However, with its typically heavy use of fertilizers, agrochemicals, municipal wastes and sewage as inputs to the production of crops, vegetables and livestock feeds, UPA bears severe risks of environmental pollution and food contamination. Little quantitative data exists about the sustainability and efficiency of UPA as determined by nutrient fluxes, about its contribution to maintaining agro-biodiversity and about heavy metal and pathogen contamination of produce. This project therefore aimed at (i) quantifying nutrient inputs, transfers and potential problems of UPA activities in the three West African cities of Sikasso (Mali), Bobo Dioulasso (Burkina Faso) and Kano (Nigeria), which differ in their population density and biophysical conditions; and at (ii) building coherent linkages and networks among international scientists, local scientists, UPA farmers and supportive institutions such as municipal officers and policy makers, agricultural extension and marketing services as well as NGOs. The ultimate goals of this project are (i) to reduce nutrient losses by closing nutrient cycles and increasing nutrient use efficiency and (ii) to explore options for a reduced produce contamination with pathogens, pesticides and heavy metals by a judicious use of wastewater and by increasingly following organic approaches to food production. The results of field research and modelling from this project are expected to contribute scientific data in support of informed policy and extension decisions.

**Methodological approach.** The project couples process-oriented biophysical research and the use of bioeconomic models with a north-south transfer of knowledge in the quantification and modelling of nutrient fluxes and a south-south transfer of expertise on soil and product contamination with faecal pathogens, pesticides and heavy metals. Based on a detailed classification of land use patterns, which was verified by a baseline survey using a formal questionnaire, the structure of UPA was analysed for each city (Abdulkadir et al. 2010; Dossa et al. 2010ab) and representative households were chosen for further in-depth investigation. For each of the selected UPA households, all quantities of agronomic inputs applied (irrigation water, chemical and organic fertilisers and pesticides) to each crop and the quantities of harvested (e.g. grain) and recycled (e.g. straw) products with their N, P and K concentrations were



determined. In Kano and Sikasso, the number and type of animals kept, changes in livestock numbers due to births, sales and deaths were recorded every eight weeks, along with quantitative data on the output of meat, eggs and milk and on changes in animal live weights. At the same time, the quantities and the N, P and K concentrations of feeds used and of livestock manure produced were determined. In addition, feed samples were screened for *in vitro* digestibility. In Sikasso and Bobo Dioulasso, the contamination of irrigation water, soils, and of selected vegetables and animal products with faecal pathogens of human and animal origin (bacteria: *Coliform bacteria*, *Salmonella sp.*, *Escherchia coli*, *Klebsiella pneumonia*, *Proteus mirabilis*, *Providencia sp.*, *Shigella sp.*; parasites: *Shistosoma larvae*, *Entomoeba coli*, *Balautridium coli*) was analysed in detail. At selected garden sites in Bobo Dioulasso, Sikasso and Kano, nutrient balances were calculated for representative plots. Leaching losses of N, P and K were determined concurrently with a water balance study over 24 months. CO<sub>2</sub> and CH<sub>4</sub> emissions from soils, manures and composts, N losses due to denitrification (N<sub>2</sub>O) and ammonia (NH<sub>3</sub>) emissions were measured over 24h every 8 weeks at selected sites using a closed chamber method. In the heavily industrialized city of Kano, concentrations of selected heavy metals, namely cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) were determined in selected vegetables, garden soils, aeolian deposits, composts and irrigation water during five cropping cycles (Abdu et al. 2010abc). The geo-referenced data on nutrient inputs, transfers, vertical losses and outputs through different amendments, transformation products and end products of UPA will be used for the calibration and validation of a spatially explicit biophysical model, integrating horizontal and vertical flow data from the three cities.

This project involves a team of five African PhD students and one postdoctoral scientist. The PhD students are enrolled at the University of Kassel (Germany), Wageningen University (The Netherlands) and the Université catholique de Louvain (Belgium). Each PhD student is jointly supervised by the African lead scientist from the respective country and one of the European scientists in a tandem approach. To familiarize all partners and especially the students with the different methodologies for nutrient flux measurements and with the scientific equipment, a training course, jointly organized by the local African partner institution (INERA), the German Institute for Tropical and Subtropical Agriculture (DISTL) and the African Network for Soil Biology & Fertility of the Tropical Soil Biology & Fertility Institute (AfNet) was held at Bobo Dioulasso from April 1st to May 4th, 2007 January 2007. In January 2009, a project meeting was held in Dar es Salaam (Tanzania) during which sampling methods and data exchange were critically reflected, and synchronised between the different study locations. During the original three years time frame of the project (May 2007 – April 2010), the five African PhD students and the postdoctoral scientist completed their field research on their respective individual topics on urban and peri-urban agriculture in the three cities. While four of the PhD students are currently

working on data evaluation and preparation of publications, the fifth has already completed his PhD and is now continuing to work on aspects of heavy metal contamination of groundwater in Kano urban gardens as a postdoctoral scientist.

Throughout the project, regular informal project-stakeholder meetings were organized at each study site, during which knowledge, ideas, experiences and preliminary project results were shared with all stakeholders. The final results of each study site will be presented in a formal stakeholder workshop that will target all relevant stakeholders (UA farmers, local scientists, and supportive institutions such as municipal officers and policy makers, agricultural extension and marketing services as well as NGOs).

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## Nutrient flows and balances in urban and peri-urban agroecosystems of Kano, Nigeria

ABDULKADIR, A.<sup>1,2</sup>, VAN KEULEN, H.<sup>1</sup>

<sup>1</sup>*Wageningen University, The Netherlands*

<sup>2</sup>*Ahmadu Bello University, Nigeria*

Nutrient balance studies are increasingly being used to assess the sustainability of farming systems, the approach which investigates inflow and outflow of the major nutrients in agricultural production systems. In this paper, 16 households representing three different urban and peri-urban farming systems were studied using the MonQI toolbox (formally known as NUTMON) as a nutrient monitoring approach for quantifying nutrient inputs and outputs. Full nitrogen (N) balance was negative at -36.3, -9.4 and -5.4 kg farm<sup>-1</sup> yr<sup>-1</sup> for the commercial garden and crop-livestock (cGCL), commercial livestock and subsistence field cropping (cLsC) and commercial gardening and semi-commercial livestock (cGscL) farm types respectively. Full balances for phosphorus (P) are 10.3, 23.2 and 16.9 kg farm<sup>-1</sup> yr<sup>-1</sup>, and -31.0, 51.2, and -8.0 kg farm<sup>-1</sup> yr<sup>-1</sup> for potassium (K) in the cGCL, cLsC and cGscL farm types respectively. However, partial balances were positive for all nutrients across the farm types except for K which was negative in cGCL farm type (-30.4 kg farm<sup>-1</sup> yr<sup>-1</sup>). Full balances at vegetables/crops level reveal negative N (-115 and -236 kg ha<sup>-1</sup> yr<sup>-1</sup>) and K (-97 and -137 kg ha<sup>-1</sup> yr<sup>-1</sup>) balances in cGCL and cGscL farm types respectively but balances were positive for all the nutrients in cLsC farm type (52 kg N ha<sup>-1</sup> yr<sup>-1</sup>, 122 kg P ha<sup>-1</sup> yr<sup>-1</sup> and 240 kg K ha<sup>-1</sup> yr<sup>-1</sup>). Partial balances for land uses were positive for all nutrients across the farm types except for potassium that was negative in cGCL (-94.7 kg ha<sup>-1</sup> yr<sup>-1</sup>) and cGscL (-127.3 kg ha<sup>-1</sup> yr<sup>-1</sup>) farms types. Partial nutrient balance in livestock production activity indicated a positive balance for cGCL and cGscL farms for all nutrients and negative balance for all nutrients in cLsC farm type. Results here shows that phosphorus is not deficient but N losses through leaching is high and need to be arrested to curb the associated negative environmental effect. Potassium losses are evident in these systems under partial balances and threaten K nutrient availability for vegetable and crop production. Appropriate policies should aim at improving efficiencies in nutrient use as well as reducing the negative environmental effect associated with inefficient nutrient management in the Kano UPA sector.

**Keywords:** MonQI, NUTMON, sustainability, farm management, production systems, farm

## **Vertical matter flows in urban gardens of Bobo-Dioulasso, Burkina Faso: Gaseous emissions of nitrogen (N) and carbon (C)**

LOMPO, J.-P.D.<sup>1</sup>, COMPAORÉ, E.<sup>2</sup>, SEDOGO, M.P.<sup>2</sup>, PREDOTOVA, M.<sup>1</sup>,  
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In sub-Saharan Africa, urban and peri-urban farming (UPA) plays a major role as a survival strategy of the urban poor with lack of purchasing power and low access to food and contributes in meeting the increasing food demand of the rapidly growing cities. However, the UPA sustainability and the possible environmental pollution caused by these high input, high output farming systems are an increasing concern. This study has investigated vertical matter flows especially gaseous emissions of N and C in the urban gardens of Bobo-Dioulasso, Burkina Faso. According to the results of a baseline survey involving 111 households, two socio-economic types of gardens were found: “Market gardens and commercial crop-livestock” (referred to as G1) and “Market gardens and semi-subsistence crop” (referred to as G2). Gaseous emissions were quantified in one garden representing each group from March 2008 to March 2009, using a photo-acoustic multi-gas monitor. Surface gas samples were taken during the day’s coolest (5-8 am) and hottest (1-3 pm) hours for 4 cropping cycles of cabbage. Gas samples were automatically analysed for nitrous oxide (N<sub>2</sub>O), ammonia (NH<sub>3</sub>), carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>).

The highest losses of N and C occurred during the hottest periods of the days indicating the effects of temperatures. The major form of N gaseous losses was NH<sub>3</sub> compared to N<sub>2</sub>O. CO<sub>2</sub> losses were significantly higher than CH<sub>4</sub> losses. The estimated annual N losses reached 210 and 174 kg N ha<sup>-1</sup> in G1 and G2 respectively, while total C annual losses were 18.2 and 11.4 Mg ha<sup>-1</sup> in gardens G1 and G2 respectively. Gaseous emissions of N and C represent an important pathway of matter losses in Bobo-Dioulasso. Additional studies are needed to determine inter- and intra-annual variations and to find out strategies to reduce N and C gaseous emissions in UPA in Bobo-Dioulasso. These could focus on the effects of different fertilizers application modes and times on gaseous emissions.

**Keywords:** Carbon, emissions, nitrogen, nutrient flows, urban gardens, Bobo Dioulasso, Burkina Faso

## Vertical nutrient fluxes in soils of urban agricultural systems: measuring and modeling the nitrogen, phosphorus and potassium leaching in Bobo Dioulasso (Burkina Faso)

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This study aimed at: (i) evaluating plot-level water and nutrient use efficiency in conventional urban agriculture of Bobo Dioulasso; (ii) quantifying vertical leaching fluxes of N, P and K at the plot level in situ and through modeling; (iii) evaluating the opportunities to increase nutrient efficiency. The study was carried out in two representative gardens. Three treatments were used: 1) gardener's practice; 2) 30 % reduction in fertilizer input, and 3) no fertilization. Four vegetable crops were evaluated (tomato, cabbage, carrot and lettuce) during 24 months at Dogona, whereas at Kodené lettuce was cropped continuously for 12 months. Water and nutrient inputs as well as soil properties were quantified. Sites were equipped with weather stations, TDR probes, pan lysimeters and ion exchange resins for monitoring the leaching of N, P and K. The results indicated low nutrient use efficiency as a result of the high input of both organic and mineral fertilizers which greatly exceeded nutrient export through harvests. Total annual inputs amounted to 1988 kg ha<sup>-1</sup> N, 883 kg ha<sup>-1</sup> P and 2095 kg ha<sup>-1</sup> K at Dogona and 3889 kg N ha<sup>-1</sup>, 1105 kg P ha<sup>-1</sup> and 3791 kg K ha<sup>-1</sup> at Kodené. About 3 % and 6 % of the input water were lost by drainage at Dogona during 2008 and 2009, respectively, and 8 % at Kodené, mostly during the rainy season, although at Kodené drainage also occurred during the dry season. The study also showed that the reduction of fertilizers by 30 % did not significantly ( $p < 0.05$ ) affected crop yields during the two years of experimentation. These preliminary results underlined the need for a better matching between crop needs and nutrients applied. Nutrient inputs may be reduced by up to 30 % without adverse effect on yields. At Kodené there may be some scope for reducing the irrigation rate. Modeling of the water balance and nutrient leaching will allow proposing better soil, water and nutrient management practices for preventing the risks of groundwater pollution.

**Keywords:** Urban agriculture, nutrient use efficiency, water balance, nutrient leaching, modelling, Bobo Dioulasso

## **Cross-country comparison of livestock production strategies in three major West African cities**

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Livestock keeping is an important part of urban agriculture, but has received less attention than crop and vegetable cultivation. As a consequence, information on its extents, problems and potentialities is limited. Conclusions drawn and recommendations made in the sparse case studies are hardly valid for the whole West African region. Cross-country comparisons are needed to scale up local findings and develop valid recommendations towards sustainable (peri-)urban livestock production systems in the region. The present study aimed therefore at a comprehensive and comparative analysis of strategies of (peri-)urban livestock producers across West African cities. Using a semi structured questionnaire, a total of 335 randomly selected livestock-keeping households (HH) were interviewed in the cities of Kano/Nigeria (99 HH), Bobo Dioulasso/Burkina Faso (111 HH) and Sikasso/Mali (125 HH). The questionnaire included inter alia information concerning different livestock species kept; herd size, structure and dynamics; feed and feeding strategies; manure management; livestock marketing, and main production constraints.

Major livestock species kept included cattle, small ruminants, donkey and chicken, and their average number per HH was significantly higher in Bobo Dioulasso and Sikasso than in Kano. Sheep and goats dominated in Kano (76 % and 75 % of HH, respectively) compared to Bobo Dioulasso (48 % and 40 %) and Sikasso (28 % and 40 %). Cattle and poultry were more commonly kept in Bobo Dioulasso (82 % and 69 % of HH, respectively) and Sikasso (65 % and 79 %) than in Kano (29 % and 20 %). Irrespective of the city, ruminant feeding was mainly based on grazing and supplementation with fresh grass, crop residues, cereal brans and cottonseed cake. However, use of cotton cake was more common in Bobo Dioulasso and Sikasso than in Kano. Cereal grains and brans were the two major ingredients of poultry feeds in the three cities. Most livestock keepers provided healthcare, mainly prophylactic vaccinations, to their animals. They also had easy access to markets for livestock sales and purchases. Cattle and sheep fetched higher prices in Kano while the unit prices for goats and chicken were highest in Sikasso. Manure was mainly burnt in Kano, whereas in the two other cities it was used as fertilizer in urban gardens and /or on crop fields.

**Keywords:** Cattle, chicken, livestock management, small ruminants, urban households, West Africa

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## **Mobility, networks and institutions in the management of natural resources in contemporary Africa**

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## **Human mobility, networks and institutions in the management of natural resources in contemporary Africa**

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### **Overview**

The project consortium “Human Mobility, Networks and Institutions in the Management of Natural Resources in Contemporary Africa” investigates the relation between new patterns of mobility and natural resource management in African environments. Processes of globalization, commoditization but also of rural impoverishment lead to an increasing flow of people, ideas and capital that influence the regulation of social-ecological systems. Examples of new patterns of mobility are rural-rural migration of smallholder farmers, the establishment of large scale commercial farming enterprises by migrants reinvesting economic, social and symbolic capital in rural areas and the impact of new elites circulating between urban jobs and rural home communities. Mobile people involved in these processes range from poor rural farmers and landless people to labour migrants and urban-based elites. Often these groups compete for access to and control over the same natural resources. Coalitions between local elites, national pressure groups and/or international organisations are increasingly common, giving local conflicts over resources national and even international dimensions. The complex interrelations between mobility, networks, conflicts and institutions on the one hand and natural resources on the other hand are being researched in four different regions (Namibia, Cameroon, Tanzania, Zimbabwe/South Africa).

### **1. Namibia**

**Project:** Conflict over access to natural resources on communal land in Namibia: case studies from Caprivi, Kavango, Omusati and Otjozondjupa.

**Author:** Willem Odendaal; Project Coordinator, LEAD, Legal Assistance Centre, Windhoek, Namibia

**RATIONALE:** Post independence Namibia has brought a number of socio-political, environmental and economic changes for many living in communal areas. New policies and laws have been created, new institutions have been established, access to land and natural resources have been modified and power relations have changed greatly. Against this background a number of land disputes have



taken place in Namibia's communal areas in recent years, primarily as a result of increased conflict over access to natural resources. The project analyses the conditions and consequences of four different cases of conflict over land in order to gain insights about unanticipated and frequently ignored side effects of the challenging land reform process in Namibia.

**PROBLEM STATEMENT:** Land reform in post-independent Namibia led to changes in legislation, the subsequent creation of new institutions and raised expectations with regard to secure tenure and access to land and natural resources. However, in communal areas, policies and legislation are not fully enforced, or sometimes contradictory in terms. Quite often the role and duties of institutions with regard to the distribution and management of land and its natural resources are not clearly defined and are sometimes in conflict with each other and/or not sufficiently implemented. Additionally, since independence there has been a new elite emerging, as a direct result of their relationship to the politically and economically powerful. These new elites often hailing from urban areas, have had a significant impact on existing rural institutions, how decisions over natural resources are done and as a result power relations within communal areas. These seem to have created a platform from which "land grabbing" in Namibia becomes possible.

**OBJECTIVES:** The project investigates the role of legislation, the capacity and weakness of new institutions and the results and causes of social differentiation with regard to conflict over natural resources on communal land in Namibia through the analyses of four different case studies.

**APPROACH:** Approaches applied in the project range from the investigation of applicable legislation and their implementation, qualitative interviews with role players and other stakeholders in conflicts over natural resources to observation and analysis of institutional meetings. The history of the conflicts and the characteristics of stakeholders in conflicts are analyzed using court documents, interviews, demographic data, network analysis, etc.

## 2. **Cameroon (Western Highlands)**

**Sub-Project:** Impact of mobility and land use on farming systems and biodiversity in the humid Savannah zone of Cameroon.

**Author:** Christopher Mubeteneh Tankou; Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon.

**RATIONALE:** Cameroon is an agricultural economy and the rural sector, which accounts for 30 % of GDP, plays a significant role in her economy. Despite its importance in the economy of the nation, the rural sector faces many problems that account for declining productivity and biodiversity orchestrated by population pressure, mobility and improper land use. Generally, scarcity of land in this part of Cameroon influences the rural-rural mobility of farmers from land-

deficit to land-surplus areas.

**PROBLEM STATEMENT:** One of the great challenges to alleviate the present scenario is to gain a sound scientific understanding of the interactions between and feedback processes of population pressure, human mobility, land use, farming systems and biodiversity in the complex and highly diverse tropical ecosystems in general and the humid savannah agro-ecological zone of Cameroon in particular.

**OBJECTIVES:** The main objective of this study is to determine the impact of land use change associated with mobility on farming systems and biodiversity which can provide guidelines to prevent land degradation.

**APPROACH:** The research methodology is based on surveys and field sampling.

### 3. **Tanzania (Lake Eyasi Basin)**

**Sub-Project (a):** Migration and Demographic Changes: Implications on Land Transformation and Changing Livelihood in Lake Eyasi Basin in Karatu District.

**Author:** Florian S.C. Silangwa; Institute of Resource Assessment-University of Dar es Salaam/Institute of Social and Cultural Anthropology, University of Cologne.

**RATIONALE:** As the population has increased with the influx of migrant farmers, livestock keepers as well as casual laborers in the Lake Eyasi Basin, the pressure on available land resources has increased. Among the migrants in the area are wealthy farmers and agro-business people from urban areas and surrounding villages who claim land from poor local people and heavily invest in agricultural inputs such as fertilizers, water pumps, herbicides and pesticides.

**PROBLEM STATEMENT:** Despite the increase of population and agricultural investment in the area, very little has been done to examine the impact of population mobility and migration on the traditional land tenure systems and management as well as their associated impact on the socio-economic conditions of the people. The understanding of population dynamics and changes in land management systems and their associated socio-economic effects in Lake Eyasi Basin is an essential tool in determining current and future population needs and sustainable land resource management and development.

**OBJECTIVES:** The objectives of the study are to examine the driving forces of population mobility and migration in Lake Eyasi Basin as well as to assess the impact of population mobility and migration on changing land tenure systems and management. Furthermore the study intends to analyze the extent to which changing land tenure systems and management affect the socio-economic conditions of the people. Conflicts and threats over land resource use in villages around Lake Eyasi Basin and the response of displaced people to the breakdown of their traditional living condition are also investigated in the project.

**APPROACH:** The research methodology is based on qualitative and quantitative analysis of population mobility and demographic change. To understand people's perception of land transformation, methods like historical narratives, observation, qualitative and quantitative interviews, and focus group discussions are applied. In addition satellite images and topographical maps from 1980 to 2000 and documents in archives will be analyzed.

**Sub-Project (b):** The implications of Climate change on land use pattern in Lake Eyasi Basin

**Author:** Emmanuel E. Hanai; Institute of Resource Assessment, University of Dar es Salaam/Department of Geography, University of Cologne.

**RATIONALE:** Mobile people impacting on environments range from poor rural farmers and landless people to labour migrants and urban-based elites. These dynamics impact on natural resources significantly and result in altered soil structures, hydrological dynamics and vegetation patterns. The rationale for this project is to facilitate research and build capacities and partnerships around these complex issues.

**PROBLEM STATEMENT:** The growth of economic activities around Lake Eyasi Basin has attracted a number of people to the area. Lake Eyasi Basin supports various socioeconomic activities such as agriculture, livestock keeping, fishing, salt extraction, tourism, forestry and wildlife. Among these activities, agriculture and livestock keeping are major economic activities that support a number of livelihoods of people living in the area. However, these activities are seriously affected by climate change that brings about a number of dynamics resulting in changed land use patterns. Climate variability has affected rainfall pattern and availability of water resources in the Basin. This has greatly influenced human mobility, land use and has created pressure on resource use leading to serious environmental degradation in the area.

**OBJECTIVES:** The main objective is to study the influence of climate variability on land use change as the main driver of human mobility, pressure on water resources and other forms of adaptations in Lake Eyasi Basin specifically at Mang'ola/Barai catchments.

Specific objectives are to analyze the land use patterns and land use change associated with climate variability (adaptations) and migrations and to study interrelations that exist among climate variability, human mobility/migrations and land use patterns.

**APPROACH:** Statistical and correlation methods are used to analyze hydrological parameters (e.g., rainfall pattern, temperature, relative humidity, evaporation rate) in order to determine their implications on water resources and their availability, water consumption on irrigation farming and land use. Statistical techniques are applied to relate land use change to meteorological and social-economical factors so that the main driving forces of land use change – either

climate variability or human activities at regional/watershed levels – can be identified. Qualitative and quantitative interviews on the historical background of the area regarding observed instances of climate variability are conducted with members of the local communities.

#### 4. **Zimbabwe (Mwenezi District)**

**Project:** Women Silently Curving Access to Land and Livelihoods after Fast Track Land Reform at Merrivale farm, Mwenezi District, Zimbabwe.

**Author:** Patience Mutopo; Institute for Cultural and Social Anthropology, University of Cologne.

**RATIONALE:** Land is an important resource for African communities as it shapes their livelihoods. Women in Africa have always been undermined in accessing land as individuals.

Land use, land management and tenure regimes in Zimbabwe have been greatly transformed following the Fast Track Land Reform Programme of 2000, which resulted in the subdivision of large white-owned commercial ranches and redistribution to “emerging” black farmers led by the country’s former liberation fighters.

It should be noted that during the national land reform program in Zimbabwe, only 18 % of the women benefited from the process and the rest were male beneficiaries (Utete 2003).

**PROBLEM STATEMENT:** Merrivale farm is located in Masvingo Province, Mwenezi District, in the southern part of Zimbabwe. In terms of social differentiation most of the women at Merrivale farm resident at different plots either as wives, widows, mothers or daughters, their residential status and relation with the plot holders is the major determining factor of accessing non timber forest products, mopane worms and water. Access to these natural resources is governed by several institutional arrangements that have been borrowed from local communal areas in Mwenezi where most of the settlers came from. As the women access land they grow ground nuts and bambara nuts (ground nuts) together with baskets manufactured out of reeds that they trade in South Africa. Non permanent mobility to South Africa for trade purposes by the women involves the use of a carefully structured network of actors who enable them to embark on trading trips in South Africa.

**OBJECTIVES:** The project seeks to demonstrate how women at Merrivale farm have emerged as important actors in accessing land for their own livelihoods. The objectives of the research are to find out the mechanisms used by women at Merrivale farm to access land in the aftermath of the Fast Track Land Reform Programme as well as to examine how access to land serves as basis of accessing non timber forest products, mopane worms and water. A further objective is to unravel the role of non permanent mobility as an important livelihood source

to unravel the role of non permanent mobility as an important livelihood source in shaping the land based livelihoods of the women.

**APPROACH:** In order to interrogate these objectives ethnographic methodology based on the case study approach has been used. It was an in-depth study of 20 households. Corollary to that, participant observation, in depth interviews, focus group discussions, transect walks seasonal calendars and wealthy ranking were used in order to have detailed information that helps to bring out inherent results. Making the study multi-sited, the author has been involved in trips with the women to unravel the non permanent mobility component and to understand the commodity chain process involved in trading in South Africa.

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## Overview poster

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### The Programme

The relation between migration and natural resource management is an important and urgent question in the era of globalisation characterised by an increasing flow of people, ideas and capital and a proliferation of new forms of regulation of social-ecological systems. These new mobility dynamics have led to a growing heterogeneity of resource users, dislocated forms of decision making, the hybridization of knowledge bearing upon resource utilization and institutional development engaging migrants, diasporas, administrations as well as locals in decisions on local resource use. New coalitions but also new conflictive arrangements have led to the emergence of entirely new forms of collective action within social-ecological systems.

### Research Themes

Three thematic study groups have been established to provide comparison across the cases.

#### *Theme (1): Conflict, Institutions, Organisations*

The analysis of different kinds of conflicts pertaining to natural resources is an important take off point in all regional study groups. Conflicts are manifold and pitch agro-industrial enterprises vs. smallholders, farmers vs. herders, local farming against tourism. To what extent are contemporary conflicts over natural resources linked to new patterns of mobility? Researchers will focus on the strategies of individuals and organisations and document their efforts to build new coalitions around natural resources, their attempts to control access and their ways to adjust labour at the household level to new requirements. Efforts to establish new institutionalised ways of access to and administration of natural resources often originate in attempts to prevent conflicts, accumulate capital and/or to increase livelihood security. Mobility has a major impact on the process of institution building.

#### *Theme (2): The Legal Regulation of Natural Resource Management and Community/State Relations*

States set legal frameworks for land tenure systems. Legislations are in place which stipulate who has the rights to allocate, administer and transfer natural resources. In recent years many African countries have undertaken major reforms of their land

law and of legal frameworks pertaining to natural resources. While in Namibia and South Africa such legal changes have had profound consequences on the local level, in Cameroon and Tanzania changing legal frameworks did not affect local resource management to the same degree. In all cases legal regulation of natural resource management is negotiated in a complex manner.

*Theme (3): Patterns of Resource Dynamics*

Natural limitations produced by geological and geomorphological conditions may restrict land use, but they can be removed and altered by social actors applying their skills and experiences. However, natural resources can also be degraded through inappropriate management techniques and/or highly intensive use. Key to an analysis of the processes that underlie livelihood-landscape inter-actions is a firm grounding in the locality that places emphasis how local people and other relevant actors such as policy makers and scientists (including ourselves) read the landscape and the changes that occur around them. Thus, focusing on the practices of everyday life allows one to see locally specific modes of exploitation of resources and the social form(s) of organisation that these are embedded in. Hydrological processes, vegetation change and soil dynamics are the three fields within branch of the project we project will concentrate upon.

**Keywords:** Migration, natural resource management, networks, institutions, legal frameworks, resource dynamics, conflict.

## **Conflict over access to natural resources on communal land in Namibia: Case studies from Caprivi, Kavango, Omusati and Otjozondjupa**

ODENDAAL, W.

*LEAD, Legal Assistance Centre, Windhoek, Namibia*

Post independence Namibia has brought a number of socio-political, environmental and economic changes for many living in communal areas. New policies and laws have been created, new institutions have been established, access to land and natural resources have been modified and power relations have changed greatly. Against this background a number of land disputes have taken place in Namibia's communal areas in recent years, primarily as a result of increased conflict over access to natural resources. The project analyses the conditions and consequences of four different cases of conflict over land in order to gain insights about unanticipated and frequently ignored side effects of the challenging land reform process in Namibia.

The focus of the research is the description and analysis of (1) relevant legislation and changes in legislation; (2) institutions, their purpose and their actual impact and (3) rural elites and the remaining rural population in terms of political affiliation, gender, access to resources, ethnicity, etc.

**Keywords:** Namibia, communal land, elitisation, institutions, land reform, natural resource management



## **Women silently curving access to land and livelihoods after fast track land reform at Merrivale farm, Mwenezi district, Zimbabwe.**

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The Fast Track Land Reform Programme in Zimbabwe has led to new configurations in land use. Rural livelihoods have been characterized by the need for more land. This has increasingly led to more women emerging as strategic actors as they seek to acquire land, an important economic, social and political resource for African states. Access to land by women manifests itself as a basis of creating new livelihood portfolios. I analyzed how women accessed land at Merrivale farm in the aftermath of the land reform programme. I also demonstrated how access to land serves as the entry point for accessing other natural resources such as non timber forests products like mopane worms, indigenous vegetables and water. Non permanent mobility is examined as it emerges as an important livelihood option for the women. The women travel to South Africa to sell their agricultural produce opening up a new avenue of land based livelihoods. The social creation of markets in South Africa is opening up new agro economic dimensions in Zimbabwe.

**Keywords:** Zimbabwe, gender, women, rural livelihoods, land access, mobility, land reform

## **Impact of mobility and land use on farming systems and biodiversity in the humid Savannah zone of Cameroon**

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During the early stages of development, increased population generally leads to an expansion in cultivated area and, in many cases, conflict between the different users of land and water resources. Once most good quality land is already exploited, further population increases tend to lead to expansion accomplished by human mobility, land use change, intensification of farming systems and modification of biodiversity. As the natural vegetation comes under greater pressure, biodiversity is threatened and there may be growing tension between development and conservation goals. The population-environment disharmony can cause very severe impacts on agriculture. It has become increasingly recognised that major drivers in both mobility and migration are on-going environmental degradation induced by population pressure. What are the different mobility categories (inter-village, intra-village or urban-rural) and how equitably are the positive and negative impacts of mobility distributed across different societal groupings (income, age, ethnicity, gender etc). Is mobility-related energy, land and materials use sustainable in the context of overall supply and alternative demands for these resources?

**Keywords:** Cameroon, mobility, land use change, agriculture, biodiversity

## **Migration and demographic changes: Implications on land transformation and changing livelihood in Lake Eyasi Basin in Karatu district**

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Rural-rural and urban-rural migration and mobility in the area of the Lake Eyasi Basin are becoming more pronounced and population has increased tremendously in the area. The movements of people in the area are seasonal although at times they tend to be permanent migrants. The majority of people who have settled permanently in the area are from within the district.

Due to migration the Lake Eyasi Basin is now mainly dominated by other ethnic groups than the traditional inhabitants. The influx of people in the area leads to pressure on land and consequently, reduced area for pasture and land degradation. People who seek land for agriculture have increased the value of land, consequently, changed the traditional land tenure system from communal ownership towards more privatization of land.

As a response to declining pastures, some pastoralists have decided to move to other areas. The present system of land grabbing is basically a desperate attempt to preserve pasture at individual level. As a response to increased cost of agricultural production poor landowner/farmers have remained with options (selling or renting land, enter into sharecropping agreement with wealthy people or agro-businessmen) that seem not to improve people's livelihood but accelerate poverty and land conflicts among people in the area.

**Keywords:** Tanzania, migration, natural resource management, population growth, conflict.

## **The implications of climate change on land use pattern in Lake Eyasi Basin**

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Climate variability in areas around Lake Eyasi has affected the natural ecosystem of the area as well as human activities and has greatly influenced human mobility. The aim of this study is to investigate the level of climate variability as the driver of human mobility in Lake Eyasi Basin. Trend analysis for rainfall and temperature for about 48 year's from 1960 to 2008 has been done to illustrate the level of climate change and variability. Analysis shows that the trend line for annual rainfall decreases at a rate of -4.6 illustrating that rainfall may decrease even more than the existing situation. The trend line crosses below the average line in 1985, the time when the trend line starts to be below the average level. Drought events are more pronounced in 1990s and 2000's when the trend line was increasingly diverging downward from the average line. The nature of rainfall changes shows a decrease mainly in quantity rather than in seasonal patterns. Also, the trend line for mean maximum and minimum temperature shows an increase at a rate of 0.02 and 0.024 with correlation coefficients of 0.24 and 0.55 respectively. Both mean maximum and minimum temperature have increased showing significant change in climate. Pastoral societies and farmers are absolutely affected by these changes and migration has been one of the coping mechanisms. Migration towards Mang'ola valley for irrigation farming has severely increased over the past twenty years resulting in growth of irrigation farming and decrease of pastoralism in Mang'ola valley. These changes illustrate clearly how climate variability has contributed to migrations in areas around Lake Eyasi.

**Keywords:** Tanzania, climate variability, natural ecosystems, human mobility, land use change

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## **Managing forest wildlife for human livelihoods in the Korup-Oban Hills region, West-Central Africa: A multi-agent systems model to assess socio-economic and ecological sustainability**

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## **Managing forest wildlife for human livelihoods: A multi-agent systems model to assess socio-economic and ecological sustainability**

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### **Rationale**

In West and Central Africa, wildlife exploitation is an important source of protein and income for rural communities who have few alternatives for either, constituting an integral part of livelihoods. Though historically wild meat (“bushmeat”) extraction has been sustainable, current human population has in many areas surpassed the carrying capacity of forests. As a result, this important food and financial resource of poor communities is rapidly declining, putting at risk the future of a large section of the least privileged of the society. The dramatic pressure imposed on the populations of many targeted species, as well as the anticipated socioeconomic effects that a collapse of wildlife populations could have, has led many conservation and wildlife managers to talk of a “bushmeat crisis”.

In most countries, wildlife is considered state property and complex laws regulate access to it. In practice however, there has typically been little national-level active management outside of protected areas. This has resulted in the development of low-sense of ownership among local communities and an unregulated, illegal, and unmonitored “scramble” for quick-profiting from wildlife. In order to change this situation, governments are gradually contemplating devolving user rights to communities, creating the necessary incentive for a sustainable use of the resource. The major assumption of such community wildlife management (CWM) initiatives is that it is possible to both improve people’s livelihoods and to safeguard wildlife for future generations. The feasibility of this management model has been much debated but rarely tested in a holistic approach.

### **Aims**

The primary objective of this collaborative research is to develop effective community-based wildlife management (CWM) systems for the Korup-Oban Hills region, by assessing the conditions under which bushmeat extraction can be ecologically, socially and economically sustainable. In addition, it is our intent to examine the role that

different land-use systems can have in landscape-level wildlife management and conservation (complementing the existing network of protected areas).

### **Study Area**

The Korup-Oban Hills region extends over 10,000 km<sup>2</sup>, saddling the Cameroon-Nigerian border from the Gulf of Guinea and inland for 130 km. It is part of the largest continuous forested area in the Cross-Sanaga Rivers biogeographical region and it is renowned for its rich biodiversity and high levels of endemism. Rainfall is high (2,500-4,500 mm) with a prolonged rainy season and a brief but pronounced dry season. Korup National Park (1,260 km<sup>2</sup>) and its Support Zone (including Nta Ali, Rumpi Hills and Ejagham Forest Reserves) forms the Cameroonian part of the study area. Local population density is 9.3 km<sup>2</sup> (50,000 inhabitants in 182 villages, including 1,500 in 5 villages within the park). The Cross River National Park's Oban Division (3,000 km<sup>2</sup>) is located on the Nigerian side. Local population density is 10 km<sup>2</sup> (40,000 inhabitants in 39 villages, including 2 villages within the park). The flora and fauna is similar across the study area and illegal hunting is a major problem for medium/large animals, the populations of which have in many places drastically declined due to the pressure. In Cameroon, remaining forests are relatively undisturbed, while in Nigeria intact rainforests are primarily limited to the most inaccessible, hilly areas.

### **Methodological approaches**

- **Multi-agent systems modelling (MAS)**  
To be developed with local participation, the MAS will serve as the main tool of the project for testing the social, economic and ecological sustainability of wildlife management scenarios proposed by local communities. It will take into consideration multiple parameters affecting the quality of rural livelihood (e.g. economics access to services, food security, vulnerability to seasonal changes, policies, and local culture). This modelling framework can also be used as a companion modeling tool in negotiations between stakeholders
- **Field Research**  
Although data for some sociological parameters considered by MAS has been extracted from existing government and NGO reports, additional data are collected via interviews and surveys of local stakeholders. In addition, biological data for selected wildlife species (targeted by the bushmeat trade; i.e. duikers, primates) are collected via recce walks and transect surveys.
- **Involvement of local actors**  
Locals participate in all stages of the project, from the development of the wildlife management scenarios to be tested in MAS to the final testing of selected models. Stakeholder meetings are conducted also at divisional level.

The project is divided into five sub projects, which were defined during a methodological workshop and for which work packages and data utilisation plans were elaborated jointly:

- SP 1 (Bobo): Development of a Multi-Agent Systems model (MAS) on sustainable wildlife management in the Korup Oban Hills region (part A) and Duiker populations and the spatio-temporal patterns of hunting (part B)
- SP 2 (Jimoh): Status of duiker populations in the Oban-Hills region in and around Cross River National Park, Nigeria
- SP 3 (Obioha): Socio-cultural factors affecting Wildlife Exploitation in Oban Hills, Nigeria
- SP 4 (Ngoufo): Socioeconomic factors affecting wildlife exploitation in the Korup region, Cameroon
- SP 5 (Waltert): Wildlife monitoring techniques and analyses of wildlife population change at the regional scale

The MAS is being developed with the help of the CORMAS platform, with the Cameroonian study area as spatial basis. We intended to use this as well for scenario development fitting Nigerian realities (e.g. higher human population density).

### **Anticipated deliverables and outcome**

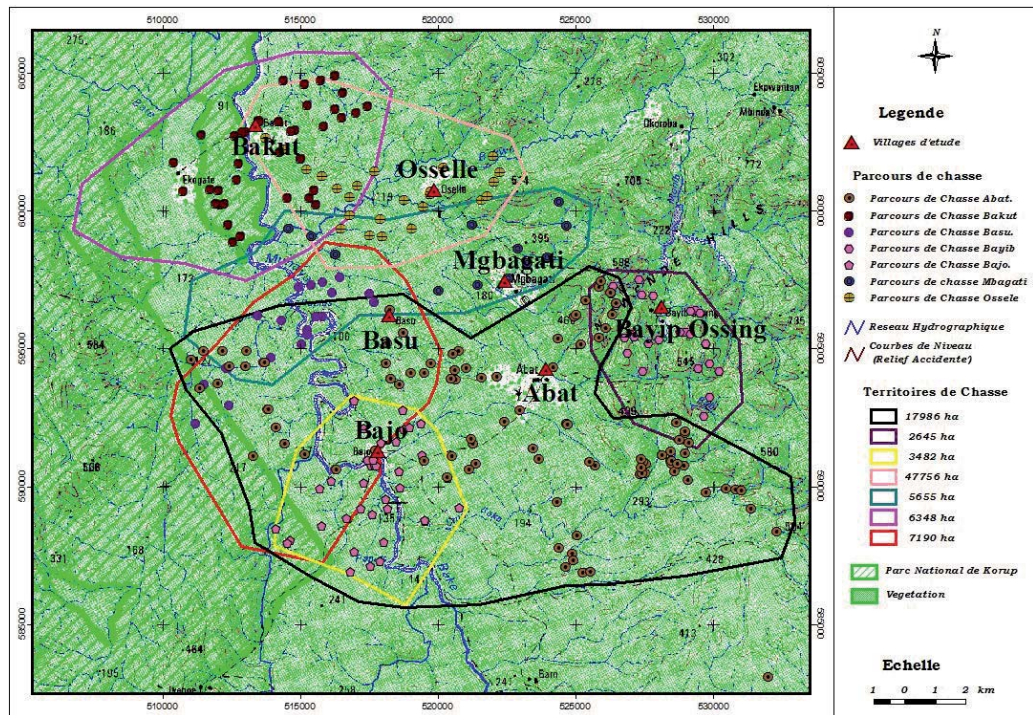
- MAS-tested sustainable hunting models for adoption by local communities
- Practical wildlife monitoring techniques
- Recommendations for protein and income generating activities, alternative to hunting
- Wildlife policy recommendations for Cameroon and Nigeria
- Capacity building of West/Central African young scientists and wildlife managers
- Reinforced collaboration and knowledge transfer between Cameroonian-Nigerian as well as between German-African academic institutions

### **Work in progress and preliminary results**

#### *Cartography of Village Hunting Territories*

MAS modelling consists of a spatial as well as an individual- (agent-)based component. In order to provide a spatial basis for the MAS and to define key agents and their characteristics, students from Dr. Bobo's lab mapped hunting territories of seven villages on the Cameroonian side of the border. Currently, these extend right into the National Park (Figure 1). Segregation of resources between villages appears to be similar in Nigeria but may suggest that, hunting is more confined to areas outside the Park, in line with preliminary wildlife abundance data.





Boundaries of hunting territories of seven villages at the border of Korup National Park

### *Hunting typology and socio-economy of hunting*

Students from Yaounde and Dschang universities cooperate in the assessment of socio-economic surveys and of the spatio-temporal distribution of hunting (frequency, duration of hunts, and type and effectiveness of different hunting strategies). Students from both Nigerian subprojects also generated data on the type and effectiveness of different hunting strategies, and the formal and informal regulations. Preliminary information from Nigeria suggests that socio-economic drivers and cultural characteristics of hunting are similar to those in Cameroon. The engagement in farming activities is possibly higher for Nigerian compared to Cameroonian hunters.

### *Abundance of target species, wildlife monitoring techniques and effects on protected animals*

In the MAS, the blue duiker *Cephalophus monticola* will serve as the principal agent for the simulation of wildlife management scenarios. The species is probably not overhunted. There are three other resident duiker species (*C. ogilbyi*, *C. dorsalis*, *C. sylvicultor*). Wildlife abundance in the study area and the core of the National Park has been assessed, and different monitoring techniques investigated, i.e. nocturnal and diurnal line transects, dung counts, playback calls and net hunts.

Field data collection on duikers and primates are still in progress and will be completed in September. An additional thesis focuses on the status of wildlife at landscape scale, facilitated and supported by our cooperating partners who contribute

long-term data from all over the Gulf-of-Guinea region (cooperation with Gesellschaft für Technische Zusammenarbeit GTZ, World-Wide Fund for Nature Central Africa programme WWF-CARPO, Wildlife Conservation Society WCS, Kreditanstalt für Wiederaufbau KFW).

In Nigeria, wildlife surveying includes four land use types (close canopy forest, secondary forest, oil palm plantations and farm fallows. Also there, different assessment methods are being compared (nocturnal and diurnal transects, dung counts, and the call method).

#### *Capacity building of West/Central African young scientists and managers*

The Forest Engineer degrees at Dschang university are the most important Cameroonian degrees for positions in Cameroon's forestry sector. The project enables students to confront themselves with field realities, something not self-evident because of the distance of Dschang to Cameroon's remaining natural forest blocks and the current curricula. A very similar situation holds for Ibadan.

At Dschang university, six MSc/Forest Engineer (Ingénieur Forestier des Eaux et Forêts) final theses have been/are being developed, supported by four more students pursuing a BS diploma degree (Ingénieur Forestier des Travaux Forestier). At Yaoundé 1, two more students have submitted final MSc (Geography) theses. Several Cameroonian students were supervised jointly between Dschang and Yaoundé.

The socio-economic sub project in Nigeria allows four students to conduct final theses (one PhD and three Masters students), the biological sub project in Nigeria has one PhD, one Masters and one honours student. Further training on wildlife and social science is realised through direct involvement of staff of the authorities of the study areas. The possibility to carry out field research using modern field equipment (digital range finders, laptops), is seen as an important advancement.

#### *Knowledge transfer between Cameroonian-Nigerian and between German-African academic institutions*

In the field, students from Dschang interacted directly with students from Göttingen Apart from joint field work, academic capacity of African researchers is strengthened through the communication of analytical methods and access to international literature, especially the web based subscriptions by the German host. A discussion paper series has been published on the project website which aims at offering introduction to basic knowledge (edited by MW). Most importantly, the funding initiative has enhanced the German-African cooperation by enabling workshops and exchange visits. The project is being widened by opening a research collaboration through two major initiatives (funded by the Council for the Development of Social Science Research CODESRIA and CIRAD – Agricultural Research for Development). The cooperation is sustainable as the cooperating African-German senior researchers have

expressed their willingness to continue to work together as a research consortium even after the present project has ended.

### **List of completed theses**

Azah, M. (2010) Feasibility of community hunting zones at the northern boundary of Korup National Park, Cameroon. (Forest Engineer, Dschang, co-supervised by Yaoundé)

Mouté, A. (2010) Current conditions of and perspectives for sustainable village hunting in the northeastern periphery of Korup National Park, southwest Cameroon [in French]. (Forest Engineer, Dschang)

Müller, M. (2010) Investigations into the population density and ecology of blue and Ogilby's duiker in Korup National Park, southwest Cameroon: application of a new call-method in connection with classic line transects [in German.]. Diplom Biologie, Göttingen.

Repp, T. (2010) Declining duiker populations in two village forests at the border of Korup National Park, Cameroon: a case study on the effectiveness of community-based wildlife management. (MSc./M. International Nature Conservation, Göttingen)

Viquerat, S. (2010) Survey of *Cephalophus* spp. in Korup National Park: Comparing diurnal, nocturnal and dung count surveys. Diplom Biologie, Göttingen

Tiomo, E. (2010) The influences of agricultural activities on animal habitat: advantages or constraints for community hunting in the northern periphery of Korup National Park. (Forest Engineer, Dschang, co-supervised by Yaoundé)

### **Theses in preparation:**

Etubo, A.C.: Forest Engineer, Dschang

Kamgaing Towa, O.W.: Forest Engineer, Dschang

Ngalim, O.Y.: Forest Engineer, Dschang

Tchanou Djetkeu, S.: Forest Engineer, Dschang

Ndengué Mekongo, L.S.: Forest Engineer, Dschang

Nsai, K.: MSc Geography, Yaoundé 1

Mbiayamba, E.: MSc Geography, Yaoundé 1

Flinkerbush, S.: MSc./M. International Nature Conservation, Göttingen

Isiugo, P.K.: PhD Sociology, Port Harcourt

N.N.: M.A. Peace and Conflict Studies, Ibadan

N.N.: M.Sc. Agricultural Economics, Ibadan

N.N.: M.Sc. Agricultural Economics, Ibadan

Olabode, E.: B.Sc. Wildlife Management, Ibadan

Adeyemi, A.A.: M.Sc. Forest Biometrics, Ibadan

Ikyagba, T. E.: Ph.D. Forest Ecology, Ibadan

Further information and discussion papers: <http://www.uni-goettingen.de/en/115492.html>

## **Socio-economic factors influencing wildlife exploitation in the northern periphery of Korup National Park, Cameroon**

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This research is based on four field studies in the Korup region, Cameroon, which jointly address the relationships between social/economic conditions and the sustainability of communal wildlife management (CWM), in order to identify and characterise main agents and their relationships in a Multi-Agents Systems Model (MAS). Seven villages are part of the study area in the northern periphery of Korup National Park. Research consisted of (1) a baseline socioeconomic study regarding the feasibility of community hunting zones, (2) a study on the advantages and constraints of agriculture in regard to the establishment of community hunting zones, (3) a study on the belief systems of potential importance for sustainable wildlife exploitation, and (4) a study on existing community-based organizations, identifying their types, potentials and constraints. All studies were at household level, a total of 652 households were surveyed. Almost all (96.8 %) respondents acknowledged the decrease in the wildlife populations as compared to 10 and 20 years ago. Agriculture is now the main source of income of most households, amounting to an average of 279 000 CFA Francs (even 596 000 CFA in one village) per household from agricultural products, while hunting generates only 110 000 CFA Francs. Over 80 % of household heads are members of community-based organizations ranging from farmer groups, common initiative groups (associations registered by ministerial law n° 92/006 from 14-08-1992) and non-governmental organisations. Activities of groups include environmental sensitisation and development. We analysed in some detail conflict mitigation in these groups, which is essential also for the characterisation of interaction between agents in the MAS model. Weaknesses of community-based organisations range from no training in respect to wildlife management, conflicts of interest especially to sensitive positions (e.g. financial secretary), disrespect of wildlife regulations, and other administrative problems (e.g. lack of book keeping, planning and basic democratic attitudes). The social context is still marked by beliefs and taboos: 70 % of the households surveyed acknowledge the use of wildlife for traditional rites and some practices are against sustainability (e.g. animal products given to the EKPE society). On the other hand, animal totems do still exist in several households (e.g. for chimpanzees). Even though the people were aware of the official hunting regulations of 1994, none of the respondents hold an up to date arm licence or a hunting permit at all. The major reported reasons were expensive transport fares to the administrative offices and the lack of enforcement by the government. While traditionally, monetary fines and goods are still used to punish violations of rules, new regulations are also proposed by households' heads to include the ban of hunting by strangers and rendering obligatory for hunters to also own farms. 90.1

**Keywords:** Communal wildlife management, community hunting zone, socio-economy, sustainability

## Socio-cultural and economic factors affecting wildlife exploitation in the Oban hills of Nigeria, West Africa

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This study investigates the socio-cultural and economic factors that affect exploitation of wildlife in the Oban Hills, Nigeria. Specific factors under investigation include the household diet, nutrition and protein preferences; belief system, taboos and totem attached to the exploitation of the wildlife species; human utilization strategies of the bushmeat; hunting methods and typologies including the major types of animals hunted and sustainability of the duikers population; effectiveness of laws, legislations and enforcement mechanisms; and the patterns of conflict manifestation and mechanisms of resolution in relation to wildlife exploitation.

Five villages were purposively selected from a cluster of about fifty local villages around Cross River National Park (CRNP) in the Oban Hills area which has an estimated population of about 40,000 inhabitants of different ethnic and cultural affiliations, mainly of Ejegham and Ibibio groups. Stratified samples of households, groups and individuals were chosen as the respondents for the survey and interviewees for the qualitative data, respectively. Various techniques of data collection are being triangulated. In-depth interview and key informant interview guides and questionnaire were designed and are being used to conduct interviews among selected stakeholders, role players and community leaders in the chosen communities. Data generated from the survey are being analysed by the use of the Statistical package for the Social Sciences (SPSS).

Based on the preliminary findings, most households in the study area are poor according to United Nations Development Programme international standard and measurement of poverty. There are apparent inadequate infrastructural facilities which reduce quality of life of people in the area. Besides, there are limited sources of income, which forces the local community members to either engage in full time hunting and trading of bushmeat or in a part-time occupation in conjunction with farming, which is the main source of subsistence in the area. Apart from the direct economic gains derived from marketing and trading in bush meat, the byproducts are useful sources of traditional medicines, arts and crafts.

The study reveals that apart from the locally made guns, wires and traps, with recent development, also chemicals which are also harmful to humans, are used to kill animals. Even though various species of animals are hunted, the study reveals that duikers are most often killed compared to other animals. Remarkably, hunting activities are controlled by enforcement of legislations, laws and even informally observed totems, beliefs and taboos. The study further reveals that the hunters are usually people from distant communities and sometimes from across the border to Cameroon, which has led to a huge and extensive bushmeat trade network. In the course of hunting activities, as the question of wildlife depletion becomes apparent while the quest for resource control intensifies, various patterns of conflict unfold.

**Keywords:** Belief system, cultural values, hunting, poverty alleviation, tradition

## **Duiker populations and the spatio-temporal patterns of hunting in six villages of the Korup region, as a basis for a multi-agent systems model of forest wildlife management**

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The main objective of this subproject was to determine and characterise key agents for a multi-agent (MAS) model, which should be used as companion modelling tool for community wildlife management in the Korup region, Cameroon. Specifically, it aimed at assessing behavioural and population ecological characteristics of two species of duiker (*Cephalophus* spp.) in the study area, and the spatio-temporal patterns of hunting in seven villages (Abat, Mgbegati, Bakut, Basu, Bajo, Osselle, Bayip-ossing) in the northeastern part of the Korup support zone, and adjacent areas within Korup National Park (KNP). We combined diurnal and nocturnal mammal surveys, and net hunts and monitored and mapped activities of 25 hunters over a period of six months. We also obtained biometric and population structural data from killed duikers. Semi-structured interviews were conducted with all hunters to complement them with structured interviews with additional stakeholders serving as potential agents for our MAS. Results show that village hunting territories overlap and extend into the National Park. Hunting is unselective and practiced both during day and night. All recorded hunting activities were illegal. During the rainy season, an average hunting expedition lasted for  $1.9 \pm 0.7$  days. Mean fresh biomass off-take was estimated at  $21.6 \pm 13.6$  kg/hunter and hunting expedition, resulting in a mean of  $11.7 \pm 19.2$  kg per hunter and day. Sex-ratio of duikers was 1:0.67 and age structure was 66.7 % adults, 26.7 % sub-adults and 6.6 % young. 83.7 % of hunter catches were sold in villages and local markets, and 16.4 % is auto-consumed. A potential community hunting area of 6,236 ha, adjacent to six of the seven villages studied and to the KNP, has been proposed, but details are subject to negotiation between stakeholders because of potential conflicts about other land uses (farming), and depleted wildlife populations. In order to setup the MAS, a one-week training on the use of the Common Pool Resources Management and Multi-agent Systems (CORMAS) software platform (Lepage et al. 2010) and the SMALLTALK computer language has been undertaken by KSB, being instructed directly by the software developers (Christoph Lepage). The information basis for the MAS is currently being compiled from other subprojects and with the help of the digitally mapped study area. It includes part of the eastern side of KNP, hunting territories of the studied villages where main features are known, and the proposed community hunting area. In our case study, principal agents are blue and Ogilby's duikers, the hunter-farmer system, as well as secondary agents such as NGOs, traditional council members, bushmeat traders and the community-based hunting committee. Other agents, which actions are of potential importance are under

consideration (e.g logging company, traditional healers) and their relevance scrutinized. Parametrisation and translation into SMALLTALK is in progress. Scenarios which are mainly based on the management aspirations of the local stakeholders are being developed based on the results gathered by other subprojects, which will be consulted in an interim project workshop in November 2010.

### **Reference**

Lepage, C., Bousquet, F. & Takforyan, A. (2010): Simulations on virtual worlds: understanding the interactions between ecological and social dynamics. Download (01 August 2010) from: <http://cormas.cirad.fr/pdf/jardinplanetaire.pdf>

**Keywords:** CORMAS, duikers, hunting, multi-agent systems, modelling





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## Urbanisation and its impacts on the use of natural resources in Africa

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## **Urbanisation and its impacts on the use of natural resources in Africa**

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### **Natural resources, livelihoods and urbanisation in Africa**

Whilst urbanisation is a global issue, it is currently most pronounced in developing countries with slum and urban growth rates in sub-Saharan Africa being the highest in the world.

Rapid growth of megacities is leading to increasing challenges with respect to their governability, escalating environmental problems, and massively extended social vulnerability of affected communities (cf., e.g., Kraas 2007). Many urbanisation processes in sub-Saharan Africa, however, are not necessarily related to megapolitisation. Although the small- and medium-sized cities involved, and their urban and peri-urban environments, may, in principle, remain manageable, urbanisation here can still lead to massive land use conflicts, rapid growth of the informal sector, housing problems, and health and food insecurity for the unprivileged or deprived. Processes of urbanisation are very dynamic, spanning all facets of human livelihoods and presenting multiple challenges to planners, decision-makers and new migrants to the urban centres.

Merely contrasting livelihoods in urban areas with those in rural ones, fails to acknowledge the inextricable links and resource flows between the two. It also overlooks the significance of the peri-urban areas that lies between them. There is increasing acknowledgement that rural, peri-urban and urban environments operate as a system (i.e. a continuum) rather than independently. Therefore, there is a need to emphasise these sectoral linkages that bridge the artificial rural-urban dichotomy.

There is still a large inconsistency in the interpretation of urban change in sub-Saharan Africa. This is especially true for the peri-urban areas, and for different types of cities/agglomerations under different political, economic and social conditions. Additionally, the possible reliance of newly urbanised households on natural resources such as firewood, wild foods, medicines and locally harvested building timber has hardly been considered in urbanisation models and processes. Yet they resource have a significant role to play in reducing vulnerability.

The model developed by Turner et al. (2003) will be adapted to this complex situation and one scientific challenge will be to combine existing models of the peri-urban environments and food system approaches with the Turner model. The project focuses on access to and use of natural resources within the urbanisation process, as this aspect has been significantly neglected in research circles and hence policy fora.

## **Conceptual framework**

Currently there is no model that sufficiently describes the multiple factors influencing vulnerability in urbanisation processes, and to theoretically embed these into a vulnerability framework which can explain livelihood change and reliance on natural resources. In the past, researchers acknowledged that it is not sufficient to look at environmental exposure and stressors only, since this leaves out information about different human response strategies as well as impacts (Bohle 2001). Whilst the “Sustainable Livelihood Framework” in current use (see for example Scoones (1997) Leach, Mearns and Scoones (1997)) goes some way in presenting the key components of livelihoods and how these might change, there is greater emphasis on the capital components of livelihood in the context of vulnerability, but much less on the causes and drivers of change and the temporal dimensions of livelihood adaptation (Krüger 2003). Turner et al. (2003) developed an expanded vulnerability framework, which sets the focus on the multifaceted synergies and linkages between human and environmental aspects. In this framework Turner et al. consider disaster management, and show that vulnerability is not determined by exposure to risk only but also by the sensitivity and resilience as well as coping and adaptation strategies of those affected. Urbanisation may not be a “disaster”, but it does represent a physical and social structural change which is both significant in extent and speed.

According to Turner et al., social vulnerability can be defined as the combination of exposure, sensitivity and resilience of a system influenced both by human and natural influences (Turner et al. 2003). The way in which this framework integrates the complex dimensions of vulnerability and resilience is crucial for this study, particularly in its focus on the adaptation to change.

The interdisciplinary approach of this project will provide information and understanding about the complexity of human-environment systems in a situation of urbanisation, and look more closely at social and physical system adaptations to the complexity of urbanisation processes.

## **Objectives**

The aim of the project is:

- a) to analyse the impact of urbanization on livelihoods, with an emphasis on natural resources, in selected African countries and
- b) to develop research partnerships, training, and expertise to investigate the processes outlined above.

The project will thus contribute to a deeper understanding of, in parts, conflicting processes involving livelihood strategies, rapid urban growth, and environmental stress. It will strengthen academic research networks and south-south cooperation within Africa and offer capacity building for young scientists in applied development research topics.

The results of the research should help to:

in the field of research and understanding

- assess urbanisation processes and their impact on livelihood sustainability and resource use under different ecological, economic and social conditions;
- test existing peri-urban models in real situations;
- understand livelihood strategies of migrants and other social groups in new living environments and to develop ideas for relevant support schemes.

in the field of networking, cooperation and capacity building

- enhance the knowledge and foster among young scholars an integrated approach towards the study of urbanisation processes in Africa;
- allow policy makers a better insight in urban development processes, problems and opportunities;
- develop, together with local authorities a holistic model for urbanisation processes in Africa.

in the field of identification of entry points for intervention

- enhance the dialogue between communities, policy makers and researchers and promote participatory urban planning (Local Agenda 21 process) and the implementation of sustainable urban governance structures;
- identify possible means to improve access to food (including subsistence production), key natural resources and other basic needs (relevant to the MDGs1) through relevant research, community strengthening and policy advocacy;
- develop, together with local communities, adapted tools and strategies for sustainable natural resource management in the selected urban areas.

### **Approach**

Analogous to our research targets and project aims outlined above, we decided in favour of a multiple methodological approach. It is important to differentiate between

- a) methods to be used to assess and analyse the impact of urbanisation on the use of natural resources (research component), and
- b) methods to be implemented in order to build local capacities, strengthen networks, and identify potential entry points for intervention (capacity building and management component).

Both sets of methods must be closely inter-linked, and must refer to central analytical concepts of the “Turner model” and the resilience approach.

In order to *understand the dynamics of urbanisation, use of natural resources and livelihoods under diverse framings* an intense screening of existing literature, statistical data, etc. is needed. Vulnerability and resilience contexts, however, require an in-depth qualitative empirical approach. By means of problem-orientated semi-structured or guided interviews we will attempt to grasp what affected individuals, households or communities perceive as major threats and opportunities in the context

of urbanisation and resource use.

In order to *understand the political and institutional dimensions of governing pathways and to explore different actors' understandings of urbanisation and involved livelihoods transitions*, we will resort to the same sets of methods as described above. In addition, we will map actors and their positionality at international, national, regional and local levels, and attempt to assess their role in shaping the processes of urbanisation and resource use (for this activity cf. Marshall et al 2008). Therefore, in this step and in the following attempt *to identify possible entry points of intervention, enhance dialogue between different actors and communities, and explore enhanced procedures to sustain livelihoods under urbanizing conditions*, elements of Action Research will be integrated into our field work. Whilst there are many definitions of Action Research the key elements are that research:

1. sees knowledge as more than information, and that knowledge is a process built through participation rather than data collection alone;
2. is reflexive iteratively assessing success and failure of action, and responsive to such;
3. is focused on the needs of local actors;
4. has a democratic ethos.

The action research cycle allows for a broad mix of stakeholders and local actors as well as the academic fraternity to become involved in the programme. Whilst postgraduate students (or junior staff) and local actors such as NGOs from associated institutions in the selected cities are responsible for conducting most of the research, more senior team members from the main partner organisations provide the technical support and academic 'backstopping'. The methodological tools employed during the action research cycle are typically 'mixed suite' (Marsland et al. 1999) to include both quantitative and more qualitative techniques as well as participatory appraisal. The following techniques are integrated within our methodological framework:

- Household surveys
- Case study examples of how individual households change livelihood strategies
- Vulnerability Analysis
- Quantification of resource use and abundance
- Institutional Analysis
- Understanding of historical perspectives and trends
- GIS mapping and analysis of changes in time and space, as well as resource access.

So far, a mutually agreed standard interview schedule for livelihood assessment has been developed which captures livelihood portfolios (economic, natural resource and financial inputs and outputs) and key natural resources used by different groups along the rural-urban continuum, use patterns and preferences. Student projects focus either on building a standardized livelihoods dataset across all five countries by using

the standardized interview schedule or on specific case studies on urbanization, livelihoods and/or natural resources. The household sampling is carried out in each of the urban, peri-urban and rural zones in transects radiating out from the core.

City research sites in each of the five African countries represented in the consortium (Cote d'Ivoire, Cameroon, South Africa, Botswana and Tanzania) have been identified based on reconnaissance visits, looking at maps and aerial photos and the involvement of local experts:

- In Tanzania the town of Moshi at the foot of Mount Kilimanjaro
- In the Ivory Coast the town of Tiassalé northwest of Abidjan
- In Cameroon the town of Bamenda in the west of the country
- In Botswana the town of Palapye between Gaborone and Francistown
- In South Africa two towns, namely Queenstown (Eastern Cape province) and Phalaborwa (Limpopo province)

**So far the following students' research projects are in progress:**

Linnganani Kombani, MSc. Student, The implications of urbanisation on the use of Mopane worm and Mopane woodlands by local communities: A case study of Palapye rural urban continuum, Botswana

Nomazile Chicho, PhD student, The impact of urbanization on natural capital-based livelihood and health care: A case of Traditional Health Practitioners (THP) in Palapye and surrounding village, Botswana

Catherine Ward, MSc. Student, The use of natural resources: A particular focus on edible crops along the rural-urban continuum in South Africa

Michelle Evans, MSc. Student, Livelihood and coping strategy changes along rural-urban continua in South Africa, with an emphasis on natural resources

Maulid Bwabo, MSc. Student, The impact of migration on peri-urban farming: A case study of Hai District, Tanzania

Yusuph Kulindwa, PhD, Analysing spatial urbanisation process and its impacts on small-scale horticultural producers: A strategy to improve small scale producer's livelihood in Moshi municipality, Tanzania

Isaac Kazungu, MSc. Student, The role of micro and small agribusiness enterprises towards sustainable livelihood: a case study of nurseries in Moshi rural-urban continuum, Tanzania

Katja Giersemehl, MSc. Student, Microfinance institutions and women empowerment in Moshi-Tanzania (Germany)

Johannes Schlesinger, PhD Student, The importance of urban and peri-urban agriculture for the food security of medium-sized African cities (Germany)

Geraldine Regina Ngobe Njumbe, MSc. Student, Impact of urbanization on livelihoods with respect to natural resources along the rural-urban continuum: Case study of Bamenda, Cameroon.

Kamga Fogué Aimé, MSc. Student, Impact of urbanization on vegetable production practices along the rural-urban continuum: Case of Bamenda, Cameroon

Alexis Koffi, PhD Student, Impact of natural resources governance on households' livelihoods

in the context of urbanization: Case of Tiassalé in Côte d'Ivoire

Koffi Ehui Bla Germaine, PhD Student, Impact of urbanization on the household's natural resources use: Case of Tiassalé in Côte d'Ivoire

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## **Natural resources governance impact on household livelihoods in an urbanization context: Case of Tiassalé, Côte d'Ivoire**

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In Tiassalé, natural resources play an important role in the production systems of a large majority of households. In a context of significant population growth, rapid urban growth and an increasing commoditization of trade in goods and agricultural production factors, the operating modality and development of natural resources by local communities represent important economic, social and environmental issues. Since, Local Governance is seen as a genuine alternative to development problems faced by households of Tiassalé in particular and households of Côte d'Ivoire as a whole. In fact, communities are now placed in the centre of policies aiming at affecting their lives. In order to locally implement its development policy, the government involves local authorities, including the *Prefect*, the *sub-Prefect*, the Member of Parliament, the Mayor, the Local Chiefs, and the Civil Society in local management and decision making regarding control and natural resources exploitation.

This study focuses specifically on Natural Resources Governance Impact on Household Livelihoods in an Urbanization Context. It relies on the main assumption that when there is scarcity of natural resources due to urban growth, the management methods of these resources are adopted at different level: locally, nationally, and regionally. And these methods affect the household livelihoods.

The study addresses the issue of Natural Resources Governance Impact on Household Livelihoods through an approach based upon an analysis of decision making in management of natural resources, actors, capital analysis, and household livelihoods.

**Keywords:** Natural resources, land resources, rural land management policy, household, livelihood, urbanization, governance, land tenure, land conflict, fishery resources, poverty



## **Impact of urbanisation on natural capital-based livelihoods and health care: A case of traditional health practitioners along Palapye rural-urban continuum, Botswana**

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The proposed study is about the relationship between urbanization and the use and management of resources relevant to livelihoods and traditional medical practice along the rural-urban continuum of Palapye, one of Botswana's fast emerging urban centres. According to the UN's (2008) world urbanisation prospects, approximately half of the world's population lives in urban settlements and is projected to increase from 3.3 billion in 2007 to 6.4 billion in 2050, while the rural population will decline by 0.6 billion from today's population. Expressed in percentages of total population, the global urban population drastically increased from 5 % in 1800 to 47 % in 2000 and 50 % in 2008 and is expected to be 65 % in 2030. The world's future urban population growth will be concentrated in developing countries, largely because of their current low levels of urbanization. In this context, studies depict Africa as a rapidly urbanising continent, with Botswana reported to be the most rapidly urbanising country on the continent. In developing countries, rapid urbanisation is generally associated with increased demand and over-harvesting of natural resources and loss of biodiversity within their ecological or environmental sphere of influence. More pressure has been put on the natural resources, particularly natural forest vegetation, and this includes vegetation used for traditional medicine. This gradually influences the commercialisation of natural resources leading to over-exploitation of the forest resources. In relation to this, there is evidence that trade in natural resources, especially medicinal plants, has recently increased in southern Africa.

There is insufficient documentation linking urbanisation and natural capital-based livelihoods related to health care. The study will employ both qualitative and quantitative research techniques. The household survey questionnaire which aims at capturing a wide scope of natural resources use will be administered to households from the general community. The traditional health practitioners will be involved as key informants, on focus group discussions and guided interviews. Therefore, using the sustainable livelihoods framework (SLF), this proposed study intends to establish the extent to which these communities are dependent on the natural environments for their livelihoods and how urbanisation has affected the demand for and supply of natural capital with special emphasis on natural capital for traditional medical practice. It will also evaluate the impact of urbanisation on natural capital-based sources of livelihoods linked to health care in a fast urbanizing African environment. The outcome expected from this study includes an assessment of the main livelihood strategies employed by households and individuals along the Palapye rural-urban continuum whose disturbed

sources of livelihood are linked to traditional medical practice. It is consequently expected that the study will produce results that could inform formulation of policy regarding the exploitation and management of, as well as trade in, traditional medicinal plants within Botswana's urban fringes. It is therefore hoped the study will also culminate in viable recommendations for sustainable practices aimed at effectively and sustainably benefiting from the natural environments within the urban sphere of influence without compromising the needs of the future generation.

**Keywords:** Livelihoods, medicinal plants, urbanization

## The importance of urban and peri-urban agriculture for the food security of medium-sized African cities

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*Background / Objectives:* Urban and Peri-urban Agriculture (UPA) plays a crucial role in providing nutrition for the growing population of cities in developing countries in general and in African cities in particular. Even though the research on this topic has significantly grown within the last years, there is a notable bias on capital cities and the main economic centres. The medium-sized cities in Africa, however, have been widely neglected. So far, there have hardly been any studies on the importance of UPA in those cities which will be home to about 65 percent of the population in 2015 (United Nations 2004). Therefore, the awareness of that importance is very low when it comes to the formulation of appropriate policies concerning UPA. The formulation and implementation of policies supporting UPA, however, will become increasingly important for ensuring Food Security in medium-sized African cities in the future.

*Approach:* To convince policy makers of the importance of UPA, it is very important to provide quantitative data as well as qualitative data. This Research is conducted in Moshi, Tanzania, a city of about 150.000 inhabitants located at the foot of Mt. Kilimanjaro. To quantify the outcome of UPA of the Moshi Municipality a two-fold research approach is being applied. A rather top-down approach using high-resolution satellite data provides an overview of the area under cultivation at a certain point of time. Secondly, a participatory GIS conducted with and by the farmers themselves helps validating the findings of the analysis of satellite images and furthermore helps getting in contact with those who are affected by policy changes. Qualitative data is being collected through structured, semi-structured and unstructured interviews as well as different kinds of observation techniques and group discussions.

*Preliminary results:* A first field trip realised from May to June 2010 has shown that UPA plays a crucial role in providing food for the fast growing city of Moshi, Tanzania. At this early stage of the research no reliable statements can be made concerning the area under cultivation. It can, however, be presumed that more than three quarters of the inhabitants of the Moshi Municipality are engaged in UPA. In some areas of the Municipality, the area under cultivation exceeds the area used for typical urban functions such as housing, infrastructure etc. by far. The livelihoods of the majority of Moshi's inhabitants highly depend on the cultivation and the consumption or marketing of the crops grown on land within the city boundaries. Nonetheless, the regimentation of and the institutional support for UPA through the Municipality is still lacking. One reason being the abovementioned lack of reliable data concerning acreage, crop production and importance for the food supply of the city.

*Conclusion:* In order to ensure Food Security for the growing urban population in the developing world in general and in Africa in particular, it is important to recognise the significance of UPA for food supply as well as income generation, eventually for sustaining urban livelihoods. Policy makers not only in the big agglomerations but also in the often neglected medium-sized cities do need reliable data to form a policy framework that ensures the sustainability of urban food supply.

**Keywords:** Urban and peri-urban agriculture, urbanisation, medium-sized African cities, food security, GIS, Moshi, Tanzania



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## The role of institutions for forest resource and livelihood management in East African forest landscapes

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## **The role of institutions for forest resource and livelihood management in East African forest landscapes**

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### **The project consortium**

Since 1993 Uganda has been implementing forest decentralization reforms. These reforms have shifted some forest management responsibility from a centrally coordinated Forest Department to lower governance levels at the district, county, sub-county and private levels. Those reforms made it necessary to better understand the effect that new institutions had on livelihoods and forest conditions. UFRIC has researched incentive programs, forest decentralization, forest collaborative management systems, land-use/land-cover change. UFRIC researchers are active participants in forest policy dialogues at local and national level providing academic insight and producing policy briefs. At community level, UFRIC has trained numerous local technicians and leaders in various useful skills including: forest management techniques, alternative sources of income, awareness of their rights and roles in the context of decentralized forest management, empowerment for demanding services from government agencies. UFRIC collaborates and networks locally with NGOs and government agencies, regionally with CRCs, and globally with CRCs and Indiana and Michigan Universities.

The Tanzanian Research Center on Forest Resources and Institutions is located at the Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Morogoro, Tanzania and was founded in January 1998. The center has recorded a number of achievements, including establishment of 10 IFRI sites in various agro-ecological zones. Out of the 10 sites, 6 have been revisited and 4 visited once. The collaborative research center has published several papers in local and international journals. It has also organized 2 regional workshops one of which resulted into a joint proceeding. The collaborative research center has also been able to establish a digital library with technical back stopping from the Indiana University.

The Kenyan collaborative research center was established in 1997 with assistance from UFRIC. The center is located at KEFRI (Kenya Forestry Research Institute). The initial objective of the center was to study causes of deforestation and its effects on the forest condition and the livelihoods of forest adjacent communities. In addition

the center investigates incentive structures for reducing deforestation. The first site was established in 1997 and since then, the center has established 15 sites and revisited 13 of them. Communities have been sensitized on participatory management of the forests. The results from these studies have influenced policy reforms especially related to participatory forest management. The collaborative research center also shares information from research findings within the country, East African region and at international levels through site reports, policy briefs and scientific papers. Kenya has historically had a centralized forest management structure, with decisions concentrated in a hierarchically structured forest department. In 2005 Kenya passed a new law that decentralizes management to lower administration levels, even including communities. The substantive impacts of these reforms on the livelihoods and property rights of the poor, women and other marginalized groups are currently being investigated by KEFRI. Forests are selected to ensure both institutional and ecological variation. Thus within the range of forests sampled a range of property regimes are represented, from private, individualized forests, to community forests to state forests managed by various state agencies. Similarly, the complement of forests sampled represents some ecological diversity, ranging from coastal lowland forests, through tropical rainforests to high altitude. The collaborative research center plans to continue to build the capacities of researchers to collect data on established and new sites in order to answer some of the emerging governance and livelihood issues.

The Environment and Coffee Forest Forum, formerly Ethiopian Coffee Forest Forum (ECFF) is a non-profit civil society association, established on October 19, 2005 as per the Ethiopian penal Code No. 404 issued in 1960. The Association was established by a group of professionals, prominent public and business people, scholars, and community leaders, in order to strengthen and promote networking among different institutions and organizations involved in the conservation and use of forest resources in Ethiopia. It focuses on developing strategies for sustainable use and conservation of forest coffee and other non-timber forest products, conservation of biodiversity, research, conservation education and communication and implementation of sustainable use concepts developed from research findings. ECFF has established partnership with different national and international organizations engaged in conservation and sustainable use of coffee genetic resources and biodiversity. Currently, ECFF is working with the Center for Development Research (ZEF) of the University of Bonn, the Institute of Biodiversity Conservation, Addis Ababa University and the Ethiopian Institute of Agricultural Research. ECFF is also working closely with the German Federal Agency for Nature Conservation (BfN). BfN is supporting different outreach activities and building the capacity of ECFF. Currently, ECFF is working on landscape planning for the establishment of a biosphere reserve and conservation education with BfN, awareness creation workshops for policy makers and senior researchers and trainings to development agents and conservation practitioners. ECFF

has also established development oriented research projects with private companies like Illy Café, and Robera Coffee.

### **Project summary**

Deforestation and food insecurity in Ethiopia, Uganda, Kenya and Tanzania are threatening the sustainability of livelihoods in forest landscapes. Most frequent and underlying causes for this are market-, policy- or institutional failures. The research network on forest resources and institutions (IFRI), includes partners from Uganda, Kenya and Tanzania and has produced pioneer knowledge on the importance of institutions for sustainable livelihoods in forest landscapes. The IFLEA project intends to strengthen the capacities of this network by training MSc and PhD level students and enhancing network linkages between the members of the network. Further, the network is committed to establish another collaborative research center in Ethiopia. Young researchers are being trained in the theoretical and methodological approaches of the network. Strengthening the network is done by a “training for trainers” course which intends to prepare and coordinate the trainers of the intensive MSc and PhD training courses. These courses are provided by the newly established Ethiopian CRC and colleagues from the network will provide share their knowledge and prepare input for these events. Further, two annual meetings which bring together students, senior researchers and guests are carried in order to plan the activities of the coming years, discuss network and collaboration issues and exchange research results. Applied funds are used for research equipment, travel, student stipends, and training.

### **Results achieved so far**

The Ethiopian collaborative Research Center has been established and formally made part of the global IFRI network. For the training of trainers workshop, Dr. Franz Gatzweiler from ZEF, Dr. Bahati from UFRIC and Prof. Luoga from Tanzania came to Ethiopia. During the following training workshop in October 2009, ECFF has trained 6 MSc students of which 3 have submitted and defended their thesis. Each 2 students have done research in 3 forests: Yayu, Belete Gera and Arero forest. The training workshop was attended by graduate students from different universities and the Ethiopian IFRI-CRC database manager. Instructors for the training were drawn from different universities in Ethiopia and abroad, and from ECFF. Julie England, the database manager from the CRC in Bloomington, Indiana University was invited to give a two-weeks training on using the database and analyzing data.

ANDENET DERESE

### **Assessment of institutions affecting livelihood strategies and forest resources management: The case Yayu forest (MSc thesis)**

A study was conducted to assess the influence of local level institutions, community and forest resource attributes on the use, management and conservation of forest



resources in Yayu forest of Illu Aba Bora Zone, Southwest Ethiopia. The study findings revealed the existence of various formal and customary institutions that influence forest management and use in the study area. The formal institutions contributed to forest resource management in performing collective choice level activities such as alienation and exclusion and determine operational level activities. On the other hand, Informal local level institutions such as council of elders, or religious institutions, and *jiga*, *dabo* and *idir*, were involved in operational level activities. Additionally, informal institutions are also used as a platform by the government to initiate formal dialogue to create awareness about forest resources use, management and conservation. Along with the inefficient and complex institutional setup, the prevailing poverty and lack of forest management guidelines are the major critical problems of conservation of Yayu Forest. Sustainable forest management can't be possible without the proper recognition and involvement of functional informal institutions in the area.

DISASA MERGA

**Local knowledge and institutions affecting forest resources management vis-a-vis livelihoods: A case study of Belete-Gera forest, southwestern Oromia regional state (MSc Thesis)**

This study deals with forest management from the perspective of local knowledge and institutions in relation to the livelihood of local people with particular reference to Belete-Gera Forest Priority Area of Jima Zone, Oromia Regional State, Ethiopia. The research addresses the role of local knowledge and institutions in forest management vis-a-vis livelihood of the local people. The study is based on the field research conducted in Gera district for two solid months ranging from 21 December 2009 to 21 February 2010. Different tools of data gathering mechanisms were employed; structured and unstructured interviews, focused group discussions, observation and survey were utilized. The data were analyzed qualitatively in the conceptual frameworks of political ecology and common property theories. The qualitative analysis of the study reveals that understandings of local people about the values of forest and forest management are remarkable. They are well aware of ecological, economical and socio-cultural values of forest in the study area. The study also indicates that customary institutions of the local people play a great role in forest management. Traditional leadership such as *abba laga* and *shane* are still active and play a great role in resource management.

HALAKE DIDA GOBESSA

**The impacts of development interventions on customary institutions of forest resource management among the Borana Oromo of southern Ethiopia (MSc thesis)**

This thesis is about the impacts of development interventions on customary institutions of forest resource management, among the Borana Oromo of Southern Ethiopia. The study is initiated as result of observation of deforestation of the Borana forest-

lands. The results of the study show that most of the ceremonial grounds and holy trees of the Borana are situated inside the forest areas. The mobile ritual villages of the Borana usually reside inside the forests to perform various cultural practices and thus, the belief systems attached to the forest grounds are the basic means of forest management. Different customary institutions at various levels and their members are responsible for forest management. However, development interventions ignored the customary institutions of resource management and used a top-down development approach. Inappropriate development interventions, ignoring the traditional customary institutions brought erosion of customary institutions and deforestation. It is recommended that a participatory development approach should be employed including the communities in problem identification, planning, implementation, monitoring and evaluation.

EMILY OBONYO

**The potential of local institutions to improve natural resource governance and livelihoods in Kenya's forested landscapes (PhD research)**

This research aims at understanding the structure, drivers and dynamics of local institutional change in Kenyan forest landscapes, as local communities make use of their new rights and respond to the opportunities and challenges of the New Forest Act. Understanding better the features of cultural diversity and the drivers of institutional change or continuity, will help both, local communities and government authorities to work together towards localized, and tailor-made institutions which fit to local forest conditions as well as to the attributes of local forest users.

DANIEL WAISWA

**Integrating remote sensing, geographic information systems and community based appraisal for sustainable management of forest resources in the Lake Victoria crescent, Uganda (PhD research)**

Forest cover loss through deforestation and forest degradation is at an alarming rate in Uganda. Attempts to address forest cover loss focusing on promotion of sustainable forest management have been ineffective due to inadequacy of information at sub-national and local. This dissertation research seeks to provide local scale information to forest stakeholders. The research will (i) stratify and explore land use and land cover dynamics, with specific focus on forest cover, in Uganda's Lake Victoria crescent since 1980s, (ii) characterize the spatial distribution of land use and land cover dynamics, with specific focus on forest cover, in Uganda's Lake Victoria crescent since 1980s, and (iii) determine potential drivers of forest cover change including opportunities and constraints to sustainable forest management in Uganda's Lake Victoria crescent since 1980s.

## **Integrating remote sensing, geographic information systems and community based appraisal for sustainable management of forest resources in the Lake Victoria crescent, Uganda**

DANIEL WAISWA, UGANDA

Despite the various roles played by forests, including providing livelihoods for millions of people worldwide, forest cover loss through deforestation and forest degradation is at an alarming rate, especially in tropical countries such as Uganda. Attempts to address forest cover loss focusing on promotion of sustainable forest management have unfortunately been ineffective due to inadequacy of information at sub-national (local) scale among other issues.

This dissertation research therefore seeks to provide such local scale information to forest stakeholders. The research objectives include:

1. Stratify and explore land use and land cover dynamics, with specific focus on forest cover, in Uganda's Lake Victoria crescent since 1980s,
2. Characterize the spatial distribution of land use and land cover dynamics, with specific focus on forest cover, in Uganda's Lake Victoria crescent since 1980s, and
3. Determine potential drivers of forest cover change including opportunities and constraints to sustainable forest management in Uganda's Lake Victoria crescent since 1980s. This is to be achieved through integration of remote sensing and Geographic Information Systems (GIS) techniques with social science's community-based appraisal techniques.

The generated information will enhance sound and informed decision-making amongst forestry stakeholders and subsequently lead to development of alternative strategies for promotion of sustainable forest management in Uganda.

## **The potential of local institutions to improve natural resource governance and livelihoods in Kenya's forested landscapes**

EMILY OBONYO, KENYA

Kenya has come a long way to its New Forest Act from 2005. Decentralization efforts resulted in Participatory Forest Management in which local communities were allowed to participate in forest management, were told how to participate and had to sign contracts with governmental authorities, which could not easily be changed. This approach has been taken in many PFM projects throughout Eastern Africa and produced unsatisfactory results. It frequently created conflicts, overlooked local institutional structures and did not create ownership and responsibility with local forest communities. With the 2005 Forest Act communities are now able to register as Community Forest Associations and thereby have received considerable authority to devise their own rules for the management of their forests. This is an extraordinary change in policy, moving away from merely decentralizing to allowing self-governance to emerge.

How do local communities formulate rules and organize themselves to manage their forests sustainably? Which capacities do local communities have to master these new challenges? How do they organize themselves, collaborate and establish their rules for forest management? And how do different cultural groups cope with those challenges and why do some perform better than others?

Many indigenous forest communities in Kenya have used the forests for generations without knowing the origin of the rules for forest management, or without a specific set of rules exclusively for the management of forests. Rules, norms, values and beliefs intertwine with local customs which determine the relations between people and nature. Often local institutions are part of cultural and spiritual systems enforced by elders or priests. These belief systems nevertheless have a natural resource conservation aspect to them and can be translated into principles for successful collective action in the management of common pool resources.

This research aims at understanding the structure, drivers and dynamics of local institutional change in Kenyan forest landscapes, as local communities make use of their new rights and respond to the opportunities and challenges of the New Forest Act. Understanding better the features of cultural diversity and the drivers of institutional change or continuity, will help both, local communities and government authorities to work together towards localized, and tailor-made institutions which fit to local forest conditions as well as to the attributes of local forest users.

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## **Agricultural use and vulnerability of small wetlands in East Africa**

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## **Agricultural use and vulnerability of small wetlands in East Africa**

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### **Rational**

African agriculture is traditionally upland-based. Production potentials are limited by soil nutrient depletion and land degradation. Furthermore, about one half of the agriculturally used land is affected by drought and nearly 80 % are characterized by unfavourable soil conditions. Demographic growth, intensified land use, and globalization effects such as climate change phenomena and the global use of local resources, further exacerbate upland degradation and soil-related problems. A declining production potential of the upland areas forces farmers to increasingly cultivate marginal or traditionally not used areas such as wetlands. The current shift from upland to lowland agriculture became prominent in eastern Africa in the mid-1980s and has recently accelerated. Particularly the small wetlands with <500 ha have been put under heavy use pressure in the recent past. They make up an estimated 12 million ha in Kenya and Tanzania and comprise primarily inland valleys and alluvial flood plains. Such permanent or temporarily flooded areas are characterized by fine-textured, relatively fertile soils, and present potentially highly productive sites for agriculture. Due to water availability and a high resource base quality, wetlands are seen to increasingly absorb the growing pressure on land for food production. Provided the application of sustainable use practices, wetlands may well develop into the “breadbasket” of the region.

### **Problem statement**

Wetlands are not only potential sites for future agricultural production; they also fulfil numerous social and ecological functions and provide a wide range of ecosystem services. These diverse services are solicited by an increasing number of users with divergent interests, increasingly resulting in user conflicts and the loss of the wetlands' ability to fulfil the diverse functions. The usual conversion of pristine wetlands into sites of production follows a step-wise evolutionary pattern. The spatial extent and speed of this land use change depends on a range of social and economic factors that are still poorly understood. Starting from an extensive use of the natural vegetation (usually papyrus, diverse other *Cyperus* species and *Typha*) as grazing ground and for providing thatching materials, smaller patches may be cleared and cultivated to flood-tolerant taro (*Collocasia esculenta*) during the wet season and/or other subsistence crops on non-flooded areas during the dry season (mainly maize). These interventions affect only marginally the hydrology and hence the various ecological and social functions of the wetland. The construction of drainage canals accelerates the conversion

of natural wetland sites, allowing for a larger-scale production of upland field crops (mainly field vegetables), often during both the dry and the wet seasons. A receding water level accelerates the mineralization of soil organic matter and strongly affects the remaining natural vegetation. Depending on the intensity of the interventions, the sites lose their wetland character and become highly productive cropland. However, the access to the water is strongly restricted and with the natural swamp vegetation disappears the habitat for natural fauna and flora. Such intensely used wetlands may maintain their characteristics of highly productive agricultural land (resilience), but in some instances, soils tend to degrade rapidly and invasive weed species further reduce the production potential (vulnerability). Such degraded or destroyed wetlands are abandoned and become fallow or grazing land. To date it is largely unknown, which wetlands are sensitive to diverse anthropogenic interventions, which are able to sustain their production potential under intensified land use, and which are essential providers for ecosystem services and should hence be protected.

### **Objectives**

Wetlands have been largely neglected by research, as they are relatively small and very diverse regarding hydrology, soil type, production potential, and the agro-ecological zone in which they occur. Little is known about the driving forces of wetland use, about wetlands agricultural potential or the wetlands ability to adapt to the changing needs of the resource users. There is a need to reconcile demands for production with concerns for environmental protection, and to provide a quantitative basis for assessing the potential of wetlands in East Africa. Specific research activities presented thereafter comprise:

1. to capture the current diversity of wetlands in terms of types, spatial distribution and driving forces for change and/or use;
2. to determine the role of prototypic wetlands as sites for plant biodiversity and providers of ecological services under changing use;
3. to determine the dynamics, availability and quality of soil and water resources under intensified use and link the processes with the production potential;
4. to identify drivers of land use change and quantify factor interactions.

### **Approach**

These research questions were addressed in four study areas that were selected based on their diversity in climate, base rock, and wetland type as follows:

- Floodplains in the arid highlands formed on granite (Rumuruti, Kenya);
- Inland valleys in the humid highlands formed on volcanic material (Karatina, Kenya);
- Inland valleys in the sub-humid mid-hills formed on gneiss (Lushoto, Tanzania);

- Floodplains in the semi-arid lowlands formed on fluvial sediments (Korogwe, Tanzania).

The wetlands within each study area differed in terms of anthropogenic use pressure and the type, intensity and duration of land use. The multi-disciplinary team comprising geographers, hydrologists, vegetation ecologists, soil scientists, and agricultural ecologists was working jointly at the same time at the same sites to maximize interactions and synergies.

## **Findings**

The development of guidelines regarding the future protection or use of wetlands requires their systematic classification and the characterization of their diverse uses. In a first step, the wetland diversity was therefore characterized following a rapid rural appraisal by a multidisciplinary team and categorized by principal component, cluster and discriminate analyses. Fifty-one wetlands were inventoried in the four typical landscape units of Kenya and Tanzania. Each wetland was subdivided into sub-units of 0.5-458 ha based on the dominant land use. The resulting 157 wetland sub-units constituted the sampling frame for the determination of their biophysical and socio-economic attributes and for their categorization. They comprised five cluster groups, primarily based on area, flooding regime, physical accessibility, land use intensity and market proximity. The main wetland categories were: (1) wide permanently flooded valley bottoms and highland floodplains under extensive use (n = 41); (2) narrow permanently flooded inland valley swamps that are largely unused (n = 25); (3) large inland valleys and lowland floodplains with seasonal flooding under medium use intensity for upland food crops and lowland rice (n = 37); (4) completely drained wide inland valleys and highland floodplains under intensive food crop production (n = 26); and (5) narrow seasonally flooded valley bottoms under permanent and year-round intensive horticultural production (n = 26). Wetland type and hydrological regime were associated with specific vegetation forms and soil attributes. Agricultural land use of wetlands was largely linked to their physical accessibility, the seasonal flooding, and the availability and use of adjacent upland areas, irrespective of wetland size or soil type. The proposed typology has been used to guide further in-depth studies on the agricultural potential and vulnerability of wetlands. These in-depth studies are structured into three area clusters:

1. The spatial extent of wetlands in different environmental settings was quantified and different land uses were differentiated by aerial photography. Recent changes in land use were documented by time series analyses of satellite imagery. Driving forces of wetland use change and human environment interactions were determined by questionnaires and interviews with key informants and analyzed by multi-variate statistical and modeling approaches. The main findings are summarized in the abstract by Mwita and Sakane.



2. Vegetation is an indicator of resource availability, resource base quality and land use. The vegetation formations were assessed under changing land use using species composition and coverage, while indicator species for different conditions of hydrology, trophic level, and hemoroby were determined through floristic inventories and their relation to bio-physical characteristics. In addition, the recovery potential of the initial natural vegetation was assessed by the analysis of diaspores in soils under different land uses and use durations. Key findings are presented in the abstract by Handa, Mogha and Alvarez.
3. The production potential of a wetland is determined by the availability of water and the ability of the soil to support intensified agricultural uses. The spatial-temporal dynamics of water resources were assessed by stratified and transectional soil moisture determination using TDR probes and hydrological models, while soil parameter changes under different land use types, durations and intensities were determined by Near-Infrared Spectroscopy and soil physico-chemical analyses. The crop response to soil parameter changes was assessed in greenhouse studies in potted soil. The findings on these bio-physical characteristics of wetlands are summarized in the abstract by Kamiri and Bhme.

In the first three-year phase of the project, we characterized a large number of wetlands in Kenya and Tanzania regarding their biophysical characteristics and socioeconomic attributes. We have gained substantial knowledge regarding the area coverage, diversity, descriptive attributes, and uses of wetlands. In the upcoming second research phase we will focus on the main wetland categories to quantify their production potential by combining agronomic yield gap and vegetation observation trials with remote sensing and modeling approaches. The resulting assessment of ecosystem functions and agronomic potentials will be extrapolated by regional up-scaling and will provide guidelines for future wetland protection or uses. The combined findings are seen to improve our understanding of the potential and vulnerability of wetland and to provide the quantitative basis for guiding decisions concerning protection or future agricultural use of small wetlands in eastern Africa.

**Keywords:** Kenya, land use, resilience, Tanzania, vegetation

## Land use land cover changes and their determinants in small wetlands of East Africa

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Small wetlands in East Africa have in the past few decades become focal points of agricultural production, resulting in a rapid conversion of pristine wetlands into sites of production. We identified land cover / land use patterns in representative wetlands and determined key drivers responsible for wetland conversion. Time series Landsat images (1976-2003) and aerial photographs (2008-2009) were used for the classification and the quantification of changes. Ground truthing was done through intensive field surveys. Driving forces of change were determined qualitatively through structured questionnaires and group discussion with key informants.

Within the surveyed areas, wetlands made up 3-5 % of the total land area. The two dominant wetland types identified comprised inland valley swamps (87 %) and floodplains (13 %). Un-supervised and supervised classifications of remote-sensed data differentiated six major land uses within the surveyed wetlands. They comprised close-to-natural situations as well as strongly anthropogenically-influenced land uses. Their relative share differed between wetland types. While the dominating land use was crop cultivation in all wetlands, its share was much larger (57 %) in inland valley than in floodplain wetland (35 %). Natural vegetation and shrub-dominated fallow areas occupied 30 % of the floodplains and 17 % of the inland valleys. The presence of grazing land and open water was restricted to floodplains, while settlements covered some 14 % of the area, irrespective of the wetland type. A further category comprised bare patches referring to either freshly tilled land or bare fallow. These different land uses have dramatically changed during the past 30 years. Most apparent is the expansion of cropped land at the expense of natural vegetation. Between 1976 and 2003, 56 % of natural vegetation was converted to agriculture in the highland flood plain sites and 52 % in the lowland floodplain. Another change is the expansion of shrub-dominated fallow land which proliferated by more than 60 % in the floodplains during the past 30 years.

These recent changes in wetland uses appear to be linked mainly to their physical accessibility, the seasonality of flooding, and the availability of land in adjacent upland areas. Thus, unused wetlands were strongly associated with permanent flooding and poor physical accessibility. Permanent and input-intensive cropping was associated with wetland drainage, intense use of adjacent areas (upland shortages), the physical accessibility of the wetlands and market proximity. Thus, permanently flooded wetlands in remote rural areas with low population pressure may be maintained in a close-to-natural state while the seasonally flooded, drainable inland valley and floodplain fringes in peri-urban areas are seen to play a key role in sustaining livelihoods and improving food security in the future.

**Keywords:** Aerial photography, Landsat, remote sensing

## Vegetation changes and indicators of wetland use and potential in East Africa

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Wetland vegetation differs between environmental settings and the wetland types and is a reflection of the wetlands' biophysical attributes, mainly its hydrology and trophic level. It will change with increased anthropogenic disturbance (hemoroby) in the frame of conversion from pristine wetlands to sites of agricultural production. This may also include changes in the soil seed bank. Vegetation may be used as an indicator of resource availability and resource base quality to assess wetlands' vulnerability or production potential.

We inventoried and comparatively assessed the vegetation in main wetland types under different land uses by an analysis of plant species as bio-indicators, a characterization of plant communities, species composition, and the soil seed bank in 224 plots of 100 m<sup>2</sup>. Species presence and percentage cover were recorded. Soil cores were collected for determination of the abundance and viability of diaspores. Vegetation matrices were developed for plant functional traits and used as indicators of changing wetland conditions. Similarities between plant species composition and diaspores were determined.

A total of 439 species from 93 families were recorded. Dominant families included Poaceae, Asteraceae, and Cyperaceae. Floodplains had higher gamma diversities compared with intensively-used inland valleys. Under permanent flooding, natural vegetation was dominated by *Cyperus papyrus* under oligotrophic and by *Typha capensis* under eutrophic conditions. With seasonal flooding, the dominant natural vegetation differed between wetland types with *Cyperus exaltatus* and *Polygonum* spp. dominating the floodplain and *Leersia hexandra*, *Cyperus rotundus* and *Kyllinga* spp. the inland valley swamps. The dry sections of wetlands were dominated by the upland vegetation of the surrounding area. Agricultural land uses comprised extensive grazing and cropping at various use intensities. In general, land use intensification increased the alpha diversity of exotic species. Dry season grazing of floodplain wetlands was associated with the occurrence of *Cynodon dactylon*, *Cyperus rotundus* and *Sporobolus africana*. Species associated with grazed floodplain fringes included *Acacia polyacantha*, and *Hyphene compressa*. Grazing areas in inland valleys were characterized by *Paspalum vaginatum*, *Sida cuneifolia* and *Cynodon dactylon*. With field drainage and soil tillage for upland crop production, mainly annual species (60%) appeared as crop-associated weeds, such as *Galin-soga parviflora*, *Portulaca oleracea*, *Bidens pilosa* and *Commelina beghalensis*. This land use change also affected the soil seed bank. Diaspores of natural vegetation gradually disappeared with land use intensification and soil seed banks were dominated by weeds of arable land, while soils under near-natural vegetation were dominated by perennial sedges. Soil diaspore assessment appears to offer a useful tool to determine the regeneration potential of wetlands. Vegetation composition, specific indicator species and diaspore counts provide a useful tool to determine biophysical wetland attributes and the wetlands' resilience or vulnerability to anthropogenic interventions.

**Keywords:** Bio-indicators, diaspores, hemoroby, resilience, vulnerability

## Effects of agricultural land use changes on soil and water resources availability in wetlands of East Africa

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The production potential of a wetland is determined by the availability of water and the ability of the soil to support intensified agricultural uses. These resources (soil and water) respond to land use changes and use durations and are likely to differ between wetland types. Water resources in their spatial-temporal dynamics were assessed using stratified and trans-sectional soil moisture determination using TDR probes and hydrological models, while soil parameter changes under different land use types, durations and intensities were determined by Near-Infrared Spectroscopy and standard soil physic-chemical analyses. The crop response to soil parameter changes were assessed in greenhouse studies in potted soil. The land use types included the unused wetland areas, grazing grounds, fields cropped under both aerobic and anaerobic soil conditions, and abandoned fallow land. The duration of cultivation ranged between 0 and 30 years.

The amount of water stored in the soil profile differed between wetland types (source of water), soil texture, and the position within the wetland, and varied between seasons. While floodplains receive most water by the overflowing of the central river, inland valleys are mainly fed by subsurface flow from adjacent slopes. Thus, floodplains dry out rapidly after flood recession in the dry season while inland valley swamps maintain relatively high soil water storage for crop production for longer periods of time. The amount and duration of available water in the floodplain is highly correlated with the soil texture (infiltration rate at saturation up to 100 mm h<sup>-1</sup> in sandy clay). In the inland valleys, water availability varies spatially between the dry fringe and the permanently saturated valley center with heavy clay soils and infiltration rates at saturation of 30 mm h<sup>-1</sup>.

Land use changes were found to highly influence the soil parameters C, N and P. Changes in land use from the uncultivated to cropped land resulted to a decline in soil C and N, while P and K varied depending on the wetland type and the specific land management. Prolonged cultivation of wetland soils resulted in further declines in total as well as labile C and N fractions (up to 50 %), especially in fields which had been cultivated for more than 7 years. Largest changes were observed in the sandy clay soils of the lowland floodplains while the clay textured wetland soils of the highlands responded least to land use intensification. Crop response in potted soil reflected the changes in both the hydrologic regime and in soil parameters. Rice biomass accumulation was mainly determined by differences in soil N and P in the inland valleys and floodplains, respectively.

Water availability and soil quality parameters determine the production potential. They differ between wetland types and environmental settings. They also respond differentially to land use change and intensification and can be used to assess the resilience of a wetland to anthropogenic interventions.

**Keywords:** Carbon, floodplain, inland valley, nitrogen, TDR

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## **Semi-arid areas in transition: Livelihood security, socio-ecological variability and the role of development interventions in East Africa**

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## **Semi-arid areas in transition: Livelihood security, socio-ecological variability and the role of development interventions in East Africa**

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### **Rationale**

Analysing rural actors' livelihood strategies and examining the contributions of development interventions can help in identifying pathways to increasing the resilience of rural livelihoods to multiple pressures caused by increasing social and ecological variability such as climate change, financial crisis, migration, changing access-regimes, centre-periphery asymmetries, and governance failures. Socio-ecological variability thus refers to variability in climatic, ecological, socio-economic, cultural and political dimensions and their interplay to produce framing livelihood conditions.

This increasing socio-ecological variability and its effects on livelihood insecurity of rural actors in semi-arid areas of East Africa highlights the limited adaptive capacities of many rural actors and questions the roles and effectiveness of development interventions in fostering favourable livelihood conditions for the rural actors.

It also calls for research that provides a thorough understanding of rural actors' livelihood strategies, and the factors that determine actors' capacity for resilience and adaptation and how to strengthen them in the face of increased variability, the projected increase in climate extremes and general socio-ecological variability.

### **Problem statement**

Semi-arid areas in transition, that is, dryland areas in Sub-Saharan Africa that are undergoing rapid changes in environmental, socio-economic, cultural and political dimensions, are confronted with multiple challenges. These comprise food insecurity, rising population density, increasing climate variability and climate change, increasing exploitation of natural resources, economic liberalisation, new governance structures, changing resource use regimes, and the accompanying potential for conflict over natural resources. Such areas face complex resource management problems that constrain rural livelihoods, and pose limitations on achieving sustainable development or the Millennium Development Goals.

In the semi-arid areas of Kenya and Tanzania, most of the rural actors are poor and depend on natural resources for their crop- and livestock-based livelihoods (Ifejika Speranza, 2006). The marginal agro-ecological potential, high rainfall variability and the remoteness of many settlements push rural actors into multi-strategies like non-farm diversification, migration and multi-local livelihoods (Ifejika Speranza, 2006).

Thus centre-periphery interactions are of increasing relevance to actors in these areas. Yet, the limited resources whose access-regimes are dynamic, and land sub-divisions lead to resource use constraints and conflicts. This situation is further compounded by policy limitations.

Recent climate change reports show that the frequency of droughts and floods will increase (IPCC WGII, 2007), thus exacerbating an already challenging condition for the inhabitants. However, climate change does not occur in isolation but in conjunction with rapid socio-economic, cultural, and political processes. Hence the condition under which the inhabitants carry out their livelihoods is one of continuous change, with risks and opportunities.

Thus livelihood strategies need to be compatible to the environmental conditions. However not all strategies lead to positive outcomes, they can lead to ambiguous and non-sustainable outcomes for the actors and their environments. Hence investigating human-environment interactions can contribute to achieving sustainability.

## **Goals and Objectives**

### ***Overall goal***

The overall goal is to contribute to knowledge on livelihoods adaptation options and ways to increase the capacity of rural actors and households to deal with socio-ecological variability in semi-arid areas in transition.

### ***Specific objectives***

The specific objectives to achieve the overall goal are grouped into the following themes:

#### ***A. Sub-project one: Livelihood strategies and socio-ecological variability***

- *Diversity of livelihoods:* To capture the diversity of livelihood multi-strategies of actors in semi-arid areas in transition and to anticipate their future development.
- *Baseline vulnerability:* To analyse how access to resources and tenure, as well as gender roles, generational divides, and multi-locality of livelihoods shape vulnerability, resilience and adaptation capacities.
- *Effectiveness of strategies:* To examine the fit of the livelihood strategies to socio-ecological variability, specifically in terms of exposure to climate change in general and droughts in particular, to insecurities of assets and tenures, to increasing dependencies of the peripheries, to unpredictability of governance, and to overriding national and international resource claims.
- *Key factors:* To examine the factors for success or failure of the various livelihood strategies in dealing with risks and opportunities.
- *Indicators and Indices:* To develop sustainability, vulnerability, adaptation and resilience indicators (and indices) for comparative analysis of

livelihood strategies at household, village and regional levels.

*B. Sub-project two: Development interventions and community-empowerment*

- *Actor perspectives:* To capture the different interests and perspectives of local and deciding actors on the roles of development interventions to foster successful livelihood strategies.
- *Impacts of development interventions:* To assess the impacts of development and policy interventions on rural livelihoods.
- *Resilience and adaptive capacities:* To identify pathways to enhance resilience and adaptive capacities of the rural actors.

*C. Overarching: Capacity Development and Development Impacts*

- *Capacity development:* To strengthen the research capacities of the institutions involved and participating scientists through collaboration, mutual learning, exchange and joint publications and to strengthen south-south academic and applied collaboration between Kenyan and Tanzanian research institutions.
- *Development impacts:* To involve the actors in the research process with the aim of exchanging and increasing knowledge, triggering self-reflection among actors and influencing policy.

## **Research Design and Approach**

A comparative case study approach is applied. Sub-project one analyses livelihood strategies in semi-arid areas under the contexts described above and how the sustainable strategies can be fostered in order to increase the resilience and adaptive capacities of rural actors and the sustainable use of resources. Special emphasis is put on the importance of multi-strategies – including their multi-locality – and on aspects of gender and generational divides in a livelihood perspective.

Building on these insights, Sub-project two examines the role of development interventions and involved actors from a livelihood perspective and identifies structural and procedural properties important in approaches to reduce poverty and enhance the resilience and adaptive capacities of the rural poor. To our knowledge, there is no research in the proposed study areas on how local actors perceive development interventions and their (development interventions) roles in development, whether they perceive them to be effective or not and the reasons why, and their opinion on how development interventions can be improved.

Four semi-arid regions in Kenya and Tanzania, selected as pairs serve as case study areas to enable comparison. Each pair has comparable ecological and environmental characteristics but show significant differences in other dynamic conditions relevant to livelihood strategies. However, agro pastoral livelihoods and high to very high poverty incidence are common features.

The first pair depicts geographically peripheral and economically as well as politically marginalised semi-arid areas in transition, as is the case for the semi-arid ar-

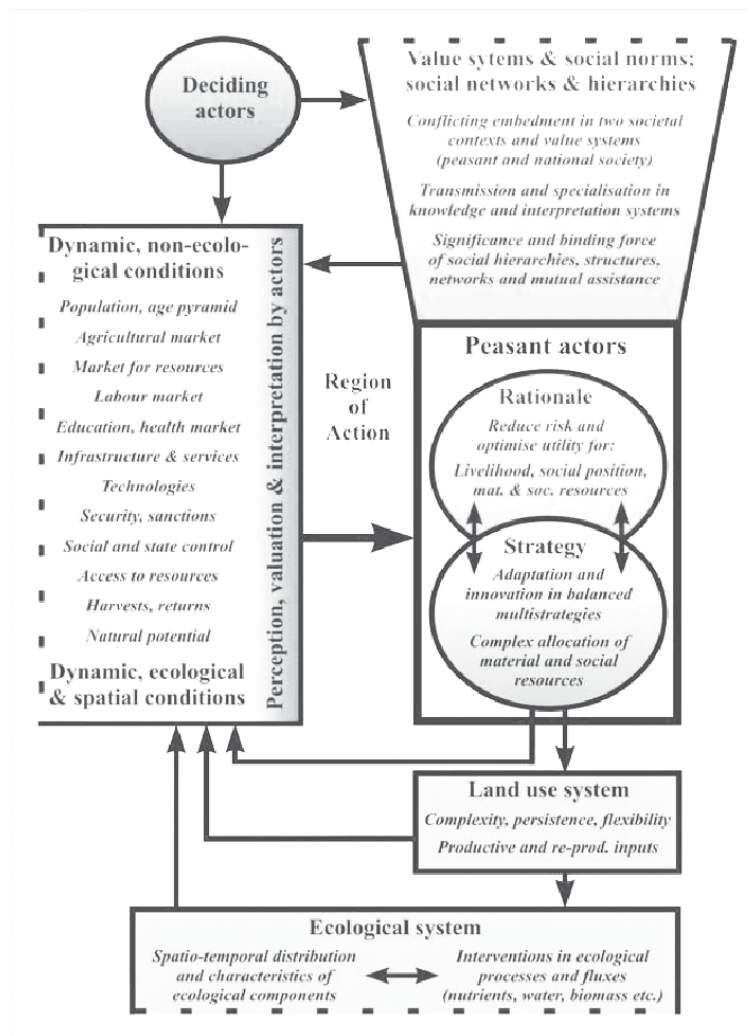


eas of the Kibwezi/Makueni Corridor in Kenya and for the semi-arid Central Tanzanian Dodoma/Singida Corridor. The second pair depicts semi-arid areas in highland-lowland systems with overlapping claims. The semi-arid part of Laikipia District North-West of Mount Kenya is embedded in the highland-lowland system of the Ewaso-Ngiro Basin whose resources are highly contested. The lower Pangani Basin in North-Eastern Tanzania shows similar characteristics, but with less pronounced changes compared to the Laikipia area. Research is also conducted on Mount Kenya and Kilimajaro.

Among the four regions, three cases have the advantage of still having the original data from former livelihood studies in Kenya and Tanzania, some of which date back to 1984, thus allowing for longitudinal analyses at single household level.

### Conceptual framework

The ‘actor-oriented model’ (see figure; by Wiesmann, 2008a and 2008b) serves as entry-point for the conceptual framework.



Actor-oriented model on smallholder areas in rural Africa (Wiesmann, 2008a:65)

It builds on social and livelihood theories, such as Bourdieu's 'theory of practice' and its key-concepts – habitus, practice, capital, and field –, (Bourdieu, 1977, Bourdieu, 1997), and Giddens's (1984) 'structuration theory' and the subsequent discourse of the post-structuration schools. However, it puts more emphasis on agency, contextuality and actors' rationale of action, as well as on the influence of actors on the production and reproduction of social structure. This additional emphasis enables to expand a perspective on adaptation to socio-ecological variability by focussing on innovative and creative processes by local actors and thereby emphasises endogenous development potentials in semi-arid areas in transition.

Its heuristic potential builds on four main components of the model that can only briefly be mentioned here and include rationale of action, livelihood strategies, dynamic conditions of action, and social structures.

The actor oriented model complements livelihood approaches since in actor-oriented terms, actor strategies cannot be understood without referring to the rationale of multi-strategy formed by the dynamic networks of meaning and activity. Supplementary concepts in livelihood research, in particular, vulnerability and adaptation provides further insights on exposure to and capacity to deal with livelihood risks. The concept of resilience as an integrated measure of the ability to cope with disturbances and change (Adger, 2000), adds a promising theoretical component to the questions of reducing vulnerability and increasing adaptive capacities.

The conceptual framework thus aims at a perspective that goes beyond analysing livelihood responses to socio-ecological change, but puts emphasis on agency, innovative capacities and therefore on endogenous development potentials.

### **Progress in research, training and transfer**

Substantial progress has been made in the three PhD studies, which are in various stages of data collection while one Masters Study is in the data analysis phase. Post-doc research activities into developing a spatio-temporal inventory of development interventions in Laikipia district as well as research into the future development scenarios of a pastoral community and the role of development interventions in this process are on-going.

Key outputs so far comprise ten publications and abstracts including six peer-reviewed journal articles, a digital library accessible to all project members, and two regional training workshops for PhD students. Two field excursions to Kenya have been conducted for 17 Masters' students from the University of Heidelberg, Germany (2009) and for 30 students from the University of Bern, Nairobi and Dar es Salaam (2010). The senior researchers have also given numerous lectures on topics of the research project in Kenya, Tanzania, Germany and Switzerland.

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## Small holder perceptions of development interventions and influences on their livelihood strategies

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**Rationale:** There is a need to improve the targeting of development interventions in terms of their nature, location and content so that they more accurately complement the diverse ways that people make a living. This study focuses on the role of development interventions, particularly natural resource oriented interventions, in reducing poverty and vulnerability, in increasing resilience and adaptive capacities, and in fostering socio-economic development in two regions: the Laikipia region of Kenya, and the Pangani region of Tanzania.

**Problem statement:** Poor people will try to minimize risk by having multi-place and multidimensional livelihood strategies; this requires a range of assets and capabilities at the individual level and at the collective level. Development interventions, be they direct or indirect, intentional or immanent, are one of a wider range of socio-ecological variables that affect the ability of the rural poor to mobilize those assets. External development actors often do not take into account the perspectives of local actors when planning and implementing projects; risking the possibility for failure and the disruption of local lifeworlds. Further, the distribution of development interventions influences broader patterns of development, and conversely serve to create poverty disparities across space.

**Objectives:** In order to improve the role of development interventions a better understanding of actor lifeworlds and decision making processes is needed. An identification of areas of fit and misfit across space and time, primarily through an assessment of the perceptions of local and external actors on the roles of development interventions, will provide one way to bridge the gap between the actors views of development.

**Approaches:** Starting with a bottom-up approach, an actor-oriented perspective of the roles of development, within wider socio-ecological conditions, will provide insight into the rationale and decision-making of both local and external actors. Local actor categories are formulated to represent three locally defined wealth classifications within a community, and for a selection of communities living along gradients of centre-periphery, agro-ecology, and livelihood zones. These actor categories form the basis for an investigation on local actor perceptions of the opportunities and constraints from development interventions.

A longitudinal perspective on the impacts of development interventions will be realised through an analysis of previous livelihood studies and of current studies. Changes in their asset levels and livelihood strategies across time can be determined,

and local-actor identified development intervention milestones juxtaposed, onto the time frame.

A meso-scale approach will be used to provide insights into the factors that determine development interventions' scale and distribution, and their socio-ecological impacts. The approach recognises that development decision-making is often channeled at this level; linking the local actor to decisions and structures at the macro-level. Hence, an institutional analysis along this vertical actor-network will be carried out.

**Research progress:** Livelihoods field data showing socio-economic impacts of the large and expanding commercial horticulture industry in Liakipia has been collected. Thirty respondents, who were part of previous livelihoods studies, were selected from representative agro-ecological zones. The first results are expected to show, through a longitudinal perspective, resulting changes in local actors' access to capital assets, and how this influences their livelihood strategies.

**Keywords:** Development interventions, livelihood strategies, actor-oriented perspective

# **The role of social capital in social learning processes for soil and water management innovations: The case of eastern and western Kenya**

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**Rationale:** This study investigates the role of social capital in triggering the spread of soil and water management innovations through social learning processes.

**Problem statement:** The uptake of Natural Resource Management (NRM) innovations in Kenya continues to be hampered by poorly understood socioeconomic, sociocultural, institutional and organizational arrangements and some of these may be traced back to the mechanisms that sustain the socioeconomic important functions of the little understood concept of social capital. Social capital is the ability to obtain benefits from the use of social relations expressed in networks, local institutions and organizations, in other words, 'it is who you know'. The study also hypothesizes that in addition to risk and insecurity aspects as well as cost-benefit calculation of respective households with their economic capital, social capital plays a fundamental catalytic role in overcoming the constraints to acceptance and spreading of new innovations through motivation, awareness, development and application through Farmer groups (FGs) and the Farmer Field Schools (FFSs).

**Objectives:** The overall objective of the study is to investigate the characteristics and effects of social learning to foster ecologically sustainable soil and water innovations in Western and Eastern Kenya through FGs and FFSs. The specific objectives are; 1) To characterize socio economic and sociocultural aspects of the peasants in both regions involved in FGs and FFS based on their life-worlds. 2) To investigate peasants' various strategies of action and their implications on taking up innovations through social learning processes in FGs and FFS or other sources. 3) To assess the effects of the larger society on peasants' livelihoods and their implications on peasants strategies of action. 4) To investigate the types of social capital available among the peasants in terms of productive and perverse social capital. 5) To identify the various dimensions of social capital within the types of social capital and their implications on social learning processes related to soil and water management technologies in the FFSs and FGs. 6) To explore ways of addressing mitigation failures and biases of dissemination of soil and water technologies through social learning processes in the FGs and FFS.

**Approaches:** The context for the study is highland-lowland and the research sites are; Kakamega district in the highlands of Western Kenya and Mbeere South district in the lowlands of Eastern Kenya. The methodology is divided into three phases. The

first phase involves participant observation, the second phase household surveys, the third phase focus group discussions, biographies and case studies for each region. The data collection tools to be used are field notebooks, field diaries and field logs, questionnaires, focused group discussion guides, case-study guides, a camera and voice recorder. The study uses both qualitative and quantitative data and microanalysis will be used to analyse the qualitative data while SPSS and STATA packages will be used to analyse quantitative data.

**Research progress:** I am currently conducting an ethnography for the lowland district (Mbeere south, Kiritiri division) and I have Identified and selected 12 farmer groups and farmer field schools in the region that will be the main focus for data collection.

**Keywords:** Kenya, agrarian innovations, peasantry, social capital, life-worlds approach, social learning processes, institutions, farmer field schools, farmer groups, soil and water management, syndrome mitigation and sustainable natural resource management

## **Climate variability and food security: Household opportunities and constraints in coping strategies in food insecure areas of Dodoma and Singida, Tanzania**

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**Rationale:** Given the over-dependence on rain-fed agriculture by the majority of people living in semi-arid areas of Tanzania, Climate Change & Variability(CC&V) has been one of the major limiting factors in agricultural production resulting in food insecurity and low-incomes. Increasing impacts of CC&V in particular drought and floods on food security have been associated with various adaptation and coping strategies. Coping strategies also vary between households due to varying distribution of opportunities. Identified factors or processes that shape household opportunities and constraints in coping are a starting point for distinguishing policy measures that address local manifestations of CC&V. The results of the study is expected to be used by stakeholders including scientific communities and policy makers to address issues related to CC&V and food security.

**Problem statement:** Tanzania's agricultural system is rain-dependent and highly susceptible to climatic shocks, particularly in the semi-arid areas of central Tanzania where chronic and transitory food insecurity hamper households' ability to meet their food needs at all times. Households throughout central semi-arid Tanzania are engaged in different and often multiple coping strategies. This variation between households and over time, needs to be studied in order to identify key factors or processes that affect household ability to secure a livelihood when faced with increasing climate variability. Despite the amount of research on food insecurity, coping as well as livelihood strategies in semi arid central Tanzania, little has been done on the identification and assessment of opportunities and constraints of households in strategies to cope with food insecurity in the context of climate change and variability. This study intends to fill these knowledge gaps.

**Objectives:** The overall objective is to assess household opportunities and constraints in coping strategies in food insecure areas of semi-arid Central Tanzania. The specific objectives are:

- To identify the major coping strategies used by food insecure households
- To examine the opportunities that exist to food insecure households in the study areas
- To examine the constraints associated with the identified major coping strategies



- To analyse how socio-ecological factors affect household ability and choice to engage in selected coping strategies
- To analyse the perceptions of smallholder farmers on interventions made by government and other agencies related to food security issues in the study area.

**Approaches:** A combination of qualitative and quantitative data collection methods will be used. Both quantitative and qualitative methods play a useful and complementary role in improving our understanding of a situation in a given area.

**Research progress:** A preliminary survey and pretesting of the developed questionnaire in the study area, have been completed. Some relevant documents at the district and village offices have been reviewed. The sample villages have been identified and data is currently being collected.

**Keywords:** Climate variability and change, food insecurity, coping strategies



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## **Biomodels – Modelling of the domestic energy system based on biomass energy in rural areas in southern Africa**

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## **BioModels: Modelling the domestic energy system based on biomass energy in rural areas in southern Africa**

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### **Introduction**

Fuelwood has remained the dominant form of energy used by rural communities across sub-Saharan Africa. In South Africa, it has been estimated that 78 % of rural households use fuelwood. Fuelwood use has remained high even when households have access to other forms of energy, including electricity, and despite the introduction of programmes or policies such as Free Basic Electricity and the Solar Home Concessions Programme which are aimed at increasing low income households' access to modern, clean energy. In addition, programmes which introduce alternative technologies to improve the efficiency of cooking with fuelwood, thereby reducing the collection requirements and emissions, have often been unsuccessful.

Households use biomass to meet cooking, water heating and space heating needs. The use of biomass to meet basic energy needs is often associated with poverty. This is because biomass can frequently be obtained by households at no cost other than hours of family labour and requires no specialised appliances. However households that remain reliant on biomass due to a lack of ability to access alternative 'modern' fuels, for financial or other reasons, could be considered to be in a state of 'energy poverty'. The widespread use of biomass and poverty are closely linked, and it is recognised that in order to achieve development people must be able to move from 'traditional' fuels to 'modern' fuels. Additionally, there are many unanswered questions relating to fuelwood harvesting patterns such as the response of Savanna woodlands to harvesting, the opportunity cost of harvesting fuelwood, and coping strategies which households develop in response to fuelwood scarcity. Whilst harvesting of fuelwood is seldom the cause of total deforestation, it does contribute to loss of species diversity, change in woodland structure and soil degradation. This in turn impacts on biodiversity, access to fuelwood resources, and the opportunity cost of collection as with increasing scarcity of the preferred fuelwood species, the women are forced to spend more time collecting fuelwood.

Energy-environment-economic models have become a commonly used tool to test policies relating to energy use, energy trade and the social, environmental and economic impacts thereof. Models can also be used to address the concern of the continued dependence of low income households on fuelwood for their basic energy needs and, through the use of indicators, to visit the environmental and social impacts of supply alternatives. Models focussing on rural energy supply and demand have tended to focus on meeting demand for end uses such as cooking and lighting and the characteristics of frequently used technologies, and have failed to include the important aspect of fuelwood supply demand dynamics.

### **Objectives and Approach**

Solutions to the problems need to be multi-faceted and integrated and need to be based on sound scientific data. Key information gaps include

- a) data on utilization pattern of energy and appliances in rural households,
- b) quantitative data on above-ground woody biomass,
- c) the linkages between urban and rural areas in the use and trade of biomass,
- d) opportunities (including social and economic) and constraints for the use of fuel-efficient technologies by poor rural communities dependent on biomass energy.

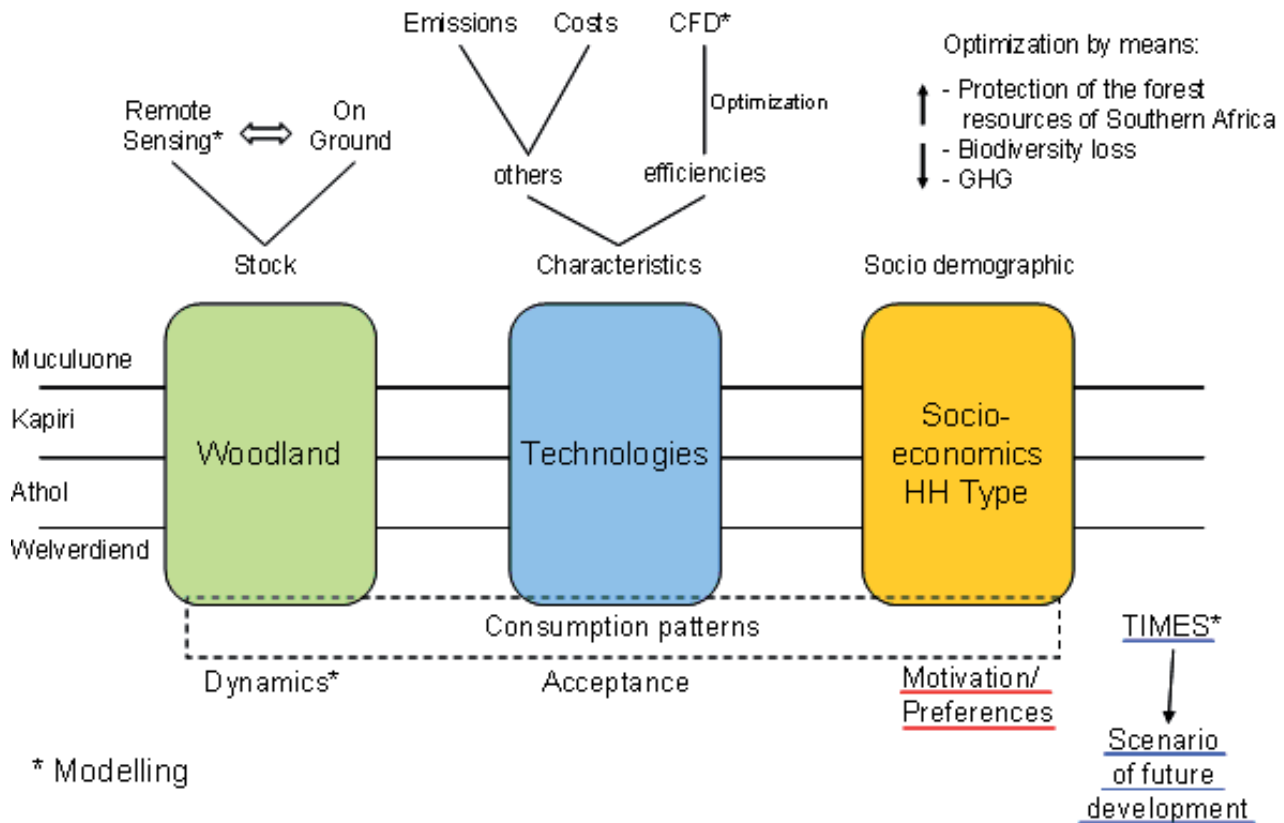
Quantitative data will be very useful for the development and role-out of sustainable energy options and are an important prerequisite to identify the market potential of new clean fuels and appliances and the administrative burden of real interventions.

With this background the main objectives of the BioModels project are as follows:

- Identifying the market potential of new clean fuels and appliances as well as the administrative burden of real interventions
- Development of strategies for a sustainable usage of bioenergy in rural areas in Southern Africa
- Incorporation of qualitative socio economic factors in quantitative analyses using a further developed modelling approach
- Academic education and establishment of a self-sustaining research network of young scientists in the field of resource management in Southern Africa

With the participation of five PhD candidates from five higher education institutions in three southern African countries (South Africa, Mozambique and Zambia) the project is divided in the four work packages 1) Woodland, 2) Technologies, 3) Socio-economic assessments and 4) Energy Systems Modelling.

Modelling components are also part of the biomass assessment by remote sensing, the modelling of woodland dynamics and the optimization of improved stove technologies using Computational Fluid Dynamics (CFD).



To validate and calibrate the approach four study sites are chosen: Wilverdiend and Athol in Bushbuckridge, Mpumalanga, South Africa, Kapiri in Zambia and Muculuone in Mozambique.

### Woodland

The lack of quantitative data on extractable standing woody biomass makes it difficult for energy planners to ascertain the sustainability of exploiting such resources. Field inventory surveys use conventional assessment techniques to estimate above-ground woody biomass (AWB) quantities in woodlands. Sampling was carried out along transects radiating outwards from the residential areas towards the fenceline of each settlement. Each transect consisted of three rectangular training plots which were demarcated using a combination of conventional surveying and Differential GPS instruments. Tree parameters such as diameter above ankle height or diameter at breast height and height were measured before applying existing allometric equations to estimate the amount of AWB in the training plots. Large scale estimation of biomass using ground-based methods is both tedious and time-consuming.

Spaceborne polarimetric synthetic aperture radar (POLSAR) techniques were adopted to estimate the amount of above ground woody vegetation in the communal savanna woodlands. The first stage involved classifying the scattering mechanisms within the SAR scene to identify the woody vegetation classes since the microwave signal responses differently to certain components of the woody vegetation. The woody vegetation classes are closely related to forest double bounce, anisotropic, dihedral and dipole scattering mechanisms. The second stage involved the investigation of the

correlation between the microwave backscatter intensity to the biomass density for selected training plots using bootstrapping statistical analysis. Significant correlation was found between the HV and VV polarisation data and above ground biomass.

With regard to woodland dynamics present-day woodland characteristics for each village communal woodland area in Bushbuckridge were compared against the structure and species composition as it stood in 1992. Thus allowing us to trace how these woodlands have developed in response to 17 years of continuous fuelwood extraction. The woodland parameters that were considered in this quantitative assessment included changes in: total on-farm AWB, average stem diameter and height, size class distributions, proportional representation of coppice stems and species composition. The density of harvested stems within each woodland was taken to indicate a specific harvesting intensity, showing the intensity of fuelwood extraction from the woodlands relative to each village and compared between the years to assess how this may have changed.

### Technologies

Bioenergy use in rural domestic energy demand can be categorised into two, namely Heat Energy and Light Energy. Bioenergy heat energy applications are typically cooking, water heating and space heating. Bioenergy light energy applications are typically indoor lighting. The major forms of Bioenergy currently in use in rural areas are Fuelwood, Charcoal and crop and animal residues. Fuelwood is used in its primary form and the traditional energy norm. Charcoal is a transitional form of fuelwood which is also widely used. Crop and animal residues may be deemed to be alternative energy forms. Bioenergy sources must undergo a conversion process to transform them from raw energy sources into useful energy that can meet household energy demands. The technologies can be classified into intermediate technologies, which are used to convert the form of bioenergy from its primary source to another intermediate form for example fuelwood to charcoal, and into end use technologies, which are used to convert bioenergy into energy forms meeting domestic applications demand for example fuelwood to heat energy.

Firewood was established as the most significant fuel in the overall rural domestic energy setup. Below is a table comparing the firewood consumptions across the surveyed regions.

Parameters	Unit	South Africa	Zambia	Mozambique
avg daily hhold consumption	kg per day and per household	13	26	13
annual per capita consumption	kg per capita and annum	584	1988	1104

### Socio-economic assessments

A questionnaire was designed with the intention of capturing the socio-economic determinants of fuelwood use by the villages as well as data which could be used to quantify or distribute reported household energy consumption of each fuel between end uses. A comparative village description contrast was done across the researched villages in Mozambique, South Africa and Zambia. The village descriptors used were population, proximity, resource access and land tenure systems. Further comparison was drawn by analysing the household sizes and literacy levels. Household income characteristics were reviewed identifying total income, main incomes sources and expenditure.

Parameters	South Africa	Zambia	Mozambique
Household size range	1 - 16	1 - 9	1 - 9
Average house-hold size (mean)	6.3	4.8	4.5
Average income level per house-hold and annum	USD 2976	USD 709	USD 328
USD available per hhold/day	USD 8.2	USD 1.9	USD 0.9
% of total income	Empl. 49 % Social grant 43 % Other 8 %	Empl. 57 % Sell. 36 % Other 7 %	Empl. 60.8 % Selling produce 39 % Other 0.2 %

Empl.: Employment; Sell.: Selling agricultural and woodland products

The household end uses in the areas are lighting, water heating, space heating, cooking, and other electric uses such as fridges. The fuels common in the areas are wood, paraffin, electricity and in Zambia Charcoal. With the questionnaire also the use prevalence in terms of the bioenergy resource and conversion devices was determined. Arising from use prevalence assessment the impact of resource conversion chains could be assessed to determine where improvements could be most appropriate. Energy Conversion improvements are classed into two categories, namely process enhancement and technology enhancement. The process enhancement is achieved through user behavioural interventions cutting on energy wastage with same technological setup. Technology enhancement is achieved by varying conversion devices and fuels.

### Modelling the energy system of rural villages

Modelling a rural village requires detailed representation of resources, technologies and demands. Typically a low income household will use several fuels. In addition, an appliance may be used to meet more than one end use demand. For instance a wood stove may meet the demand for both cooking, water heating and space heating. And a household may use either wood or paraffin to heat water, depending on the availability.

In order to realistically represent the household's decisions around energy, it is necessary to include the cost of fuelwood collection that is borne by the household in terms of time or calorific value. When this is included in the optimisation, the cost perceived by the household, and thus the choice of households to switch to alternative fuels as distance to the harvesting site



increases with increased woodland degradation can be included. Equally if the household is stressed in some way, perhaps due to loss of income, households may choose to revert back to fuelwood harvesting as the only means to supply their energy needs, and the increase in household activity required can be calculated.

Thus, on the demand side, key model features are the seasonal useful energy demand profile for households with different socio-economic circumstances over the planning horizon and optimisation which includes the perceived cost of fuelwood collection and the correct representation of energy pathways.

A key feature of the model is the endogenous calculation of the availability of fuelwood over time, and under different demographic or social scenarios. To achieve this, the total fuelwood potential of the woodlands must be calculated and described in such a way as to allow it to be reactive to changing scenarios of fuelwood demand or extraction by the village residents. In this sense 'demand' is determined by harvester species and size preferences. The fuelwood stock includes all standing trees and bushes within the communal woodlands that are targeted for fuelwood harvesting by the village residents. The rest of the woodland population then contributes to the fuelwood potential. This will be calculated from annual growth and deadwood production capacity of the standing stock itself (including non-targeted species) and in-growth from recruitment of seedlings and coppice regeneration of harvested fuelwood trees.

The woodlands are seldom used only for fuelwood, and the impact on wood availability is often greatest from clearing for agricultural reasons. Thus harvesting for other sources and reduced availability for clearing are also included in the model.

### **Conclusion**

Results from woodland research projects allow the quantitative estimation of AWB in savanna woodlands using both ground inventories and spaceborne microwave data. However, there are many unanswered questions relating to fuelwood use and availability. We believe that the work within BioModels will allow a more holistic exploration of strategies for the sustainable utilisation of communal woodlands.

## **Biomass energy conversion technologies in rural southern Africa**

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**Background:** The significance of energy utilization has become globally pivotal as the world with an ever rising population and developmental surge, has greater demands for energy resources than ever before. This has led to the escalation of energy poverty in lower income communities and more so among the rural poor of the world. In the rural setting domestic energy demand of communities has historically been met predominantly by bioenergy resources. In the African context traditionally the most frequently used biomass resource has been firewood. In southern Africa firewood has historically been converted into heat energy by the use of the open fire stove since the advent of mankind's discovery of technology to harness fire.

**Problem statement:** Protracted use of firewood and Charcoal production and use have a negative socio-economic impact capitulating deforestation leading to soil erosion, siltation of rivers, depletion of carbon sink, health risks associated with migratory charcoal burners, air pollution during production process and soil degradation. Wood usage yields similar negative aspects as those found in charcoal as well as disturbance of forest eco-system, leading to depletion of indigenous trees that are used as sources of food, medicine and timber and depletion of natural habitat of certain species of flora and fauna.

**Objectives and approach:** The purpose of this poster is to ascertain whether rural household energy conversion methods and technologies have evolved over time to newer and more efficient energy pathways. Further if this transformation has not taken place what have been the hindrances preventing rural communities to do so. Hence this would enhance intervention strategies to improve energy utilization and ultimately reduce energy poverty in these rural communities.

This will be determined by investigating the energy conversion process chains in use rural household domestic households from the biomass resource to the end use energy demand. The basis of analysis is quantitative survey data obtained during a survey of a rural community in Central Zambia.

## A model methodology representing fuelwood supply and demand dynamics

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The collection and use of fuelwood is part of daily life for many rural African households. These households rely on local communal woodlands for fuelwood as well as other resources such as timber, fruit and medicine. Preferentially deadwood is collected for fuelwood but as it becomes scarce community members begin harvesting wood from trees for fuelwood. The availability of fuelwood resources in communal woodlands are therefore impacted upon by community harvesting, as well as land clearing for agricultural purposes. Two rural villages Werverdiend and Athol in Mpumalanga, South Africa were used as case studies in order to examine the relationship between communities relying on fuelwood to meet their energy needs and the ability of the surrounding communal woodlands to continue to meet their energy needs. The villages chosen as case studies are surrounded by Savanna woodlands in which fuelwood can be harvested at no cost other than the labour supplied by the households. The most common use of fuelwood by households is for cooking, water heating and to heat themselves outside their homes. Other fuels available to households in the village which provide alternatives to the use of fuelwood are paraffin and in most cases electricity.

There are many circumstances which impact upon the harvesting and use of fuelwood. Harvesting activities increase with population growth, including migration into an area. Income and local policies related to the protection of the natural resources, as well as policies intended to improve the livelihood of the rural poor through access to social grants and subsidies also impact the fuel choice of households.

This paper looks at the energy needs of the rural communities of Athol and Werverdiend and the continued use of fuelwood to supply those needs. Through the use of a detailed household questionnaire administered in both Werverdiend and Athol, household fuel preferences and quantities of fuels used by households for different purposes are captured. A methodology is presented for including supply dynamics for fuelwood which are impacted upon by the quantities of available biomass stock (dead and live wood, seedling recruitment and coppice shoot regeneration), and demand dynamics captured in the efficiency with which fuels are used by households, household demographics and population growth.

## **A tale of two villages: The woodland dynamics of fuelwood harvesting in communal landscapes in southern Africa**

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**Background:** Firewood remains the dominant source of domestic energy for many rural households in southern Africa. Due to limited financial resources, most rural societies are unable to make the transition to cleaner sources of energy, such as electricity. These societies remain dependant on the woodlands surrounding their settlements as a source of cheap energy. Increasing pressure with population growth on local wood resources may lead to unsustainable woody biomass harvesting practices which results in environmental degradation and the decline of human wellbeing, particularly in the high-density, communal savanna woodlands of southern Africa where demand for woody biomass is high.

**Problem Statement:** Evaluating the sustainability of current fuelwood harvesting across different sites in southern Africa requires an evaluation of the environmental impacts of harvesting practices to establish the patterns of woodland degradation that are linked to this. Accurate, cost-effective methods to supply information on present woodland structure and fuelwood availability at the large scale are required to provide the basis of forecasts of fuelwood availability in the future based on these woodland degradation indicators.

**Objectives and Approach.:** We undertook to evaluate the impact of almost two decades of continuous fuelwood harvesting on the structure and species composition of two villages of similar socio-economic characteristics in South Africa. A longitudinal comparative analysis using data gathered in 1992 and compared against woodland characteristics in 2009 was carried out. The dynamics of woodland structure and species composition were taken as indicators of how other southern African communal landscapes could develop over time since fuelwood harvesting practices such as targeting preferred species and size classes, are similar across the region. An innovative method, marrying the use of radar remote sensing, calibrated using fine-scale ground-based woodland surveys in the study area, was developed to provide fuelwood availability estimates in other countries.

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## **MECHAL – An integrated research approach to develop adaptive management strategies by small-scale farmers in semi-arid South Africa and Ethiopia under changing climatic and policy conditions**

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## **Developing adaptive management strategies by small-scale farmers in semi-arid South Africa and Ethiopia under changing climatic and policy conditions**

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### **Rationale**

In order to address land management challenges under climate change conditions we need to ensure that science and local knowledge are jointly integrated for the development of adapted land management. The ever-growing complexity of the socio-ecological environment that land users and other stakeholders encounter and the exponential specialisation of scientific knowledge lead to a widening gap between science and local stakeholders. Thus, often intended beneficiaries are not able to benefit from “new solutions” devised by science as they might not be accessible or not deemed to be appropriate to local land users (Oettlé & Koelle 2003). Participatory Action Research (PAR) methodology (Kemmis & McTaggart 2000) intends to bridge this gap. PAR involves all stakeholders and scientists in an ongoing process that involves jointly formulating research questions, contributing to research design, collective engagement in data analysis and interpretation and discussion of ways of achieving improvement in the light of the research findings. Implementation of such solutions involves monitoring the adapted land management measures and incorporating this data and understanding in the ongoing research, hence the action research appellation. The MECHAL project strictly follows the Participatory Action Research approach for the developing of adaptive management strategies by small-scale farmers in semi-arid South Africa and Ethiopia.

### **Problem Statement**

Small-scale farmers in semi-arid lands are typically restricted to marginal lands where they must typically cope with environmental uncertainty, resource degradation, overcrowding and weak government support. Most rural households in semi-arid sub-Saharan Africa depend on natural resource use as part of their livelihood strategy since these areas are frequently characterised by high unemployment and poor remuneration.

neration. Agriculture thus plays a prominent role in the stability of rural communities. Increasing unreliability of rainfall and drought duration and frequency is predicted for many semi-arid African regions. These conditions are likely to threaten the livelihoods of small-scale farmers. In the event of extreme climate variability these communities may lose their investment in agriculture. However, experienced farmers in arid areas have developed strategies to cope with past droughts and atypical rainfall patterns. Such coping strategies may be relevant for developing new approaches to managing more severe climatic fluctuations. Without intervention, the current overcrowded conditions on the land are likely to result in the over-utilisation of resources during droughts, which could well lead to irreversible desertification, destruction of biodiversity and increasing poverty.

The two research sites of MECHAL, Hantam in the West of South Africa and Arsi Negelle district in the central Rift Valley of Ethiopia, are situated in the only global biodiversity hotspots in semi-arid areas. Both areas are traditional farming areas, where small-scale farming plays a major role in supporting livelihoods. Both areas already experience changes in weather conditions (Archer et al. 2008) and are predicted to be strongly impacted by climate change.

In addition to livestock farming, small-scale farmers in the Hantam region have been farming with rooibos tea (*Aspalathus linearis*) for many decades. It is one of few crops that thrive in this area, and has become the most important agricultural product. Production is primarily based upon the cultivation of a fast-growing cultivar. However, the unprecedented drought of 2003–2006 resulted in the mortality of much of the cultivated rooibos, and it is predicted that climate change will further impact on the production of the variety of rooibos currently under production. Conservation of existing biodiversity is crucial to ensure the survival of six wild genotypes of rooibos which may be better adapted to survive under climate change scenarios (Malgas & Oetlé 2007). Following the drought and subsequent fall in the price of rooibos tea due to oversupply of the market in the following good years, many farmers are now struggling to adapt to changing conditions. Some small-scale farmers are successfully marketing their tea via organic and fair trade niche markets worldwide and benefit from better prices and more stable prices. However, in the face of climate change organic production could be jeopardized due to the ecological and market stresses that are anticipated.

The study area in Ethiopia, the Arsi Negelle district, is also largely a small-scale farming area. In the course of the past 30 years, people from surrounding highland areas migrated into the district. Growing of teff, wheat, sorghum, and vegetables on plots which are often less than one hectare in size as well as small-scale livestock farming with cattle and goats are the typical land use strategies of the rural population in the study area. Despite a mean annual rainfall of 1200 mm, crop failures occur once every two years on average due to erratic rainfall. The most common coping strategy during times of drought is the burning and selling of charcoal which has contributed to

rapid deforestation and recurrent drought. About 60 % of the households sell charcoal and wood. Consequently, the once densely forested savannah dominated by *Acacia* spp. some 30 years ago is today virtually deforested. Frequent political turnover and ensuing changes in land administration have increased fragmentation of holdings and enhanced tenure insecurity, especially among the landless and smallholder households (Kebede, 2000). Despite declining farm size and continuing fragmentation, local people have developed systems of adaptation and coping strategies. In the study area, the majority of the farmers have ideas on how to develop and manage their savannah forest and to make better use of it. However, the impacts of these strategies of individual households on the environment are largely unknown. Organized efforts to assist farmers' decision making by providing timely weather forecasts and analyzing likely weather impacts have been absent.

### **Objectives**

MECHAL aims to identify and evaluate existing strategies to cope with droughts and to develop, implement and evaluate new, innovative farming and other land use practices adapted to climate change conditions in semi-arid areas of South Africa and Ethiopia through an action research approach. This process is intended to enhance the resilience and problem solving capacity of the land users.

### **Approach**

In order to increase resilience of farmers in South Africa and Ethiopia, effective adaptation techniques are being identified, developed and shared amongst small-scale farming communities. During this process the applied learning methodology is tested and analysed to be applied in other areas of community based adaptation processes. As part of the participatory process, Climate Change Preparedness workshops and Local Level Monitoring of climate and local water resources have been conducted regularly by local stakeholders and project team members in South Africa, and will be initiated in Ethiopia in due course. The rationale, the process and first results of these approaches are described below.

### **Climate Change Preparedness Workshops**

Climate Change Preparedness workshops (CCP workshops) for farmers were held every three months in the Suid Bokkeveld. The workshops are a central event in the participatory action research process with the local community, which aims to foster an adaptive learning process. The workshops serve as a platform for reporting back on ongoing research and monitoring activities, and as a forum to debate and agree upon future research or monitoring activities. Reflection on existing practices in the course of the workshop contributes to increased resilience to climate variability and change. New approaches to respond to climate stresses are also explored. Seasonal weather forecasts are a central component of the process: anticipated weather impacts are



debated, and past forecasts are compared with local climate monitoring results (temperature and rainfall) to assess their relevance and accuracy. Microclimatic variations are assessed to ascertain what adaptation strategies would be most suitable for specific localities. Seasonal calendars drawn up at each workshop for each farming area are important records of the interaction between climate events and farming / livelihoods activities.

Parallel to the adult climate change preparedness workshop, a workshop for children is also offered. This workshop comprises learning activities on climate change, erosion control and sustainable farming practices. The benefit of these parallel workshops are twofold: they allow the land users from tomorrow to engage with the pertinent issues early – and at the same time women are free to attend and focus on activities in the adult workshops.

The implementation is currently documented and a publication describing the methodology and tools used is in preparation.

### **Local level monitoring in the Suid Bokkeveld**

*Water monitoring* A hydrological census has been started on the farms in the Suid Bokkeveld as a response to an expressed need to monitor water resources on farm to better adapt to changing conditions or climate variability and extremes. The hydrological census included a variety of participatory methods such as participatory GIS, participatory video, and narrative interviews. The aim is to compile water baseline studies at the beginning of the project so that the initial impacts of improved adaptation measures can be ascertained in 2 years time. This is an important aspect for monitoring and evaluation of adaptation projects. A more detailed modelling of groundwater processes is currently planned in collaboration with the Council of Geoscience.

#### *Temperature & Rainfall monitoring*

Three automated weather stations measuring air temperature and rainfall have been installed at farms across the study area. A full weather station has been installed on Dobbelskopskop, a central location in the study area. All weather stations are monitored by local farmers and the results are used in the CCP workshops.

#### *Environmental Envelope of wild Rooibos and impact of projected climate change*

A correlative species distribution modelling approach will be followed in order to assess the potential effects of climate change on the range of *A. linearis*' (wild rooibos) ecotypes. The aim of correlative models is to approximate the environmental conditions that are suitable for a species by comparing existing species' localities with a range of environmental and climatic factors that can reasonably be expected to affect its physiology and persistence. Two BSc students at the University of Hamburg

studied environmental conditions of wild rooibos populations as baseline data for the analysis of the impact of projected climate change on these populations.

### **Assessment and of adaptation strategies in the Ethiopian study area**

In addition to the climate change preparedness workshops, the Ethiopian team focuses on adaptation strategies and livelihood diversifications of small-scale farmers in the Arsi Negelle district. The study comprises an assessment in a participatory research approach of the impact of drought on livelihood diversification, with special focus on gender dimension. The study will assess the effectiveness of currently applied strategies of households, and those of the state. The study will assess the impact of population growth and food aid on the adaptive capacity of small holders in order to adjust relevant technical and policy recommendations.

#### *Natural resources conservation and management (land use system, tenure system)*

The Arsi Negelle area is overgrazed and trees are cut extensively for charcoal and firewood. Livestock and wood products are the major sources of income for the local people. The impact of the drought on the land use and natural resources may be readily observed in the area. The characteristic woody species include *Acacia senegal*, *A. etbaica*, *A. seyal*, *Balanitis aegyptica*, *Euphorbia cundelabru*, *Dichrostachys cinera*, *Croton dichogamus* and *Ziziphus spp.* Modelling of long term trends of climate change on the resource base and on household income, both with and without interventions in adaptive farming, will be investigated. Identification and comparison of different woodland resource management techniques that enhance resilience to droughts will be carried out.

The cultural aspects of natural resources conservation and management will be appraised and incorporated in the regional and local governance of forest and natural resources conservation and management. The local people will be empowered and become active participants in the sustainable management and conservation of natural resources in their respective areas.

#### *Preparation of a participatory climate change adaptation handbook*

Based on the experiences with the participatory processes described above, a training manual documenting a participatory approach for community based adaptation to climate change is currently in preparation. The expected date of publication is end of 2010.

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## **Habitat conditions of wild Rooibos tea (*Aspalathus linearis*): Environmental abiotic and biotic drivers of its performance**

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*University of Hamburg, Germany*

Climate variability and change endangers the livelihoods of many farmers all over the world. In the case of Rooibos tea farmers in the south-western part of South Africa, small-scale farmers are particularly affected. *Aspalathus linearis*, the name of the species that is used for producing rooibos tea, is very variable but only one eco type, the Nortier variety, is currently used for cultivation. However this eco type is not as drought resistant as some of the wild eco types. For this reason habitat conditions of wild Rooibos which have not yet been researched in detail were studied. The aim was to find the abiotic and biotic parameters driving the performance of wild Rooibos plants.

*Aspalathus linearis* is endemic to the south-western part of South Africa which is predominately semi-arid and mountainous. Covering the main part of the distribution area, 39 plots were sampled by taking into account geography and climate, age since last fire, soil and soil surface characteristics. Furthermore the cover of vegetation structure was estimated in classes based on different growth form types. Growth properties within a sample of 10 Rooibos individuals were measured.

Principal coordinates analysis (PCO) distributed the plots based on similarity in their vegetation structure along axes. The first axis showed significant correlations with altitude ( $p=0.000$ ), mean annual temperature ( $p=0.000$ ), mean annual precipitation ( $p=0.008$ ), latitude ( $p=0.03$ ) and the second axis also with slope ( $p=0.000$ ) and longitude ( $p=0.000$ ). These parameters and in addition heat load index showed also significant influence on Rooibos growth properties.

Different structures of the vegetation structure that co-occurs with Rooibos were found by cluster analysis. Only abiotic parameters varied between the groups, and not the Rooibos parameters.

The drivers that influence Rooibos properties the most appear to be geographical (mainly altitude) and climatic (precipitation and temperature) conditions. Influence of the co-occurring vegetation structure as well as soil and age since last fire could not be ascertained. The results underline the significance of the climate change discussion as climatic parameters as the drivers of *Aspalathus linearis* seem to be the determining factor.

The shift in natural habitat to wild rooibos due to climate change could pose a serious challenge to the farmers. New management strategies should take the findings of this research into account and cater for a buffer zone to allow shifts in habitat of *Aspalathus linearis* in the future.

**Keywords:** Rooibos, climate change adaptation, biodiversity

## **Establishing a baseline for adaptation processes – participatory water monitoring and learning for increased resilience to climate variability and change**

KOELLE, B.

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The farmers in the Suid Bokkeveld have a profound knowledge of the environment and the changes over time. The climate on the Bokkeveld Plateau is highly variable: in good years annual rainfall exceeds 500mm, yet in years of extreme drought as little as 50 mm of rainfall has been recorded in the more marginal areas of the plateau. Farmers have developed traditional mechanisms to deal with drought. However, the weather conditions observed since 2003 indicate that these are not sufficient to address extreme climatic events and increasing water scarcity.

In the course of a quarterly climate change preparedness workshop in 2009, farmers from the Suid Bokkeveld decided to monitor water resources throughout the year, so as to better understand the processes in the landscape and to develop new ways of planning for dry years – thus increasing their resilience to drought.

Monitoring is structured as a learning process that takes place on various farms in the Suid Bokkeveld. Maximum and minimum temperatures are recorded, all relevant water sources on farms are mapped and qualitative information is also documented. A participatory video process has been used to document the on-farm hydrological census. The following products will be produced, and will be used as a baseline for monitoring the effectiveness of applied adaptation measures and / or climate variability and change:

A map detailing the on-farm water sources, including water quality and current use of each water source.

A participatory video documenting the water situation as monitored on farm so as to enable farmers to compare the future situation (in 2,5 and 10 years time) to the 2010 baseline. Further qualitative information (e.g. how water supply changed in drought times, history of water sources, plans, ideas, visions) will also be included.

The baseline study supports an ongoing monitoring process that will explore how the water resources change during variable climatic events and at the same time allow farmers to experiment applying new adaptation strategies and to monitor their impact. This process is supported by a Participatory Action Research process on groundwater modelling in the study area so as to ascertain the potential impact of climate variability and change on farmers' livelihoods in the future.

**Keywords:** Climate change adaptation, participatory action research, baseline for adaptation

## **Climate change implications for rooibos production as livelihood strategy amongst small-scale farmers in the Hantam region of South Africa**

LÖTTER, D. AND ARCHER, E.

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Traditional small-scale farming in the semi-arid Hantam region of South Africa comprises cultivation of commercially propagated rooibos tea as well as harvesting endemic wild types of rooibos (*Aspalathus linearis*). Rooibos, being a rain-fed crop is strongly influenced by the climate especially through fluctuations in precipitation and the occurrence of extreme events. Increased frequencies of dry spells, late onset of winter rains and heat stress have been reported to cause severe crop failure.

Economic and ecological effects of anticipated climate change on these rain-fed agricultural systems could thus be significant without appropriate adaptation measures. According to regional climate models, the semi-arid western regions of southern Africa may experience a decrease in winter rainfall accompanied by a broad temperature increase and more frequent droughts. The expected increase in temperatures and altered rainfall patterns may modify crop performance and existing spatial distribution patterns and suitability of wild and cultivated rooibos. Bearing in mind the marginal nature of the area, even slight variations in temperature and precipitation may have severe implications for all farming associated activities. In addition, land use change driven by habitat loss due to the massive expansion of the commercial rooibos industry in recent years has also led to the loss of many indigenous and endemic species including *A. linearis*, threatening the very resource base on which the industry depends. Under these scenarios, small-scale farmers are expected to be most severely affected. Given the significance of small-scale production to sustain social and economic development in the semi-arid Hantam region, the direct reliance of local farmers' extended livelihoods on natural ecosystems; and farming activities being inextricably linked to climate variables, it is imperative to consider climate and land use change implications for the sustainability of farming practices in an already marginalized environment.

A multiple research approach, applying both qualitative as well as quantitative methodologies will be followed. Involving small-scale farmers and other stakeholders is an essential component of ensuring the applicability of research outcomes for the local farmers. To characterize and understand the climatic context of the study area, a statistical time series analysis of climate data will be performed to ascertain precipitation and temperature trends. Regional climate models will be employed to generate projected ranges of change for all identified climate variables. A correlative species distribution and spatial suitability modelling approach will be followed to assess geographic distribution of endemic and cultivated rooibos under altered precipitation and temperature regimes. Specific relationships between climate, crop growth and productivity will further be explored through remote sensing techniques.

The research will make recommendations to facilitate adjustment of existing or development of new adaptation mechanisms that are most appropriate for the farmers and their environmental context.

**Keywords:** Regional climate models, rooibos, species distribution modelling, climate change

## **Developing adaptive management strategies by small-scale farmers in semi-arid Ethiopia under changing climatic and policy conditions**

BEKELE, T.

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Sustainable natural resources management could be made possible through the practical use of social programmes like the public work project for prevention of soil erosion caused by clear clearing of forests. This project is aimed at the southern and central rift valleys of Ethiopia to carry out case studies for consideration of cultural and socio-economic aspects in forest resource management. Foci sites are used as case studies in preparing teaching modules and implementation of climate change adaptation measures. The research undertakings are situated in the Central Rift Valley, and the Arsi Forest Industry Enterprise, Danshe area. The participatory action research process is aimed at making people realize that public benefit could be obtained from forest resources and that income sources of local people could be supplemented by non-timber forest products, diversified crop production and tourism in the rift valleys. In this respect, the cultural and socio-economic values that could impact the conservation and management of the natural resources of the study area will be described. Evaluation and promotion of the best experiences to other areas will be undertaken based on the local socio-cultural and environmental settings.

The trees are preserved from the original forest during clearance. The species and density of the trees vary across the eco-climatic zones. Some of the trees preserved on-farm in the area have been recognized as soil improvers.

**Keywords:** Conservation, environment, soil erosion, socio-economic, rift valley

## **MECHAL – Developing adaptive management strategies by small-scale farmers in semi-arid South Africa and Ethiopia under changing climatic and policy conditions**

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Mechal is an Amharic word that describes resilience to adverse conditions. The MECHAL project aims to identify and evaluate existing strategies to cope with droughts and to develop, implement and evaluate new, innovative farming and other land use practices adapted to climate change conditions in semi-arid areas of South Africa and Ethiopia through an action research approach. This process is intended to enhance the resilience and problem solving capacity of the land users.

The two research sites of MECHAL, Hantam in the West of South Africa and Arsi Negelle district in the central Rift Valley of Ethiopia, are situated in the only global biodiversity hotspots in semi-arid areas. Both areas are traditional farming areas, where small-scale farming plays a major role in supporting livelihoods. Both areas already experience changes in weather conditions (Archer et al. 2008) and are predicted to be strongly impacted by climate change.

In order to increase resilience of farmers in South Africa and Ethiopia, effective adaptation techniques are being identified, developed and shared amongst small-scale farming communities. During this process the applied learning methodology is tested and analysed to be applied in other areas of community based adaptation processes.

As part of the participatory process, Climate Change Preparedness workshops and Local Level Monitoring of climate and local water resources have been conducted regularly by local stakeholders and project team members in South Africa, and will be initiated in Ethiopia in due course. These learning processes aim at increasing resilience to climate variability and change as well as to changing policy and social conditions.

As part of the learning process, the effect of climate variability and change on livelihood strategies of the small scale farmers will be explored in various studies in South Africa (focusing on Rooibos tea and livestock) and Ethiopia (focusing on agro-forestry and livestock).

**Keywords:** Climate change adaptation, livelihood strategies, Ethiopia, South Africa, participatory action research



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## **The advancement of Malagasy biologists: Capacity building for the next generation of conservation leaders in collaboration with South African scientists**

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## **The advancement of Malagasy biologists: Capacity building for the next generation of conservation leaders in collaboration with South African scientists and students – Phase II.**

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### **Rational**

The past 20 years has seen considerable development of Malagasy field and conservation biologists. Numerous nationals with robust modern educations are obtaining important posts in different sectors and making a measurable difference in the advancement of science on this island nation. Given the combination of uniqueness and threat to the biota of Madagascar, the advancement of conservation biologists is paramount and the process of improvement and reinforcement through capacity building takes time and needs continued bolstering. Over the past decades, we have been devoted to this style of development for Malagasy biologists, which is a viable means to ensure the long-term future of science and conservation programs on the island. The building or reinforcement of infrastructure for national associations and non-governmental organizations is a critical step in capacity and institutional development, including curricula gaps in the Malagasy university system. Finally, it is also vital to help support the development of students associated with collaborating African colleagues, for exchanges of ideas, for regional capacity building, and as well as creating ties amongst young southern hemisphere scientists. English language development for Malagasy students is considered crucial for their integration in the international scientific community.

Apart from academic advancements, the project includes training of local assistants in standardized field techniques, taking data, doing preliminary analyses, communication, and language training. These para-taxonomists work closely with the Malagasy and international student/researchers working at various sites.

### **Problem statement**

The remaining natural habitats of Madagascar continued to be reduced by human actions and perhaps less than 20 years remain to advance conservation programs on the island before the last large blocks disappear. This habitat destruction coincides with considerable socio-economic-political ideology shifts in the country, which has also negatively impacted the national university system. Further, the current tendency in

Madagascar associated with the management and conservation of biodiversity is exploitation associated with human development, without much regard to broader ecological aspects. Hence, the reinforcement of capacity and improvement of knowledge on the island's unique and fragile biodiversity is indispensable. As the only viable long-term means to advance such programs is by nationals, rapid capacity advancement of Malagasy graduate students is paramount.

### **Objectives**

We seek to advance the capacity of Malagasy conservation biologists, allowing them to use modern tools and knowledge to enhance programs for their country and help alleviate a portion of the ecological hardship the people of the island will endure and at the same time protect one of the world's biotic jewels. We seek for these individuals, as working members of the national and international scientific communities, to enter different portions of governmental and non-governmental institutions and establish and advance new programs for the advancement of science.

### **Approach**

Nearly two decades ago, WWF-Madagascar created the Ecology Training Program (ETP) for the advancement of Malagasy graduate students enrolled in national universities and working in domains associated with conservation biology. The principal idea was that if Madagascar as a country was going to advance in ameliorating the biological crisis of the island, it was primordial for nationals of international capacity to lead this effort with modern scientific knowledge and tools. With the financial aid of organizations such as the Volkswagen Stiftung, major advancements were made and several generations of Malagasy scientists with the needed experience and credentials passed through this program and obtained critical posts. In 2007, the ETP was transferred to a Malagasy International Association by the name of Vahatra (which means grass roots in Malagasy), most of the founding members of which were products of the ETP, as well as being professors in the national university system and renowned scientists. This step was the natural evolution of such a capacity-building project, empowering national mentors to advance with the next generations of students under a Malagasy construct. Vahatra is dedicated to advancing conservation biology on Madagascar by: 1) training Malagasy scientists in order to advance biological, ecological, and conservation policy-making; 2) providing academic and research opportunities for promising Malagasy students and researchers; and 3) furnishing logistical, financial, and supervisory support to Malagasy students in fields related to conservation in collaboration with local universities. Associated with these three objectives are regular biological inventories carried-out for several months per year by teams from Vahatra in different forest areas across the island.

These objectives are met with a variety of direct actions, which increase the capacity of national scientists in different fashions:

1. **Mentorship** – Direct and personal guidance of young graduate students across a range of subjects from the theoretical to practical associated with their thesis research. National and international scientists provide this mentorship.
2. **Hands on activities** – This includes a wide variety of activities with professional mentors, ranging from field schools for neophyte students, assistance with research, data analysis, and developing writing skills, as well as journal clubs and a seminar series.
3. **Access to infrastructure** – Advancement is directly linked to knowledge and communication. Students at Vahatra have access to the internet, considerable computer facilities, one of the most important reference libraries in the country, and a wide variety of field equipment.
4. **Professional advancement** – students are exposed to a variety of different aspects for their personal professional advancement, which include special courses on writing, including scientific manuscripts, grant proposals, and presenting seminars.
5. **Para-ecologists** – local people (para-ecologists) are integrated and trained for research and conservation projects to foster an understanding of the values of pristine ecosystems with their services and functions.
6. **International perspectives** – exposure to different views through overseas visits and attendance of meetings, field activities in collaboration with South Africa scientists, and developing ties and collaborations with scientists outside Madagascar.

### **Actions to date**

1. **Mentorship** – Between the ETP and Vahatra programs, nearly 90 Malagasy graduate students terminated their higher degrees. The vast majority of these individuals remain in the domain of science, particularly fields associated with conservation biology. Of particular importance is the fact that former students are now amongst the mentors, which is a real hallmark of advancement, and allows rapid growth in capacity building.
2. **Hands on activities** – Each year Vahatra organizes at least one field school for young graduate students enrolled within the national university system, which provides inexperienced students and researchers from Madagascar, Comoros, South Africa and elsewhere the means to understand different techniques and develop ideas for thesis topics. At the same these field schools provide a means for Vahatra to evaluate which students are the most logical to choose for mentorship and enrollment in the program. We are currently working with approximately 14 Malagasy graduate students, assisting them with their thesis research, data analysis, and writing.

As of 2010, 13 South African graduate students have participated in four annual field schools, and have profited from exposure to comprehensive field training in different natural environments in Madagascar. These students have benefited as they have been able to build MSc and PhD projects around material collected on these and other field trips, focusing on the genetics and ecology of bats. In addition, South African field biologists have participated in the field schools, and in the training of developing Malagasy and South African field biologists.

3. **Access to infrastructure** – Vahatra owns a modern building a few minutes walk from the university. Within the office are wireless internet links, which allow students access to the web and a considerable number of portable computers. The library is continuously added to and is widely used by Vahatra students and other student-researcher visitors from across the island and overseas. The large student working room is also used as a meeting place for the journal club, special events, and conferences. The storeroom of field gear and different types of equipment properly fulfills the needs of the vast majority of students and collaborators.

Funds from the grant have been used to maintain a functional and well-stocked molecular biology laboratory at the University of KwaZulu Natal in Durban, South Africa. This laboratory hosted a six-week training visit by three graduate students and two professors from Madagascar, and has supported work leading to five masters and three doctorates (in progress) among South African students. These laboratory facilities continue to be available to Malagasy students. VW Foundation funding has also been used to send one South African doctoral student on four extended research visits to Stellenbosch University, to allow them access to infrastructure and training in cutting-edge cytogenetic techniques.

4. **Professional advancement** – A variety of different measures have been taken to fulfill this aspect. In the context of individual advancement of students working with Vahatra, their mentors provide considerable direct attention, which spans the gamut for conception of ideas, testing of hypotheses, data collection and analysis, and writing up results. Literally, hundreds of scientific papers and tens of books and monographs have been published resulting from these activities, many authored or co-authored by students. Special courses have been presented at The University of Antananarivo on writing scientific papers and grants. The latter course was presented in early 2010 and the exam was a structured grant proposal. An international review panel reviewed these and five students received mini-grants associated with their DEAs, financed by the VW grant. The students are responsible for financial statements and all administrative aspects of these mini-grants (reports to their professors, government departments, and granting agency).

A bi-monthly seminar series has been going at Vahatra for over two years, where Malagasy researchers present the results of their work to an audience of

40-80 people. A journal club has been organized where students actively dissect the pros and cons of published scientific papers, learning in detail the process of thinking through ideas and their expression. Further, Vahatra publishes an international journal called *Malagasy Nature* that is devoted to the natural history of Madagascar and surrounding islands. This refereed journal provides the means for Malagasy researchers to get over an often-difficult hurdle of learning how to formulate manuscripts and publish the results of their research. Members of Vahatra work closely with certain authors to help develop manuscripts suitable for publication. In total, three numbers of the journal have been published, with the fourth due shortly.

In the context of the current VW grant, five students were engaged to conduct Ph.D. research. Of these, two students have secured their degrees and moved on to post-docs, two are scheduled to finish in the next few months and move on to post-docs, and the fifth will present by the end of 2011. In addition, two DEA students taken on in the context of this project have made good progress and should have submitted *mémoires* before early 2011. All of these VW students follow English language courses at the American Cultural Center in Antananarivo.

The VW program was instrumental to raise additional funds for international student exchange, funded by the German Academic Exchange Service (DAAD). Over the course of the last three years, we developed a functional network with mutual visits of Malagasy students between the universities of Braunschweig, Göttingen and Hamburg.

Collaborative research and collections of bats from Madagascar formed the basis of five completed MSc studies at UKZN; three of these students have progressed to Ph.D. level. One of these students have received further training and funding from the University of Stellenbosch in the cutting edge field of molecular cytogenetics and her doctoral research has already resulted in the publication of a paper in a leading journal, coauthored by South African and Malagasy researchers and postgraduate students. The grant partially funded the participation of two South African PhD students in the 2009 Tropical Biodiversity Conference in Bonn, Germany, where they presented their work. This grant has further provided opportunities for the professional advancement of three South African academics, through their participation in both the Malagasy and South African aspects of this joint program.

5. **Para-ecologists** – Eight Malagasy para-ecologists were trained in the context of the work. They continue to record phenological data, run small tree nurseries, monitor tortoise populations and act as tourist guides upon request. The professional training has been very satisfying. The major hurdles still are problems to communicate with non-Malagasy speaking visitors. In principle, the para-ecologists should have followed professional language courses in French,

which would entail them to leave their home village. The logistics, mental barriers and time constraints make this difficult.

6. **International perspectives** – Clearly, in order for young Malagasy students to gain capacity and have a broader view of where they fit within the international scientific community they need points of reference. A considerable number of students working with Vahatra have the chance to travel overseas to work with collaborators and colleagues in different laboratory and museum settings, as well as attend scientific conferences and meetings to have direct exchanges with their contemporaries and peers.

In the context of this VW project, collaborations with colleagues at the University of Kwa-Zulu Natal in Durban have been instrumental in providing new perspectives in the field during joint field schools in Madagascar and in the laboratory setting in South Africa. These collaborators also serve as important role models and mentors, providing different views and advice on a variety of topics and projects. Three Malagasy Ph.D. students and two Malagasy professors from the Animal Biology Department at the University of Antananarivo attended a special course in Durban given by Jennifer Lamb and Peter Taylor on molecular genetics and ecological modeling, which also included daily English language training sessions. Two Malagasy PhD students participated in a field workshop given by Peter Taylor on acoustic methods of surveying bats held at Sudwala, South Africa. Information from these courses and workshops has been enveloped into curricula of these professors and within the Ph.D. research of these students. Further, either before or after the field schools, the visiting professors from the University of Kwa-Zulu Natal present seminars at the University of Antananarivo on timely and important subjects that students and professors may not have been exposed to.

## **The advancement of Malagasy biologists: Capacity building for the next generation of conservation leaders in collaboration with South African scientists and students – Phase II.**

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The remaining natural habitats of Madagascar continued to be reduced by human actions and perhaps less than 20 years remain to advance conservation programs on the island before the last large blocks disappear. As the only viable long-term means to advance such programs is by nationals, rapid capacity advancement of Malagasy graduate students is paramount. In order to ameliorate this problem, we seek to advance the capacity of Malagasy conservation biologists, allowing them to use modern tools and knowledge to advance programs for their country and alleviate a portion of the ecological hardship the people of the island will endure and at the same time protect one of the world's biotic jewels. We seek for these individuals, as working members of the international scientific community, to enter different portions of governmental and non-governmental institutions and set new programs for the advancement of science. Apart from the academic activities we seek to integrate local para-ecologists to foster understanding of the values of nearly pristine ecosystems with their services and functions.

Using as a catalyst for a variety of different capacity-building activities, the recently created Malagasy Association known as Vahatra, our focus is on the advancement of Malagasy graduate students enrolled in national universities and working in domains associated with conservation biology. The principal idea is that if Madagascar as a country is going to advance in ameliorating the biological crisis of the island, it was fundamental for nationals of international capacity to lead this effort with modern scientific tools. With the financial aid of organizations such as the Volkswagen Stiftung, major advancements were made and several generations of Malagasy scientists with the needed experience and credentials passed through this program and obtained critical posts. Vahatra is dedicated to advancing conservation biology on Madagascar by: 1) training Malagasy scientists in order to advance biological, ecological, and conservation policy-making; 2) providing academic and research opportunities for promising Malagasy students and researchers; and 3) furnishing logistical, financial, and supervisory support to Malagasy students in fields related to conservation in collaboration with local and South African universities. These objectives are met with a variety of direct actions, which increase the capacity of national scientists in different fashions, and include mentorship, hands on activities, access to infrastructure, professional advancement, and enhanced international perspectives. In particular there is a strong and growing link with South African universities, whose students and staff have benefited professionally in opportunities to participate in both collaborative research and training exercises.

**Keywords:** Madagascar, South Africa, graduate students, capacity building, advancement of knowledge



## Identification of cryptic Malagasy species of insectivorous bats using bioacoustics, morphology and genetics

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Insectivorous bats are able to navigate on the wing and find prey during the night by emitting and receiving echolocation calls. These calls, which are often species-specific, can help bat ecologists to identify a given species in the field with relative ease. In Madagascar, there have been a considerable number of new and often cryptic bat species described in the past decade. Therefore, a previously developed vocalization library, based mostly on recordings made of released non-vouchered specimens, needs to be updated. An excellent example of this problem is with the long-fingered bats of the genus *Miniopterus*, which in recent years has risen from four to 11 species. A portion of this current project is to create a new library for all Malagasy and Comorian members of this genus based on individuals bioacoustically recorded and then vouchered for morphological and molecular work. For the morphological study, external standard measurements were taken from specimens and subtle differences were noted. The echolocation calls of restrained individual free-flying bats were recorded in a flight cage or attached to a zipline. Time expanded echolocation calls were saved and analyzed using Bat Sound software. Temporal (pulse duration, inter-pulse interval) and spectral parameters (FmaxE, Fmin, Fmax) were then taken. The specific identifications of these individuals were based on morphological and molecular genetic (cytochrome *b*) characters. Examples presented here include two cryptic species, *M. sororculus* and *M. majori*, which occur sympatrically. Our work clearly shows that the combination of bioacoustics, morphology, and molecular genetics are essential in the definition of the Malagasy and Comorian *Miniopterus* echolocation library.

**Keywords:** *Miniopterus*, bats, echolocation calls, Madagascar

## Habitat use and roosting ecology of the endemic bat *Myzopoda schliemanni* in western Madagascar

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Daily movement patterns, roost site selection, home range area and foraging habitats of Malagasy bats are poorly known. We used radio-telemetry to investigate these parameters in the 10-gram Malagasy bat *Myzopoda schliemanni* during 2007 and 2008 in western Madagascar. This species is one of two in the Myzopodidae, an endemic family to Madagascar. It was described in 2007 and the species name is in honor of Prof. Dr. Harald Schliemann, a retired professor from The University of Hamburg. The fieldwork was undertaken during three distinct seasons/periods (transitional, wet/warm and dry/cool) and in five different habitats at the study site (marsh corridor, *Bismarckia* palm savannah, dry deciduous forest, saltpan and mangrove). Thirty-three individuals of *M. schliemanni* (17 males and 16 reproductive females) were captured while foraging and fitted with radio transmitters weighing 0.37 to 0.52 gram. Telemetry receivers were used to track these individuals to their foraging areas, as well as day and night roost sites, and each individual was followed for an average of 8.6 days  $\pm$  0.1 SE. These 33 bats used 150 different day roosts, 100 % of which were in the dead and still attached leaves of *B. nobilis* within the palm savannah habitat. These roost sites held one to 32 individuals. Bats changed roosts every 1–7 days, utilized the same roost for 2.8 consecutive days  $\pm$  0.16 SE and used an average of 5.5 roosts  $\pm$  0.62 SE during the radio-tracking period. This is the first time a member of the genus *Myzopoda* has been found roosting in the leaves of the *Bismarckia*, which is the dominant tree in the anthropogenic palm savannah of lowland central west. The area individual bats used for foraging varied from 15 to 205 ha (100 % minimum convex polygon). For the first hour after emergence from the day roost site, individuals foraged nearby, then flew to open water to drink and subsequently traveled up to 3.6 km away to continue foraging. Differences were noted between the sexes and season in home range size and foraging periods. Habitat dominated by marsh corridor, a key food resource zone, was over represented compared to its percent availability. *Myzopoda schliemanni* is one of the few endemic Malagasy mammals that uses anthropogenic habitats and is therefore not threatened by deforestation, although the loss of roosts to bushes fires and the use of the palm leaves as building materials certainly have an impact on population dynamics.

**Keywords:** Habitat use, home range, roosting ecology, *Myzopoda schliemanni*, Madagascar

## Toward a molecular phylogeny for the Molossidae (Chiroptera) of Africa and the western Indian Ocean region

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We present phylogenetic information based on new nuclear Rag2 and mitochondrial cytochrome *b* sequence data for 6 genera of Molossidae (*Chaerephon*, *Mops*, *Mormopterus*, *Otomops*, *Sauromys*, *Tadarida*) and 15 species, primarily from Africa and the Malagasy region (Madagascar and neighboring islands), and further include sequences of 17 mainly New World taxa sourced from Genbank. There is strong support for the monophyly of the Molossidae included in this study. The monotypic genus, *Tomopeas*, is the most basal member of the extant Molossidae. The Malagasy region taxa *Mormopterus jugularis* and *M. francoismoutoui* are supported as a basal clade with an age of 31.2 MYR, and are not monophyletic with the South American form, *M. kalinowskii*. Asian *Otomops wroughtoni* and *O. formosus* and Afro-Malagasy *O. martiensseni* and *O. madagascariensis* form a strongly supported 19.8 MYR-old clade whose broader relationships among Molossidae are not clearly defined. There is strong support for a 17.2 MYR-old combined *Chaerephon/Mops* clade, in which members of these genera show some paraphyly. The monophyly of the genus *Tadarida*, represented in our analyses by *T. brasiliensis* from the New World and *T. fulminans*, *T. aegyptiaca* and *T. teniotis* from the Old World, is not upheld, although there is good support for a geographically disjunct 9.8 MYR-old grouping which includes *C. jobimena* (Madagascar), *T. aegyptiaca* (Africa) and *T. brasiliensis* (America). *Sauromys* is maintained as a monotypic genus, although there is support for its association with *T. fulminans* and the *Chaerephon/Mops* clade, the latter of which comprises *M. midas*, *M. leucostigma*, *M. condylurus*, *M. bakarii*, *C. pumilus*, *C. pusillus*, *C. leucogaster* and *C. atsinanana* (eastern Madagascar). An 18.37 MYR-old New World clade comprising representatives of *Eumops*, *Nyctinomops* and *Molossus* was well supported.

**Keywords:** Molossidae, RAG2, cytochrome *b*, Africa, Madagascar, phylogeny



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## **Conservation and sustainable use of amphibians in Madagascar: Integrating species and area priority assessments with a standardization of monitoring techniques**

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## **Conservation of amphibians in Madagascar: Integrating species and area priority assessments with a standardization of monitoring techniques**

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### **Background**

Madagascar is one of the worldwide regions with highest priority for biodiversity conservation and a model region for evolutionary and biodiversity research (Vences et al. 2009). Madagascar is also one of the poorest countries in the world, and its unique biodiversity has been identified as a major resource for its sustainable development. Among Madagascar's fauna, the amphibians and reptiles are a group of spectacular diversity and well known flagship species for the conservation and ecotourism in the island. The amphibians of the island are characterized both by their high degree of endemism (100 % at the level of species), and by a large species diversity with over 250 described and more than 150 yet undescribed species (Vieites et al. 2009). However, especially amphibians are worldwide one of the most threatened animal groups, with disease-mediated catastrophic declines on many continents. It has recently been argued that Madagascar presents a unique chance to preserve a rich pre-decline fauna, because disease-related declines have not yet been observed here (Andreone et al. 2008). However, ongoing habitat destruction presents very serious threats to Madagascar's fauna and flora, with probably less than 10 % of the original forest cover remaining today. However, since 2003, the protected area network has nearly been doubled, and an opportunity exists now to protect small fragments of remaining habitat that are critical for many restricted-range endemic amphibians (Kremen et al. 2008).

In addition to the creation of new protected areas, it also will be important to understand the population dynamics of amphibians because many worldwide declines of these animals occurred within reserves. Available techniques for detection of the presence and population density and health of amphibians in Madagascar are, however, so far not well established.

### **Problem statement**

The highly diverse and endemic amphibians and reptiles of Madagascar are suitable indicators to determine conservation priorities within Madagascar. They constitute an important economic resource for the country in terms of ecotouristic flagship species, potential source of pharmacologically active organic compounds, and potential for a

sustainable harvesting for the pet trade. The amphibian larvae (tadpoles) furthermore have a probable high importance for the structure and dynamics of aquatic ecosystems in mid-altitude rainforests which so far is not sufficiently understood. Research on these organisms is scientifically rewarding due to the many unanswered questions in their ecology, systematics and evolution, and is relevant to contribute to the long-term conservation and sustainable use of this important component of Madagascar's biota.

### **Objectives, Approach, and Progress to Date**

In the current implementation of the project we conduct research along four different lines and plan to integrate these to assess conservation priorities and sustainable use concepts.

1. The presence of infectious chytrid fungus in Madagascar has been assessed for the first time and the susceptibility of Malagasy amphibians to this agent tested, as well as the presence of other pathogens and parasites assessed. In this part of the project, carried out by the Malagasy PhD student Liliane Raharivoloniaina and co-supervised by the South African project partners, samples of tissue as well as skin swabs from numerous localities and species have been collected and screened using histological and molecular techniques. The results unanimously suggest that the amphibian chytrid fungus is so far absent from Madagascar. These data have been crucial for dissemination activities to various conservation agencies in Madagascar and a workshop on the chytrid fungus has been organized in the framework of the Madagascar amphibian conservation program (ACSAM) in October 2010. The parasitological screening, focused on polystome flatworms, have led to the discovery of numerous new species and two new genera of parasites infecting Malagasy frogs (see also poster abstract).
2. The efficiency and repeatability of different field techniques for amphibian monitoring, including tadpole inventories, and bioacoustics, have been comparatively assessed and a standardized protocol for long-term monitoring projects is being developed. Details of this sub-project are given in the abstract of the poster of PhD student Parfait Bora.
3. The diversity of tadpoles and their importance for aquatic ecosystems has been investigated. The tadpoles of many species remain undescribed, and their ecology almost completely unknown, despite their probable important role in many limnic ecosystems. Based on tadpoles identified by molecular techniques (DNA barcoding) we have compiled a database of over 100 tadpole morphological characters for over 170 species in the frog family Mantellidae. Many of these tadpoles were previously unknown, and descriptions of over 50 species have been published by Roger-Daniel Randrianiaina, the PhD student responsible for this sub-project, or are being published. The main goal of the research is

to analyze correlations between morphology, behaviour, and feeding ecology of Madagascan frog larvae, within an evolutionary framework. Besides standardized collection of habitat data from the field along stream transects, we have also carried our numerous experiments in the field and the laboratory, especially on microhabitat choice and activity cycles. These data are currently being analyzed. Furthermore we collected a large number of samples to analyse gut contents, gut length and gut diameter as well as dry mass of tadpole gut contents at different times of the day.

4. A fourth sub-project that started in 2009 uses population genetic and phylogeographic analyses on priority species for conservation to identify areas of endemism and of conservation relevance for the preservation of genetic diversity in amphibians and reptiles. The PhD student involved in this sub-project, Fanomezana Ratsoavina, has chosen a particular and emblematic group of reptiles, the leaftail geckos of the genus *Uroplatus*, as main focus of her study, but is also working on other species of reptiles and amphibians (see abstract of the respective poster on chameleons) and on species inventories of poorly known forest fragments in Madagascar (see section below). Leaftail geckos are highly attractive both for the pet trade and for ecotourism, and knowledge on their species diversity and genetic relationships is important for conservation assessments. Since these animals are mostly restricted to intact rainforest, their conservation is crucial.

During 2008-2010, several additional activities have been carried out in the framework of the present project:

#### *Socioeconomic study*

Ecotourism is considered to be an important economic factor in Madagascar, despite recent decreases in tourist numbers due to political turmoil in 2009-2010. However, detailed studies on its quantitative contribution to the country's economy, as well as detailed studies on the potential to improve the ecotouristic offers are lacking. We evaluated the importance of Madagascar's unique diversity of amphibians and reptiles by performing, in cooperation with the association Madagasikara Voakajy, interviews of a total of 667 ecotourists in five nature reserves between January-September 2008. Based on these data we assessed the ecotouristic potential of Madagascar's amphibians and reptiles compared to other components of its unique fauna. Visitors were best informed about mammals and reptiles, and information levels increased with subsequent visits to Madagascar. In contrast, tourists were not well informed about amphibian diversity. However, 27% of tourists considered encounters with Malagasy herpetofauna as a factor for deciding to visit the island, tourists with high zoological interest were willing to pay higher prices for specialized biodiversity tours in protected areas, and were positive about increased supply in herpetofauna related



activities. Tourist income affected travel expenditure, trip length and spending behavior; a higher total trip budget resulted a higher number of sites visited, but not an increased number of protected areas visited. We estimate annual expenditures of 26-29 million USD by ecotourists that visit protected areas. Currently, only three quarters of all Madagascar leisure tourists visit parks (around 49,000 in 2008), highlighting the importance of improving and diversifying the ecotouristic supplies to attract more tourists to Madagascar's nature reserves.

*Fieldwork and inventories in rainforest fragments* Increasing the size of protected areas is one of the objectives of several organizations working on the biodiversity conservation in Madagascar. During the last five years, the Malagasy government and several non-governmental organizations concentrated their effort on huge project for the delimitation of newly protected areas. Before establishing any conservation strategies, the knowledge of the flora and the fauna is crucial. Most such biodiversity assessments have concentrated on major blocks of intact forest that were considered to be of conservation priority. However, in many parts of Madagascar, no such large areas of primary habitat remain, and the small forest fragments persisting in these areas have often been neglected in conservation efforts. However, the remnant species located in these fragments might be local endemics that occur nowhere else than in these small isolated patches of habitat. The animal and plant populations remaining in these fragments are also relevant for research especially on biogeography and ecological requirements of particular widespread species. Starting from 2009, inventories of reptiles and amphibians were therefore carried out in numerous habitat fragments in the North, North-east, Central highlands, East and South-east of Madagascar and the encountered specimens studied using morphological and especially molecular techniques. We thereby obtained various remarkable records that represent range extensions of known species and new species that probably remain only in these fragments and therefore warrant a particular attention if they are to be saved from extinction.

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## Molecular phylogeography of a widespread Malagasy leaf chameleon species, *Brookesia superciliaris*\*

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Chameleons of the Madagascan endemic genus *Brookesia* are small to extremely small reptiles with a mostly terrestrial lifestyle. The genus is widely distributed (except in the arid south and south-west) but many *Brookesia* species are restricted to a relatively small area of the island. Speciation has been most prolific in the northern parts of Madagascar, an area that currently host about two-thirds of the 27 nominal species. The species *Brookesia superciliaris* (Kuhl) is distributed along the rainforest belt of Madagascar's east coast, from lowland to mid-elevations up to about 1000 m above sea level. It exhibits one of the largest distribution areas in this genus and is one of the largest leaf chameleons with a maximum total length of 120 mm. In the present study, we analyzed mitochondrial and nuclear DNA sequences of *B. superciliaris* to reveal the genetic variability across the wide distributional range of this leaf chameleon species. Genomic DNA fragments of the mitochondrial 12S rRNA gene and of the nuclear Phosducin gene were PCR-amplified and sequenced using standard protocols. The mitochondrial data reveal close relationship among *B. superciliaris* from mid-elevation localities, although based on geographic distances a closer sister group relationship between populations from the central east was expected a priori. A basal position of the lowland populations versus the more nested position occupied by those from mid-elevations is found. Interestingly, a low differentiation among the haplotypes from each side of the large river (Mangoro River) has been identified. Based on these results we hypothesize that big rivers do not act as a strict barrier for gene flow in *B. superciliaris*. However, populations at mid-elevation which could indicate that dispersal may have taken place in the headwaters where the river is less wide and its barrier effect thus less intense. A more appropriate dataset, with sampling occurring at each side of the main rivers and closer to the river banks, especially in localities close to rivers is required to confirm this hypothesis, and to identify possible secondary contact zones.

**Keywords:** Squamata, Chamaleonidae, *Brookesia superciliaris*, phylogeography

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\* Note: This work has recently been published in the peer-reviewed and ISI-listed journal Zootaxa (Zootaxa 2554: 62-64)

## **Monitoring frog diversity with recommendations of methods for standardization: Case studies from Ranomafana and Analamazaotra reserves in Madagascar**

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The need for standardization of field methods for Malagasy frogs has been emphasized by various researchers working on their biology, and during the workshop “A Conservation Strategy for the Amphibians of Madagascar (ACSAM)” held in Antananarivo 18-21 September 2006. However, data to achieve such a standardization are still scarce. Here we provide new data carried out in Ranomafana National Park and on the edge of Special Reserve of Analamazaotra/Mantadia between 2007 and 2008. Based on our data in Ranomafana, tadpole collection and their subsequent identification via DNA barcoding had an average success of 49 % to reveal the presence of species known to be present in the respective amphibian community, while visual encounter surveys detected 29 % and standardized call surveys (acoustic encounter surveys) 22 %. In Analamazaotra, only visual encounter surveys (average of success of 71 % of frogs) and acoustic encounter surveys (29 %) were used. These results varied widely with the importance of frog diversity at study sites, and among ecological guilds of species, for both area surveyed. The results demonstrate the need of combination of methods to increase the detectability and verifiability of species in the field. The work in Analamazaotra also revealed differences in seasonality of activity among species, indicating that long-term study are needed to better understand the phenology of Madagascar’s amphibians. We recommend a combination of visual and acoustic encounter surveys, accompanied by opportunistic trapping and collection of tadpoles, for a more complete inventory of Malagasy amphibians during a survey.

**Keywords:** Monitoring, species diversity, amphibians, phenology, DNA barcoding, Madagascar

## Discovery of the first monogenean flatworm from a microhylid frog host

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Polystomatids are endoparasitic monogenetic flatworms infecting aquatic and amphibious tetrapods with the majority in anurans and freshwater chelonians. Thus far 23 genera have been recognised within the Polystomatidae, containing more than 200 species. Whereas some frog polystomes like *Polystoma* Zeder, 1800 and turtle polystomes like *Polystomoides* Ward, 1917 and *Neopolystoma* Price, 1939 have cosmopolitan distributions, most others are restricted to single continents or geographical realms. In Madagascar, frogs of the genera *Ptychadena*, *Aglyptodactylus* and *Boophis* are hosts of the genus *Metapolystoma*, and we have recently completed the description of a new genus of polystomes that infects frogs of the subfamily Mantellinae in the endemic family Mantellinae. Here we report the discovery of a second new genus of polystome parasites from Madagascar, from the narrow-mouthed frog *Platypelis pollicaris*. This is the first record of a polystome from the anuran family Microhylidae and the third polystome genus from Madagascar. Based on molecular and morphological evidence this new polystome is closely related to *Madapolystoma* from Madagascar and *Eupolystoma* known from Africa and India. It shares with *Eupolystoma* the hugely expanded uterus and lack of vaginae, but unlike in that genus the gonads are in the middle of the body and a pair of hamuli is present. Although evidence of intrauterine development exists, no signs of an internal cycle was found.

**Keywords:** Monogenea, Polystomatidae, parasites, new genus, new species, Madagascar, *Platypelis pollicaris*



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## **Sustainable restitution / recultivation of artisanal tantalum mining wasteland in Central Africa**

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## Coltan environmental management: Sustainable restitution/recultivation of artisanal tantalum mining wasteland in Central Africa

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### Background

Tantalum is a high-tech metal used for microelectronics and rocket engines.

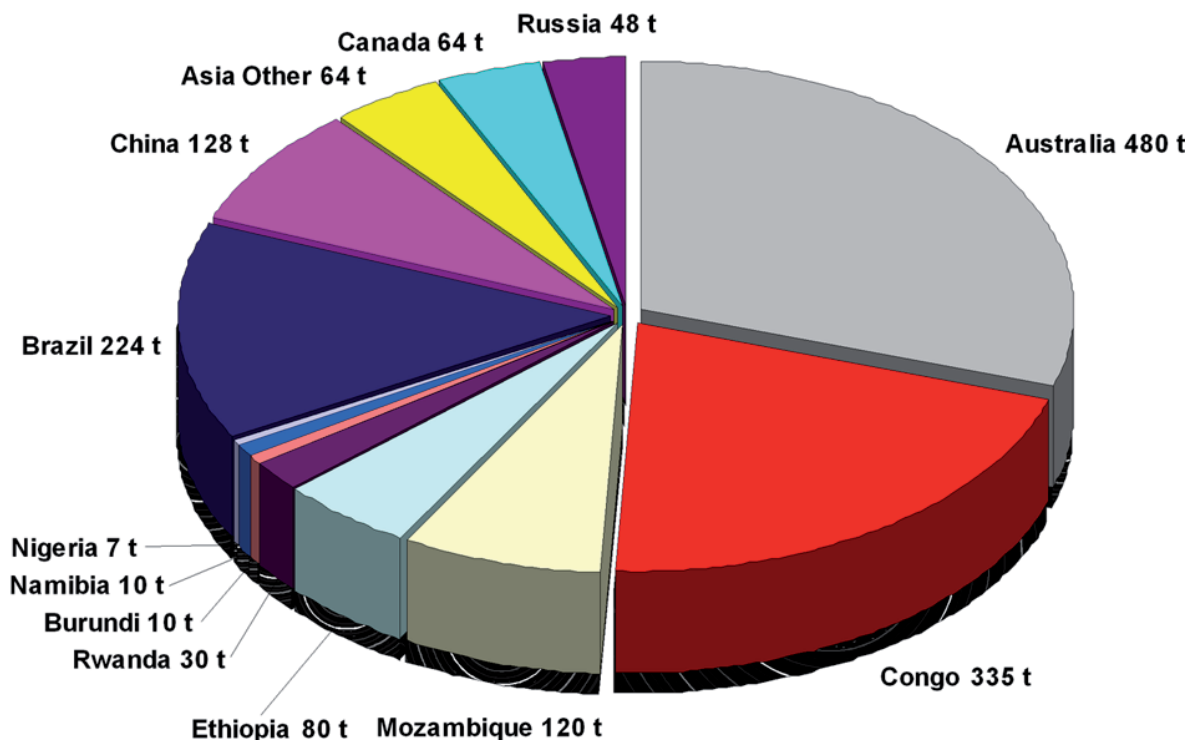


Fig 1. Tantalum world mine production for 2008. The total production is 1800 tonnes of Ta metal. Note the large share of the DR Congo which is mostly from the Kivu province.



About 25 % of the world mine production of tantalum is currently from Central Africa (Fig. 1). This share is likely to increase during the next years when prices will rise due to the shut-down of the Australian Wodgina mines and depletion of the current metal inventories.

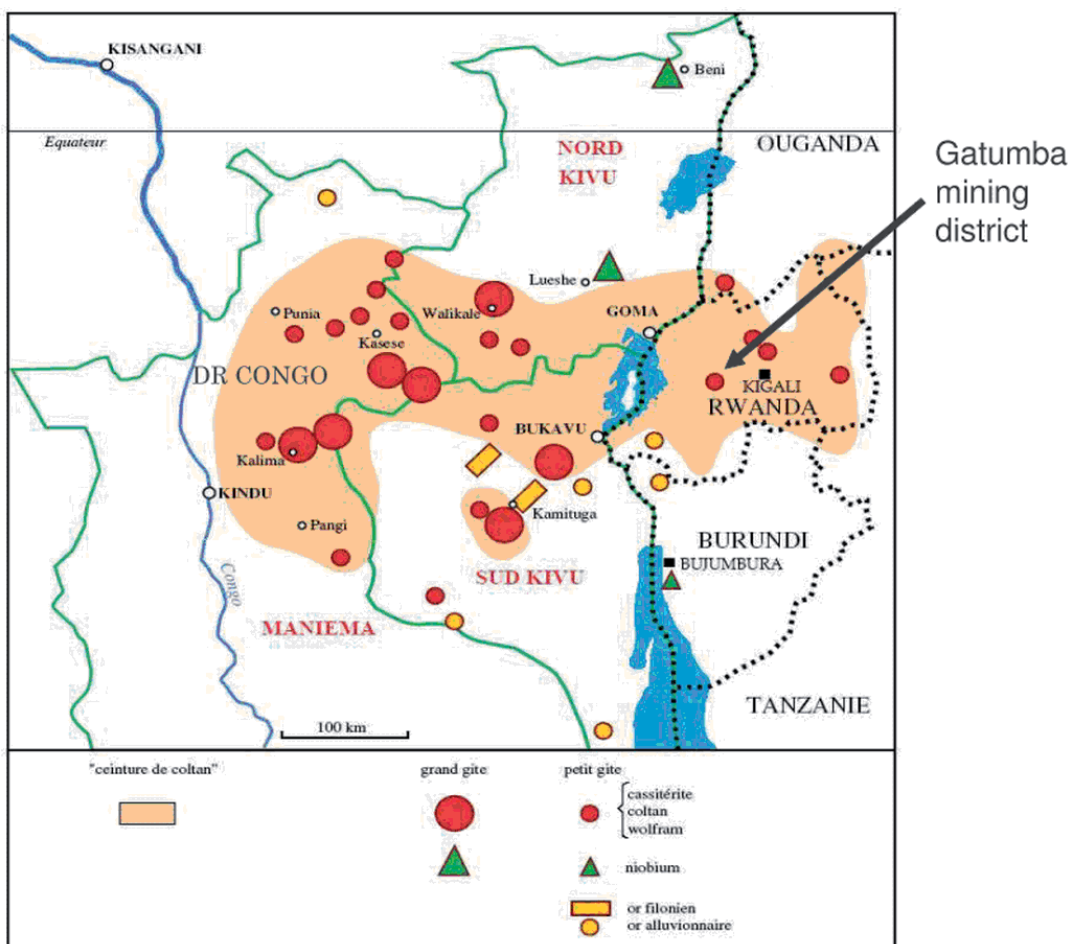
The mining of tantalum (here called “coltan”) in Central Africa is from artisanal and small-scale mines. Hundreds of larger and thousands of smaller unregulated artisanal mines were and are worked in recent years in northern Burundi, eastern Congo (Kivu), Rwanda and southwestern Uganda. Similar to the famous “gold rushes” of the past, both environment and people suffered heavily - and are still affected - from these disruptive activities. Extremely weak governance due to civil war and the genocide in Rwanda, and the fighting in Kivu that spilled over into neighboring Burundi and Uganda, have aggravated the situation. Meanwhile, a somewhat tenuous peace has been re-established in the region. Only parts of the Kivu province in Congo still experience a near-absence of government. Burundi, Rwanda and Uganda are struggling to establish environmentally acceptable mining practices while several projects of exploration and industrial mine development are established. However, scientific and practical fundamentals to guide this endeavor are scarce.



Fig 2. Tantalum ore (“coltan”) consists of the Ta-rich member of the columbite mineral group,  $(\text{Mn,Fe})(\text{Ta,Nb})_2\text{O}_6$ , a black, heavy accessory mineral in rare-metal-rich granite pegmatites

### Problem statement

Earlier, industrial mining of tin and tantalum during mostly colonial times had declined tens of years ago because of various reasons. These operations and the recent boom of artisanal mining left land wasted, chemically and physically hazardous, and unproductive. The natural soil cover is removed and washed away, barren rock is exposed, and natural water courses and valleys are flooded with coarse tailings. Debris and mud flows continue to threaten the valleys. Deleterious (toxic or radioactive) elements leached from the newly exposed rock may be a danger for people, environment and for water resources. In the environs of former and operating mines, the population may suffer from degraded conditions of employment, health, and farming.



Source : "Carte des Gîtes Minéraux du Rwanda" B.R.G.M.

Fig. 3. The Central African tin-tantalum province, and location of the main project study area of Gatumba in western Rwanda. This metal province has a historical production of about 500,000 t Sn and about 10,000 t Ta<sub>2</sub>O<sub>5</sub>, with a present-day value of about 6.5 billion USD

### Objectives and approach

The Coltan Environmental Management project is designed to combine earth, biological, agricultural, social and economic sciences for an exploratory holistic analysis of the state of a sample area at Gatumba in Rwanda that is typical of mine-affected lands

in Central Africa (Fig. 3). Considering the important role that sustainable mining may have in the region for future economic development, the aim of the project group is to provide science-based, but tangible “how-to-do” mitigation strategies and propose long-term solutions with maximum environmental quality for the coexistence of tropical farming and coltan mining in Central Africa. In addition, the larger problem of improvement of tropical soil fertility by using alkaline igneous rocks as rock fertilizer needs testing, given the occurrence of such rocks in the western rift zone (Lake Kivu to Lake Tanganyika region).

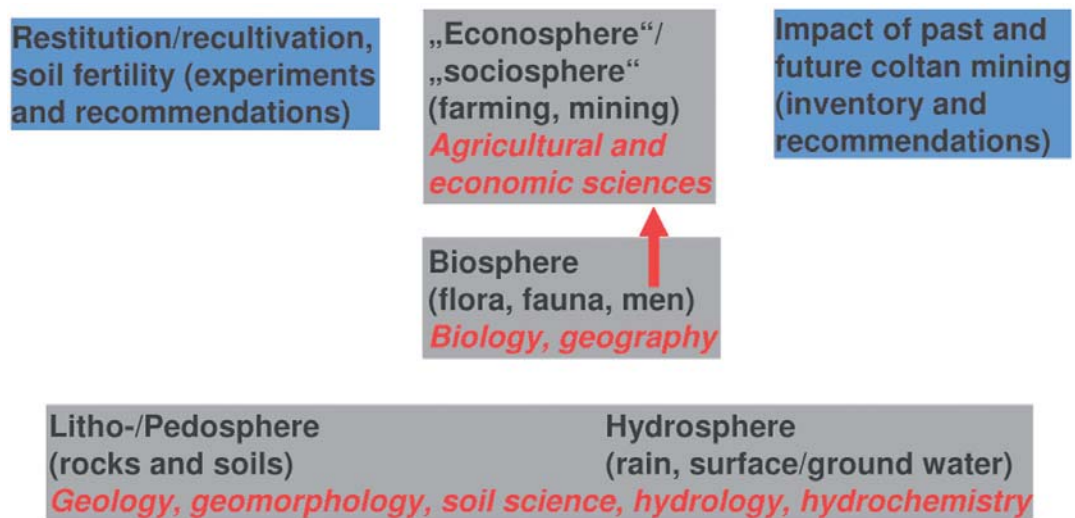


Fig. 4. Structure of the Coltan Environmental Management project. The objective is the long-term development with maximum environmental quality in the special case of coexistence of tropical farming and coltan mining. Restitution/recultivation measures aim at improvement of soil fertility. The two main research components are based on geosciences and agricultural sciences, respectively, with cost-benefit analysis of all measures suggested

### The Gatumba coltan mining district in western Rwanda

The Gatumba district has about 20,000 people who mostly live from small-scale farming (only 30 % of farms have >1 ha whereas >50 % have <0.7 ha). Coltan (and tin ore) mining at Gatumba was active in a semi-industrial manner from 1929 to 1985. Since then, mining in the district is limited to small-scale mostly artisanal activities, targeting local high-grade ore pockets. A joint venture between the Rwandese Government and African Resources is currently exploring the area with the aim to re-establish industrial mining.

A total of about 20,000 tonnes of cassiterite and columbotantalite concentrate were produced, and more than 50 million tonnes of weathered rock were moved in the past. Because mining took place mainly by hydraulic methods (“ground sluicing”), most of this mass was washed downslope from hillsides into nearby valleys, leaving behind narrow and steep ravines (Fig. 5). Bottoms of stream valleys adjacent to mines were buried by loose sediment. Stream gradients were locally changed. A sizeable part of

the ore was extracted from alluvial placers in the valleys proximal to primary deposits. In that case, the stream sediments were also shifted downstream, which disturbed the natural bedding of the valley fill and left an irregular hummocky landscape (Fig. 6).



Fig. 5. Artisanal mining of weathered tantalum-rich pegmatite by “ground sluicing” (Kabarore area, northern Burundi). The economic portion of such deposits is only about 500 g per ton ore. The 99.9 % of waste is washed down into the valley where it spills over large areas of fertile soil



Fig. 6. Waste rock is washed down the valley from the quarry in the background, and re-worked for alluvial tin-tantalum (foreground). Nganzo area, Gatumba district, Rwanda

The Gatumba district is in most aspects a typical Central African tantalum-tin mining district. Results from research in this area will be applicable to hundreds of similar

medium-sized mines, and to thousands of smaller ones. Data from reconnaissance field work in SW Uganda, northern Burundi and eastern Kivu (DR Congo) will be integrated.

### **Preliminary results and research priorities**

**Health:** There is no indication at Gatumba that (past) mining or the abandoned quarries affect public health. Health problems in coltan mining camps in the Kivu province, DR Congo, are not due to mining per se but due to societal disruption that can only be solved by better governance.

**Toxic elements:** Moderately elevated arsenic and uranium contents have been found in soil, stream sediments and tailings at Gatumba, but surface (stream) water is below the WHO safety levels. Precise sources of arsenic and uranium (including its radioactive daughter elements such as radium) have yet to be determined. The pathways of these elements from primary anomalies, dispersion in soil and river sediments to food plants, animals and humans need investigation, as well as possible ways of mitigation.

**Erosion:** The current mining practice of artisanal ground sluicing destroys large areas of fertile soil. Abandoned quarries, tailings and waste rock in stream valleys are characterized by accelerated erosional processes. Investigations must find mitigation techniques to minimise erosion and large-scale spread of mining waste downhill, in both active and abandoned mines. Optimal water management must be designed and applied, as known from small-scale mining regions in other parts of the world.

**Soil fertility:** Agricultural research must develop best practices for rapidly improving the fertility of mine site soils (technosols), as well as of traditional arable land, and for controlling soil erosion. We will study the potential for accumulation of nutrients through optimized crop rotations (including N-fixing plant species), applying rock flour from nearby alkaline lavas to improve the soil K status, and incorporating rock phosphates to increase available P contents of soils. We started both farmer participatory trials and greenhouse experiments to examine the effects of soil amendments (nutrient-rich plant residues, amended rock fertilizers, compost, mineral fertilizers). A detailed investigation will quantify the availability of organic materials suitable for composting in-situ and subsequent use as a substrate for tree nurseries and soil amendment for the recultivation of mining wasteland.

**Natural habitat:** Forestry and botany have to develop methods to re-introduce valuable native tree and bush species to mine sites that are not suitable for cultivation. Can parts of the quarries be made islands of special ecological value?

**People and sustainable mining:** We are currently developing a georeferenced land-use map of selected areas in the Gatumba district which will integrate data from geological, soil, botanical, agricultural and socioeconomic surveys, and

will be complemented by information from the local population, administration, and mining companies. The whole process will follow a farming systems approach which will incorporate local capacity (including Burundese experience). The participation of the local population is central to the project, and we will identify ways of sustainable mining which reconcile the demands from all stakeholders with a long-term perspective. Cost-benefit analysis will be applied to all mitigation measures.

**Further reading**

Biryabarema M, Rukazambuga D, Pohl W, eds (2008) Sustainable restitution/recultivation of artisanal tantalum mining wasteland in Central Africa – a pilot study. *Études Rwandaises* Éditions de l'Université Nationale du Rwanda, Butare 16: 1-174

## Toxic elements in soils, sediments and water: field activities in August 2010

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Soils and sediments in the Gatumba mining district are potential hosts of toxic element accumulations which may be available to plants or contaminate drinking water. During the dry season in August 2010, in order to determine sources and pathways of trace elements, soil, sediment, water (from stream water, groundwater and wells) and plant samples (from agricultural land and shrub land, sampled with support of the plant diversity group) were collected from different sites in the Ruhanga Coltan mining area which is part of the Gatumba Mining District. As a reference, soils which were not affected by mining (parent materials: dolerite and schist/sandstone) were sampled and water samples (not mining-affected) were taken along the rivers Gisuma and Kibilira and at the village of Gatumba.

The total number of soil samples was 132 from 16 profiles (some of the profiles were sampled in triplicate), that of plant samples was 49 (up to five species per site were identified and collected by the plant diversity group). Twenty water and sediment samples were taken from streams and 14 samples from drinking water springs (each sample in triplicate).

Toxic element accumulation is particularly expected for Fluvisols and slope water-influenced Gleysols below mining areas or on mine spoils. Hence, five Fluvisols close to the Ruhanga mining site and two close to the Nyabarongo river as well as three Technosols on mine spoil partly under cultivation and a Technosol overlying a Gleysol were included. Within the areas uninfluenced by mining activity, an umbric Leptosol, a vertic Umbrisol (both developed on dolerite), a Lixisol and a Cambisol (on sandy schist) were sampled. Water and sediment sampling sites were partly selected in agreement with the soil sampling locations. Surface water samples were taken up- and downstream of the Ruhanga mine along the Gisuma river and its receiving stream Kibilira. Sediments were collected only if the sedimentation process dominated over in situ anthropogenic disturbances. On-site analyses have shown evidence of strongly reduced groundwater from water-saturated horizons of Gleysols. Particularly the reduced environment of groundwater is expected to show an enrichment of reduced mobilised toxic elements. Hence, to exclude long term health hazard to local people,

a particular focus was set upon springs used for drinking water purposes. Also, discharge measurements were carried out as a basis for a potential hydrological model of the Gisuma catchment to serve other groups, in particular, the research on geomorphology.

The soils will be analyzed for major properties (texture, pH, organic C, total N and CEC) and trace elements according to soil horizons. Sediment, water and plant samples of the possibly mining-influenced sites and reference sites will be analyzed for trace elements. The analyses will be carried out using a new ICP-MS in the laboratory of Braunschweig Technical University. This is to follow possible pathways of toxic elements and their uptake by plants to determine consequences for food chains. Soil fertility parameters and nutrient contents in plants will be determined by the land reclamation and soil fertility groups. Additionally, mine spoil and subsoil (regolith) material was transported to the National University of Rwanda at Butare to be used for the set-up of a greenhouse experiment on mine spoil reclamation starting in September 2010.

All sampling sites were mapped by GPS coordinates to ensure exact localization during future sampling campaigns. As varying moisture conditions could influence the mobility and concentration of toxic elements, we are planning our next field activities to be conducted in March 2011 (the rainy season). As a basis of our field activities, an IKONOS satellite image was referenced and projected into WGS 84 UTM 35 in June/July 2010. This work has been complemented in August 2010 by georeferencing of 16 field points with the aim to increase accuracy of future mapping. The results will be helpful for almost all subprojects of the Coltan Environmental Management project.



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