CLIMATE-SMART AGRICULTURE: POSSIBLE ROLES OF AGRICULTURAL UNIVERSITIES IN A STRENGTHENED NORWEGIAN CLIMATE CHANGE ENGAGEMENT IN AFRICA

EDITED BY GRY SYNNEVÅG AND JAYNE LAMBROU

Noragric Report No. 64, February 2012
Department of International Environment and Development Studies
Noragric

Climate-Smart Agriculture: Possible Roles of Agricultural Universities in a Strengthened Norwegian Climate Change Engagement in Africa

Edited by
Gry Synnevåg and Jayne Lambrou

Noragric Report No. 64
February 2012

Department of International Environment and Development Studies, Noragric
Norwegian University of Life Sciences, UMB

Noragric is the Department of International Environment and Development Studies at the Norwegian University of Life Sciences (UMB). Noragric's activities include research, education and assignments, focusing particularly, but not exclusively, on developing countries and countries with economies in transition.

Noragric Reports present findings from various studies and assignments, including programme appraisals and evaluations.

This Noragric Report was commissioned by the Norwegian Agency for Development Cooperation (Norad) under the framework agreement with UMB which is administrated by Noragric.

The main contributors to this report are: Jens Aune, Siri Eriksen, Kjell Esser, Stein Holden, Randi Kaarhus, Kassim Kulindwa, Charlotte Nakakaawa, Bishal Sitaula and Gry Synnevåg.

The findings, interpretations and conclusions expressed in this publication are entirely those of the authors and cannot be attributed directly to the Department of International Environment and Development Studies (UMB/Noragric).

Synnevåg, Gry and Jayne Lambrou (Eds.). Climate-Smart Agriculture: Possible Roles of Agricultural Universities in a Strengthened Norwegian Climate Change Engagement in Africa.
Noragric Report No. 64 (February 2012)
Department of International Environment and Development Studies, Noragric
Norwegian University of Life Sciences (UMB)
P.O. Box 5003
N-1432 Aas
Norway
Tel.: +47 64 96 52 00
Fax: +47 64 96 52 01
Internet: http://www.umb.no/noragric

ISSN (printed version): 1502-8127
ISSN (online version): 1892-8102
Photo credits: Josie Teurlings (cover), Trygve Berg (title page)
Cover design: Åslaug Borgan/UMB
Printed at: Elanders Novum

CONTENTS

ABBREVIATIONS AND ACRONYMS

ANAFE	African Network for Agriculture, Agroforestry and Natural Resources Education
ARDEP	Agricultural Research and Development Fund
ARI	Agricultural Research Institute
ARU	Ardhi University
AU	African Union
BAGC	Beira Agricultural Growth Corridor
BCDP	Bunda College Capacity Building Programme
CA	Conservation agriculture
CAADP	Comprehensive Africa Agriculture Development Programme
CARD	Centre for Agriculture Research and Development
CCAFL	Climate Change Adaptation for Improved Food Security and Livelihoods
CCAFS	Climate Change, Agriculture and Food Security (a CGIAR research programme)
CCIAM	Climate Change Impacts, Adaptation and Mitigation
CFU	Conservation Farming Unit
CGIAR	Consultative Group on International Agricultural Research
CHEA	Conference on Higher Education in Agriculture in Africa
CIFOR	Center for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Center
CISANET	Civil Society Agriculture Network
COMESA	Common Market for Eastern and Southern Africa
COP17	17th Conference of the Parties to the United Nations Framework Convention on Climate Change
CSA	Climate-smart agriculture
CSIRO	Commonwealth Scientific and Industrial Research Organization
CURE	Coordination Unit for the Rehabilitation of the Environment
DCG	Drylands Coordination Group
EPINAV	Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-chains
EPMS	Environmental Protection and Management Services
ESRF	Economic and Social Research Foundation
ESSP	Earth System Science Partnership
FANRPAN	Food, Agriculture and Natural Resources Policy Analysis Network
FAO	Food and Agricultural Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FEWS NET	Famine Early Warning Systems Network
FISP	Farm Input Subsidy Programme
GART	Golden Valley Agricultural Research Trust
HU	Hawassa University
IAGTS	Indigenous agroforestry timber species

ICRAF	International Center for Research in Agroforestry
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
INADES	Institute of African Economic and Social Development/Institut Africain pour le Développement Economique et Social
IWMI	International Water Management Institute
MIROC	Center for Climate System Research, University of Tokyo; the National Institute for Environmental Studies and the Frontier Research Center for Global Change, Japan Abbreviation for the MIROC 3.2 medium resolution general circulation model produced by the Center for Climate System Research, University of Tokyo; the National Institute for Environmental Studies; and the Frontier Research Center for Global Change, Japan
MU	Mekelle University
NASFAM	National Association of Smallholder Farmers of Malawi
NEPAD	New Partnership for Africa's Development
NEPAD-PCA	NEPAD Planning and Coordinating agency
NILF	Norwegian Agricultural Economics Research Institute
NORHED	Norwegian Programme for Capacity Building in Higher Education and Research for Development
NSGRP II	New National Strategy for Growth and Reduction of Poverty (Swahili acronym MKUKUTA)
NTFPs	Non-timber forest products
NUCOOP	Norwegian University Cooperation Programme for Capacity Development in Sudan
OUT	Open University of Tanzania
PANTIL	Programme for Agricultural and Natural Resources Transformation for Improved Livelihoods
PRSPs	National Poverty Reduction Strategy Papers
RISDP	SADC's Regional Indicative Strategic Development Plan
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SADC	Southern African Development Community
SAGCOT	Southern Agriculture Growth Corridor of Tanzania
SCC	Swedish Cooperative Centre
SEMCIT	Sustainability, Education and the Management of Change in the Tropics
SIDA	Swedish International Development Cooperation Agency
SoCoCA	Socio-economic Consequences of Climate Change in Sub-equatorial Africa
SOLIBAM	Strategies for Organic and Low-input Integrated Breeding and Management
SPIA-CGIAR	Standing Panel on Impact Assessment - Consultative Group on International Agricultural Research
SUA	Sokoine University of Agriculture
TAFORI	Tanzania Forestry Research Institute
TEAM-Africa	Tertiary Education for Agriculture Mechanism for Africa
UDSM	University of Dar es Salaam

UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WB	World Bank

SUMMARY

The recent rise in the number of food insecure people in the world, coupled with incidences of crop failure due to adverse weather, have made world leaders increasingly aware that future climate change may severely limit our ability to feed the growing population towards 2050. So far, in addition to industrial emission control, Norwegian efforts to restrict climate change have focused on mitigation through forest protection (REDD+) and clean energy (Energy+). A third area of attention is climate-smart agriculture. Producing food in a more 'climate smart' way is seen as having three advantages: 1) Providing food for an increasing population, 2) maintaining food production under a changing climate, and 3) reducing greenhouse gas emission from agriculture while absorbing carbon in vegetation and soil. This report explores how Norway can support Africa's efforts to make agriculture more climate-smart through support to African universities.

Among the three benefits of climate-smart agriculture, African farmers will be most inclined to focus on the two first, the production increase and the adaptation. Mitigation may require external support. African leaders are in the forefront of developing policies and institutional arrangements for climate-smart agriculture. Among other initiatives, the *Comprehensive Africa Agriculture Development Programme* under the African Union is in the process of preparing member states for substantial investments in agriculture. Capacity building and the generation of new knowledge are essential for the achievement of climate-smart agriculture. Given the long history of Norwegian support to agricultural research and higher agricultural education in several African countries, Norway can, without doubt, make significant contributions to African food security – now and in the future.

Norwegian support to climate-smart agriculture can be based on its experience with REDD+ and Energy+ initiatives. The possible roles include: 1) Human and institutional capacity building; 2) monitoring and evaluation; and 3) establishing and maintaining partnerships between public, private and civil society actors. Drawing on studies from e.g., conservation agriculture, biofuel production and integrated land management in the Sahel, Norwegian support can contribute to the implementation of a productive and climate robust agriculture while also obtaining the goals of REDD+ and Energy+.

Interventions for climate change mitigation and adaptation, including REDD+ and Energy+ initiatives for commercial forestry plantations and renewable biomass fuels (biofuels), may restrict both men and women's access to land, forest and other productive resources. Studies so far have indicated that climate efforts may exacerbate an already precarious situation for women in many African countries due to their insecure access to land and their voiceless situation. In light of the different roles men and women play in food production and energy generation, their different needs should be attended to in the climate change agenda.

Considering the important role of the private sector in securing long-term sustainability of donor and government funded programmes in climate-smart agriculture, REDD+ and Energy+, and for the purposes of scaling up any pilot projects with limited donor or government funding, one case from Mozambique (the Beira Agricultural Growth Corridor - BAGC) and one from Tanzania (the Southern Growth Corridor of Tanzania - SAGCOT) are presented in the report. The cases may illustrate potential institutional arrangements for collaboration with private sector and farming communities in developing commercial agriculture. However, due to low returns and high risk, most African countries may not attract sufficient private investments required for the transition to mechanized food and energy production. Thus, government and

donor funding may still be required to provide incentives for the private sector engagement in climate change mitigation and adaptation efforts.

Norway, together with FAO and the World Bank (WB) has, for some time, been in dialogue with the African Union/NEPAD regarding cooperation on the strengthening of the climate dimension in the Comprehensive African Agricultural Development Program, CAADP. Support to climate-related research and education can be arranged through the Climate Programme of CGIAR, the Climate Change, Agriculture and Food Security (CCAFS).

UMB/Campus Ås has a wide network of partner universities in Africa, upon which further collaboration can be built. This report finds future arrangements under the new NORHED programme to be particularly promising for combining research and education towards climate-smart agriculture in Africa. Past and ongoing support programmes have already strengthened some of our partners to a level where they can serve as Centres of Excellence and function as hubs for regional research and education programmes. Weak universities in collaborating countries in the region may benefit through staff development and student funding mechanisms. UMB will seek to promote the experiences from the seminar series *Sustainability, Education and the Management of Change in the Tropics,* aimed at spreading the pedagogic approach of EARTH University in Africa and Asia.

Food security in Africa needs international attention, particularly with the current prospects of climate change. Fortunately, there are promising opportunities.

1. INTRODUCTION

"Around the world, the food system is in crisis. Prices have rocketed…"
The Economist, February 26th 2011

While the world was progressing towards the Millennium Development Goal #1 to reduce poverty and hunger by half by 2015, it was struck by a series of unfortunate events that brought the number of hungry and malnourished people in the world up to one billion—an increase of about 250 million in just 2-3 years. The events started with economic uncertainties in the early months of 2008, followed by an economic downturn.

In response to the food crisis, the Chief Executives Board of the United Nations established in April 2008 a *High Level Task Force on the Global Food Security Crisis* chaired by the UN Secretary-General. The Task Force pointed out in its Progress Report for 2008-2009 that the rise in global food prices was a result of long-term cumulative effects of increasing demand, declining investments in food production, conversion of agricultural land, land degradation and water scarcity. In addition, market speculations, expansion of biofuel production, rising oil prices and climate change had contributed to high food prices.

1.1. THE NEW GLOBAL POLITICAL FOCUS ON AGRICULTURE AND CLIMATE

In the following years, the food crisis was compounded by several incidences of droughts and floods around the world. In August 2010, Russia banned all exports of grain after its wheat harvest had suffered a severe drought. Argentina's soybean crop, the world's third-largest, fell dramatically in the 2010-2011 season due to drought. In Pakistan 557,000 hectares of crop land was flooded across the country in 2010, significantly reducing the country's ability to feed itself. The country was again flooded in 2011. Severe droughts and floods in Australia in 2009-2011 made worldwide headlines as well.

The impacts of climate change on our ability to feed a growing world population have been well documented in recent years. Climate models indicate that rising temperatures may have a beneficial effect on crops in the temperate areas. Tropical and subtropical areas, however, may experience significant reductions in crop productivity in a long-term perspective, i.e., towards 2080 (Fig. 1).

Paradoxically, agriculture contributes about 20 % of the greenhouse gases that causes climate change (including land clearing). The two most harmful greenhouse gases from agriculture are nitrous oxide from soils and methane from cattle, but carbon dioxide emission due to conversion of forests to crop land, is also important. On the other hand, agriculture has the potential to capture a significant part of the excess atmospheric carbon in the soil in the form of organic matter.

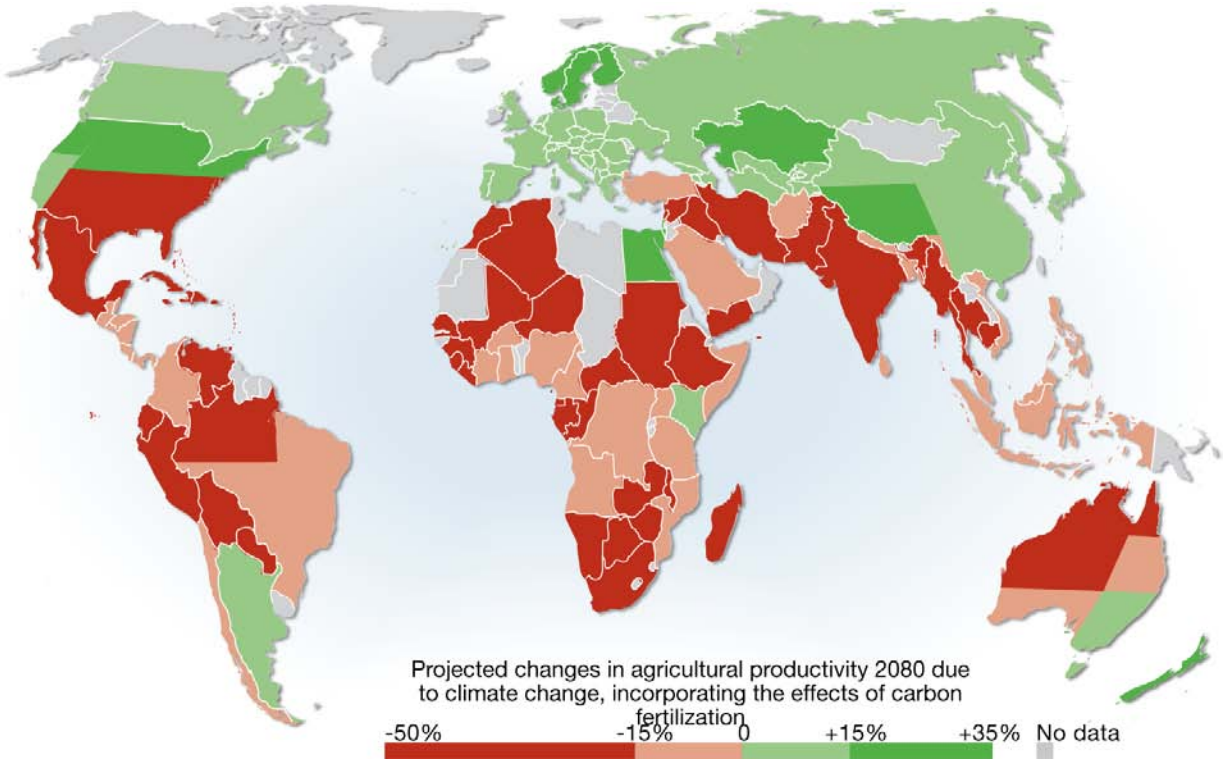

Fig. 1. Long-term projected changes in agricultural productivity from 2007 to 2080 (Cline, 2007).

Failing Millennium Development Goal #1, global impacts of extreme weather conditions and the prospect of global temperature increase beyond the potentially 'tolerable' limit of 2 °C by the end of the century, have brought the question of global food security into the midst of the climate change agenda. Thus, FAO published the report *"Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*, in preparation for the *Global Conference on Food Security and Climate Change*, held in The Hague, Netherlands in November 2010. The themes of the conference were:

1. Agriculture, food security and climate change: framing the issue and taking stock of innovations
2. Scaling up replicable models of climate change-smart agriculture: opportunities and challenges
3. Mobilizing investments from all sources for a transformational change to climate-smart agriculture
4. A road map for action

Since the Hague conference, the term *climate-smart agriculture* has been widely used to express agricultural practices that will (1) increase agricultural productivity and food security, (2) adapt agriculture to climate change, and (3) modify agriculture to mitigate climate change.

In October 2011, the *Global Science Conference on Climate-Smart Agriculture* was hosted by Wageningen University and Research Centre which co-organized the event with the Netherlands Ministry of Economic Affairs, Agriculture and Innovation and the World Bank. In preparation for the COP17 meeting in Durban in December 2011, the Wageningen Science

conference focused on three themes in its formulation of *The Wageningen Statement: Climate-Smart Agriculture – Science for Action*:

- Sustainable intensification and climate-smart solutions – enhancing food production while reducing greenhouse gas emissions
- Overcoming the barriers to climate-smart agriculture
- Managing volatility and risks – technical and social-economic options for climate-smart risk management

The *2nd Global Conference on Agriculture, Food Security and Climate Change*, "Hunger for Action", will be arranged in Hanoi, Viet Nam in May 2012. The conference will make steps forward to:

- Call on developed countries and other partners, to support the implementation and scaling-up of early action programmes, including best practice and technologies in climate-smart agriculture and food security, through regional, sub-regional and national programmes and institutions as a matter of priority
- Emphasise the importance of government-led partnerships with non-state agencies in designing strategies, policies and appropriate market based approaches to promote climate-smart agriculture
- Encourage countries to leverage private sector investments through public private partnerships in support of climate-smart agriculture
- Urge countries to invest in research, technology and information dissemination to facilitate the adaptation and application of climate-smart agriculture

To explore how agriculture can contribute to a reduction in atmospheric greenhouse gases and at the same time provide enough food for the global population, the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership (ESSP), launched in January 2011, a 10-year research programme on Climate Change, Agriculture and Food Security (CCAFS). The programme promotes six simple messages regarding food security and climate change:

1. Climate change has arrived
2. We need planned, accelerated and transformative adaptation
4. A "new" climate-smart agriculture is needed
5. A major push is needed for climate risk management
6. Farmers' efforts need to be supported by policies, incentives and knowledge

The CCAFS programme appointed the *Commission of Sustainable Agriculture and Climate Change* with the mandate to produce a clear and authoritative set of policy recommendations. The Commission proposed seven key recommendations in 2011:

1. Integrate food security and sustainable agriculture into global and national policies
2. Significantly raise the level of global investment in sustainable agriculture and food systems in the next decade
3. Sustainably intensify agricultural production while reducing greenhouse gas emissions and other negative environmental impacts of agriculture
4. Target populations and sectors that are most vulnerable to climate change and food insecurity

5. Reshape food access and consumption patterns to ensure basic nutritional needs are met and to foster healthy and sustainable eating habits worldwide
6. Reduce loss and waste in food systems, particularly from infrastructure, farming practices, processing, distribution and household habits
7. Create comprehensive, shared, integrated information systems that encompass human and ecological dimensions

1.2. THE NEW AFRICAN POLITICAL FOCUS ON AGRICULTURE AND CLIMATE

Reaching the combined goals of feeding the world and mitigate climate change will require large-scale efforts and significant resources. The task of producing 70 % more food needed for the world population by 2050, when climate change is predicted to cause a decline in global agricultural productivity, will not be easy. For Africa, the task will be particularly critical if the estimated 20 % average decline in productivity towards 2080 becomes a reality. Given the serious prospect for Africa, the issue of climate-smart agriculture was brought to a high political level at an early stage.

In September 2010 (preceding the Hague Conference), African nations convened at the *African Conference on Agriculture, Food Security and Climate Change* in Addis Ababa to address food security in a changing climate. In fact, this conference appears to be the first high-level meeting where the term "climate-smart agriculture" was used. The conference resulted in a communiqué "*reaffirming that Africa's priorities are to implement climate change programmes and projects to attain development goals, including the Millennium Development Goals, in particular to alleviate poverty with emphasis on achieving food security, especially for the most vulnerable groups*". The meeting also reaffirmed that adaptation is the priority for Africa and that there is an urgent need for immediate support for Africa's implementation of adaptation measures. The delegates requested that developed countries and all partners, as a matter of priority, support piloting and up-scaling early action programmes in climate-smart agriculture and food security (including capacity building, technology, knowledge and information), with emphasis on adaptation that creates a synergy with mitigation.

The conference in Addis Ababa was followed up by *The African Ministerial Conference on Climate-Smart Agriculture "Africa: A Call to Action*" held in Johannesburg, South Africa September 2011. In partnership with several international agencies, including the World Bank, FAO, IFAD and UNEP, the conference produced a policy brief proclaiming eight key messages:

- Food security, poverty and climate change are closely linked and should not be considered separately
- Without strong adaptation measures, and financing to support them, poverty alleviation and food security goals will not be reached
- Adaptation measures not only enhance food security but can potentially contribute to reducing greenhouse gas emissions from agriculture
- Climate-smart agriculture offers triple wins for food security, adaptation and mitigation
- COP 17 in Durban offers a unique opportunity for Africa to shape the global climate agenda and establish an agriculture work programme that is informed by science and covers adaptation and mitigation
- Climate-smart agriculture needs heightened attention in African policy processes and strategies, from national to regional levels

- Early action is needed to identify and scale up best practice, to build capacity and experience, and to help clarify future choices
- Considerable public and private finance will be needed to rapidly implement climate-smart agriculture

Clearly, the need for climate-smart agriculture has been recognized worldwide and not the least among leaders of African nations. The most serious threat of global warming to humanity is, indeed, the prospects of declining food security in large parts of the world. Agriculture holds opportunities to feed the world under a changing climate while contributing to restraining the global warming. However, major investments will be required to reach this goal.

1.3. PREDICTED CLIMATE CHANGE IN AFRICA

Africa is a vast continent with great climatic diversity. The effects of climate change on food security will also be diverse. The prospects of future droughts in Africa are often presented in the mass media. Reality, however, is far more complex.

Although the predictions for agricultural productivity for 2080 shown in Figure 1 suggest a rather negative development for food production, predictions for 2050 show a more mixed situation. Both the CSIRO and MIROC models predict increased annual precipitation for large parts of East-Africa, whereas western central and southern Africa may receive less rain (Fig. 2). The MIROC model suggests a more extensive climate change both in terms of reduced rainfall in some areas and increased rainfall in others. Increasing temperatures will neutralize some of the benefits of increased rain as indicated in the model predictions for changes in maize yield towards 2050 (Fig. 3). Increased annual precipitation in East Africa may also have negative effects on crops due to increased crop damage by floods.

For the purpose of this report, we may conclude that climate change in Africa most likely will be diverse, with less rainfall in some areas and more in others. The changes in rainfall may not necessarily cause droughts and floods. This will depend on pre-existing conditions and the seasonable distribution of the modified rainfall pattern. Therefore, in a medium time perspective, we may experience both improved agricultural conditions in some parts of the continent and reduced conditions in others. Improvements in growth conditions will most likely be limited to the next 30-50 years followed by a decline, primarily due to higher temperatures. The expected diversity of climate change in Africa and its effect on agriculture, suggests that adaptation and mitigation measures must be site specific. Attempts to formulate sweeping, continent-wide strategies for adaptation and mitigation will, most likely, have limited value.

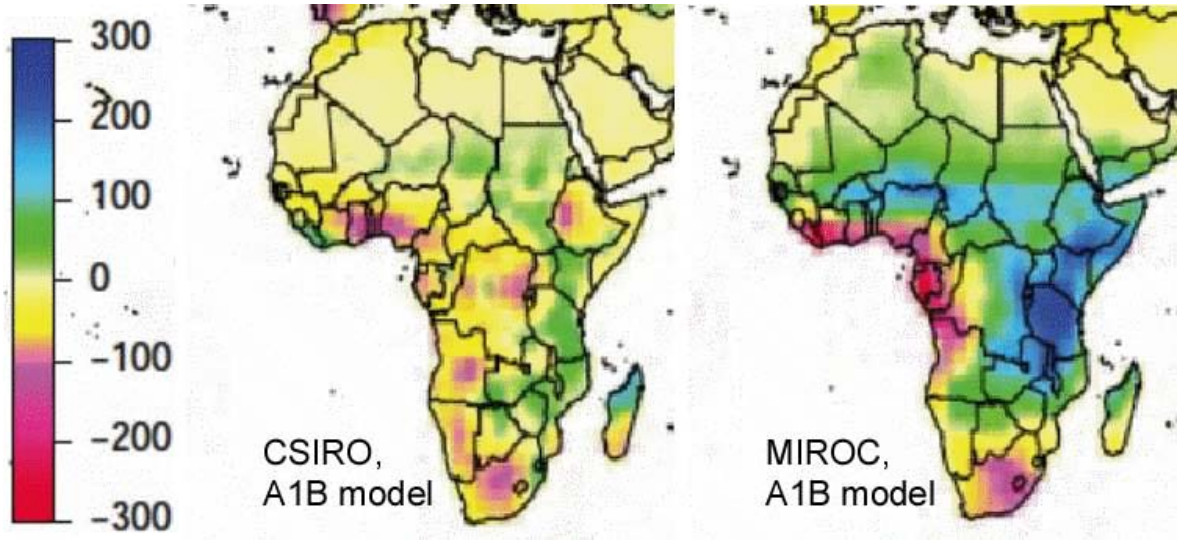

Figure 2. Change in average annual precipitation (mm water) in Africa from 2000 to 2050 according to the CSIRO and MIROC A1B models (Nelson *et al*., 2010).

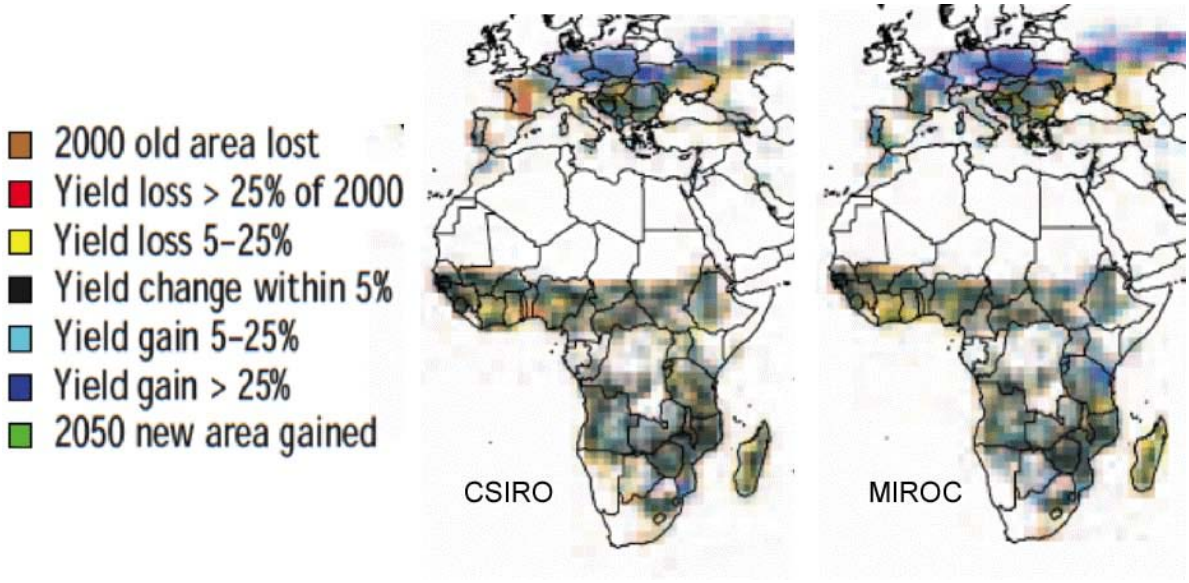

Figure 3. Yield effects of climate change on rainfed maize in Africa from 2000 to 2050 according to the CSIRO and MIROC A1B models (Nelson *et al*., 2010).

2. COORDINATION OF AGRICULTURAL DEVELOPMENT IN AFRICA

2.1. AFRICAN UNION/NEPAD AND NPCA

The 14th Ordinary Session of the Assembly of the African Union (AU) held in Addis Ababa, Ethiopia, in February 2010 adopted the Decision on the integration of the *New Partnership for Africa's Development* (NEPAD) into the structures and processes of the AU. This included the establishment of the NEPAD Planning and Coordinating Agency (NPCA) as a technical body of the AU to replace the NEPAD Secretariat. The Assembly mandated NPCA to facilitate and coordinate the implementation of continental and regional priority programmes and projects and to mobilize resources and partners in support of their implementation. It also directed the NPCA to conduct and coordinate research and knowledge management, monitor and evaluate the implementation of programmes and advocate on the AU and NEPAD vision, mission and core values.

2.2. COMPREHENSIVE AFRICA AGRICULTURE DEVELOPMENT PROGRAMME (CAADP)

The *Comprehensive Africa Agriculture Development Programme* (CAADP), established by the African Union's New Partnership for Africa's Development AU/NEPAD in 2003, has been mandated to "*Help African countries reach a higher path of economic growth through agriculture-led development, which eliminates hunger, reduces poverty and food insecurity, and enables expansion of exports*". CAADP brings together diverse key players - at the continental, regional and national levels - to improve co-ordination, share knowledge, successes and failures, encourage one another, and promote joint and separate efforts to achieve the common goals of regional food security and economic growth.

CAADP is based on four pillars: I) Sustainable land and water management, II) Development of infrastructure and improved access to markets, III) Increased food supply, reduced hunger, and improved response to food crises, and IV) Dissemination and adoption of improved agricultural technologies and investment in agricultural. New initiatives to reform and invest in tertiary agricultural education in Africa fall under Pillar IV, which thematically spans all four pillars. *Forum for Agricultural Research in Africa* (FARA) is the lead institution for Pillar IV and thus plays a central role in helping define the educational reform and investment agenda.

CAADP has been active during the last several years. Twenty-eight African countries have signed a CAADP Country Compact (a definition of broad investment priorities that is signed by relevant stakeholders), 21 have developed and technically reviewed Country Investment Plans, and 16 have held Business Meetings to map out and secure funding and to engage and encourage their governments, development partners, the private sector and other stakeholders in support of the Investment Plans. The process is rapidly progressing, and additional countries are continuously entering into CAADP processes.

A framework document for Pillar IV activities, called the *Framework for African Agricultural Productivity* (FAAP), published in 2006, is an advocacy tool, laying out general principles for African governments and the Regional Economic Communities (as organized under the African Union) to help formulate their national and regional strategies and investment plans for

implementing the Pillar IV agenda. This framework does, however, "*offer little specificity on what should be done or how to do it*" (World Bank, 2007).

Whilst the Framework for African Agricultural Productivity (FAAP) provides guidance on agricultural research, advisory services and education, its guidance on tertiary education is not yet as fully developed as it is for other elements of Pillar IV. Partly as a result of this and the resulting lack of tools for this process, Pillar IV teams have not sufficiently addressed the need for investments in agricultural education. This has led to inadequate attention to the needs of universities in the CAADP processes, specifically in the Investment Plans.

In a study of 10 out of the 21 existing CAADP investment plans (at the time of the review) undertaken by FARA, it was found that human capacity needs are only addressed in about 20 % of the Investment Plans. Thus, the review proved the perception that there is a need to address the role of universities within CAADP.

Several donors have shown a renewed interest in investing in African tertiary agricultural education, but there has been little if any coordination across these initiatives and, at times, little coordination among universities themselves in the countries receiving investments.

Over the coming years, there is a possibility of new funding from development partners, African governments and potentially from new large-scale investors in Africa's rural sector.

2.3. REGIONAL UNIVERSITIES FORUM FOR CAPACITY BUILDING IN AGRICULTURE (RUFORUM)

The *Regional Universities Forum for Capacity Building in Agriculture* (RUFORUM) is a consortium of 29 universities in Eastern, Central and Southern Africa. The forum was established in 2004 after serving as a Rockefeller Foundation programme from 1992. RUFORUM has a mandate to oversee graduate training and networks of specialization in the Common Market for Eastern and Southern Africa (COMESA) countries. Specifically, RUFORUM recognizes the important and largely unfulfilled role that universities play in contributing to the well-being of small-scale farmers and economic development of countries throughout the sub-Saharan Africa region. The consortium has several unique features for building Africa's innovation capacity and for engaging universities in development process and practice:

1. It is owned and managed by Africans

2. It derives its agenda largely from the continent wide policy frameworks especially of the African Union's New Partnership for African Development (NEPAD) Comprehensive African Agricultural Development Programme (CAADP), the NEPAD Science and Technology Framework, the African Union Policy Framework on Revitalising Higher Education in Africa, the Sub Regional Multi–Country Agricultural Productivity Programs, the National Poverty Reduction Strategy Papers (PRSPs) of the Member States and Governments, constant review of global trends and foresight planning in order to ensure that Africa has the required capacity for global competitiveness

3. It allows for joint action by the member universities. This is enhanced through joint faculty appointment for the 12 universities, payment of local fees by graduate students and national mechanisms (National Forums) which ensure wide stakeholder participation in the RUFORUM programmes

4. The consortium provides a wide array of training opportunities for stakeholders, and is in the process of establishing credit transfer mechanisms among the member universities.

Hosted by RUFORUM in Kampala in November 2011, the Ministerial Conference on Higher Education in Agriculture in Africa (CHEA), declared in its conference communiqué that "*despite progress, due to the necessary rapid increase in intake of students, the universities have fallen further back in terms of the human and infrastructural capacity required to deliver high quality education and learning experiences in agriculture and their ability to conduct high-impact agricultural research*". The ministers observed that there has been limited funding to support post-graduate training in African universities, which has grossly hampered development of the required capacity to build Africa's own capacity for capacity development.

There has been a crippling disconnect between the absolute necessity to assure the success of CAADP and the critical shortage of human capacity required to achieve that success. Resolving the lack of capacity was seen as a matter of national, regional and even global urgency. In Africa, there are only 70 agricultural researchers per million people in Africa, compared to 2,640 in North America and 4,380 in Japan. Only one quarter of African researchers hold a PhD, compared with nearly two thirds in India. The number of African agricultural researchers working on the ground has declined by half over the last 20 years due to limited or non-existent funding of tertiary agricultural education. To make things worse, more than half of the agricultural researchers working today are due to retire in the next 5 years. Clearly, the Comprehensive Africa Agriculture Development Programme (CAADP) cannot be successfully implemented if Africa does not have the requisite human capacity. To start rectifying the situation, the ministerial members were committed to the following six actions:

1. A renewed and vigorous emphasis by African governments on restoring the quality of higher education in agriculture. This is necessary to properly prepare the increased intakes of diplomas, undergraduates and postgraduates for their responsibilities to achieve CAADP targets. This will require special focus on higher degree training to produce the required capacity for delivering high quality teaching and learning experiences at African universities and colleges.

2. Increased investment in higher education in agriculture in Africa and to be included as an integral agricultural development investment in CAADP Country Compacts and Medium Term Agricultural Productivity Programmes. This should be guided by structured foresighting.

3. Take urgent actions to develop an Africa-wide action and investment plan for implementing the African Union Commission and NEPAD-PCA strategies for strengthening capacity development in agriculture that are designed to support CAADP.

4. Ensure that Ministries responsible for higher education, education institutions and other relevant actors create conducive and friendly environments for women and girls education and career advancement at all levels.
5. Advocate for increased support and engagement of the African higher education networks in policy making and programme implementation for agricultural training and research by the African Union Commission, Regional Economic Communities, NEPAD-Planning Coordinating Agency (NEPAD-PCA) and the Forum for Agricultural Research in Africa (FARA).

6. Support local and international partnerships which address critical capacity needs for sustainable agricultural development. This includes partnerships amongst universities and engagement with communities, private sector and the African Diaspora's.

2.4. AFRICAN NETWORK FOR AGRICULTURE, AGROFORESTRY AND NATURAL RESOURCES EDUCATION (ANAFE)

The African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE) is a network of 134 educational institutions in 36 African countries whose objective is to strengthen the teaching of multi-disciplinary approaches to land management. The ANAFE Secretariat is hosted at the International Centre for Research in Agroforestry (ICRAF) headquarters in Nairobi. This provides a vantage for network management, linkages with the research and development activities of ICRAF and its partners, and convenient communication facilities. The Swedish International Development Cooperation Agency (SIDA) has provided financial support to ANAFE since July 1991. Members contribute to the cost of managing specific activities. ANAFE works closely with agriculture, agroforestry and natural resource management initiatives in Africa.

2.5. FOOD, AGRICULTURE AND NATURAL RESOURCES POLICY ANALYSIS NETWORK (FANRPAN)

The Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) is a regional policy research and advocacy network whose operations are informed by major regional policy frameworks and processes in Southern Africa. These are currently the SADC's Regional Indicative Strategic Development Plan (RISDP), the SADC Heads of State Dar es Salaam Declaration, the Comprehensive Africa Agricultural Development Programme (CAADP) of the New Partnership for Agricultural Development (NEPAD) and the Common Market for Eastern and Southern Africa (COMESA) Agricultural Programmes.

The strength of FANRPAN lies in its national nodes, which consist of:

1. Government ministries responsible for food, agriculture and natural resources
2. Policy research institutions such as relevant university departments
3. Private sector national umbrella organizations which deal with food, agriculture and natural resources
4. National farmers' organizations
5. Civil society organizations

2.6. WORLD BANK

Starting in 2005, the World Bank followed up the general guidelines for attaining production goals presented in the Framework for African Agricultural Productivity (FAAP), by arranging a series of studies on agricultural education and training in Africa within six themes and drawing data from 15 countries. The study concluded that "*agricultural education and training in Africa is a vital, but much-neglected, component of agricultural development*" (World Bank, 2007). The report issued six recommendations for short-term actions:

(1) Create networks and associations that can champion the cause of agriculture, and learn lobbying techniques to generate supportive political will
(2) Modernize curricula and teaching methods at the tertiary level, along with the necessary teaching inputs
(3) Improve institutional linkages (e.g., strategic partnerships, professional networks, collaboration incentives) and knowledge access (e.g., TEEAL, AGORA, computers)
(4) Persuade development partners to fund essential operational and equipment maintenance costs
(5) Conduct labour market studies and establish a labour market monitoring capacity
(6) Work to make the agricultural professions attractive employment and career options, while recruiting many more women into this field

The report also recommended three long-term actions:

(1) Rebalancing agricultural education and training enrolments away from secondary programmes in favour of tertiary-level diploma, degree, and postgraduate programmes
(2) Strengthening and expanding a selected number of MSc programmes in areas of strategic importance to the nation, including associated staff development, so that all major MSc programmes for agriculture are available in sub-Saharan Africa within 10 years
(3) Broadening the foundation for regional PhD programs by launching a major programme of postgraduate fellowships to train 1,000 PhDs, initially abroad and eventually at home, over the next 15 years

World Bank support to tertiary agricultural education in Africa

Hosted by Noragric/UMB, the World Bank arranged a workshop in October 2011 to assess the needs for strengthening tertiary agricultural education (TAE) in Africa. The World Bank invited key stakeholders to discuss priority needs for reforming and strengthening African tertiary agricultural education as well as possible approaches and mechanisms for more harmonized and collaborative support. The workshop was intended to be a first step in launching a prospective partnership for support among development partners, academic experts and African university leaders.

A key question that was addressed at the World Bank workshop on tertiary agricultural education in Africa hosted by Noragric/UMB in October 2011 was how to define the necessary reforms and coordinate the new investment to achieve maximum positive impact.

Follow-up meetings in Zurich, London, and now Oslo involving a working group of African TAE leaders, academic experts, and selected development partner officials have generated a consensus that some formal coordination is necessary and feasible. Out of this commitment to

improved coordination, emerged the TEAM-Africa concept: the *Tertiary Education for Agriculture Mechanism for Africa*. TEAM-Africa is conceived to be a streamlined, high-calibre mechanism led by a senior African leader in TAE and staffed with a small number of respected professionals who can drive and coordinate the TAE agenda in Africa. Its near-term purpose is to i) develop a strategic vision and plan for TAE on the continent to achieve broad stakeholder acceptance; and ii) work through CAADP to ensure that high quality TAE investments consistent with this TAE vision and plan are integrated into country- and regional level CAADP investment plans. Over the longer term, TEAM-Africa will continue to strategically assess Africa's TAE sector, interact at a high level with development partners, African governments, and TAE institutions to coordinate support to the African TAE, and ensure that the continent's vision for TAE evolves appropriately over time adjusting to new developments within the sector.

TEAM-Africa will be jointly managed by two important, already-established networks of TAE institutions in Africa, the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE), with support from Forum for Agricultural Research in Africa (FARA). The advantage of being situated between these two networks is that TEAM-Africa will be able to build on and draw from the work already being carried out by each of these networks in support of African TAE institutions. Draft documents describing the proposed mechanism in more detail have been shared with the AUC's Commissioner of Rural Economy and Agriculture as well as with the CEO of NPCA. Both have since indicated their strong support for the initiative.

TEAM-Africa's establishment and evolution is currently envisaged to be supported in three phases: i) Short-term preparation phase (approx. 6 months); ii) Medium-term establishment of TEAM Africa Secretariat/Implementation (approx. 2 years) and iii) Long-term - funding through a larger TAE multi-donor trust fund (approx. 5 years).

This vision will identify the types of reforms in governance and incentive structures, new approaches to teaching, research, and outreach, and new investments needed to make African agriculture a key contributor to rural transformation, economic growth, and poverty reduction. The new vision and approaches will be larger, and go beyond TEAM Africa. However, TEAM-Africa´s role will be to make a major contribution to defining and promoting this vision as well as to coordination.

A list of priority actions to be undertaken by the partnership has been identified, including the following:

- Put TEAM-Africa into operation as soon as possible, with a director that will provide it with continent-wide credibility and a small but effective staff to facilitate key activities
- As a matter of urgency, support TEAM Africa where required to develop procedures and resources to help TAE champions at the country level to integrate TAE investments into CAADP investment plans
- Improve baseline data on the current status of development partner support to TAE in Africa
- Support TEAM-Africa in its effort to help TAE institutions conduct self-assessments that focus on key elements such as the quality of curricula and teaching methods, approaches to strengthening incentives for improved faculty performance, engagement through research and teaching with important societal problems, and others

- Support TEAM-Africa, as it develops and vets a strategic vision for TAE in which is aligned with CAADP
- Engage in an analytical exercise that projects forward the rapidly changing locus of labour demand in Africa's food and agricultural systems, and broader changes in society, including ICT and the rise of private tertiary education institutions and clarifies their implications for the types of training that TAE institutions need to offer. Such an exercise should feed back into the TEAM-Africa strategic vision
- Develop a "take-home message" for TEAM-Africa (perhaps a one-page glossy) to create awareness and support among donors, African governments, and African TAE institutions

A prioritized list of activities is organized into three broad areas: 1) establishing and promoting TEAM-Africa (the most urgent priority); 2) activities that TEAM-Africa would carry out directly (though in collaboration with partners) over the first 12 months of its existence; and 3) associated activities, primarily related to building knowledge and aligning support to TAE, that members of this partnership and others committed to improved TAE will undertake.

3. IMPORTANCE OF GENDER IN THE CLIMATE-SMART AGENDA

The United Nations Framework Convention for Climate Change (UNFCCC) makes no mention of women as specific stakeholders, and the gender dimension is limited in adaptation and mitigation interventions. Although the UNFCCC has designated a Gender Focal Point and suggested a series of steps to integrate gender into the Convention and Secretariat, the only reference to gender is in the guide on how to prepare National Adaptation Plans of Action (NAPA), with gender equality as one of the principles. Similarly, very few NAPAs recognize women as important agents in adaptation activities. Women are generally portrayed as victims without skills and knowledge to allow them become involved in the adaptation and mitigation mechanisms.

Discrimination against women is against the principles of the UN's Committee on the Elimination of all forms of Discrimination against Women (CEDAW). Gender-blind policies or programmes suppress human development as they exacerbate inequality and exclusion. This particularly applies to poor countries where the severity of marginalization is rampant. Understanding the different roles and responsibilities of the different genders is key to designing impactful interventions that improve livelihoods of target populations. Moreover, boosting smallholder farmer food production is one of the recommendations of the UN Secretary General's *High-Level Task Force on the Global Food Security Crisis*, and gender equality is a necessary condition for human development and a fundamental objective in the fight against poverty.

Despite being central producers of food around the globe, women are unfortunately the least endowed with technological inputs and are the least placed to utilize such inputs, especially in poor countries where adoption of agricultural technology for both men and women, is extremely low. Uganda's 2000 Plan for Modernization of Agriculture (PMA), for example, estimated that fewer than 30 % of subsistence farmers use improved seeds and less than 10 % practice any form of plant protection. On-farm yields are less than one third of the research station yields and most households continue to depend on 'low input - low output' technologies, particularly the hand hoe. Post harvest losses remain high at about 25 % and

most of the agricultural produce is sold in its primary form with little or no value additions. This, as the PMA argues, results from a number of factors, including the fact that technology delivery mechanisms have often been ineffective and at times non-existent.

Technological development is often modelled on western, pre-selected packages and implemented everywhere, irrespective of their appropriateness to the environmental, cultural, economic and social context. Despite their active and continuous interaction with the agricultural environment, women's technological knowledge on seed selection practices, pest and weed control measures, harvesting and food preservation technologies is insufficiently included in policy making and implementation. This omission limits the development of relevant techniques for rural farmers.

Gender disparities in the adoption, adaptation, allocation and utilization of various technologies in the production cycle also exist. Tasks performed by men, such as land preparation, harvesting and processing are the easiest to mechanize. Women's tasks, on the other hand, remain labour intensive and time consuming. Furthermore, those female tasks that are mechanized become male tasks. The successful zero-tillage wheat in the rice-wheat systems of the Indo-Gangetic Plains, was for example, mainly a male dominated endeavour with women as secondary participants. Gender differentiated technology is not a new phenomenon. Indeed, most technologies are developed and tailored according to the stereotyped roles of men and women, as both genders' use of (and association with) technology reflects their major occupations and priorities in life. Cash crop production, which is dominated by men, is characterized by availability and utilization of improved farm equipment such as tractors, and by farm in-puts such as fertilizers and pesticides. It is also associated with the cash economy where substantial financial benefits are obtained from agriculture. Subsistence farming on the other hand, which is usually dominated by women, is characterized by traditional farming techniques, rudimentary farm technology and inadequate farm inputs. Because there tends to be little consultation with women on technological development and dissemination, women are subjected to the unintended side-effects of modern technologies introduced for the benefit of others.

Empirical gender studies in conservation agriculture revealed that planned climate change mitigation and adaptation strategies had differential gendered effects; for instance adopting hand hoe based CA resulted in increased labour requirements for women, limiting their engagement in other productive activities (Nyanga *et al.,* 2011). Similarly, empirical evidence from forestry (Mai *et al.,* 2011), general studies on access to land (Kaarhus, 2010) and more specifically REDD+ initiatives (Campese, 2011) have shown gender differentiated impacts. In the recent overview, Campese (2011) shows that women are generally more vulnerable to adverse impacts of REDD+; since REDD+ and Energy+ initiatives may involve land and other natural resource (water, forests) acquisitions by both foreign and domestic actors, these studies reveal the crucial need for gender sensitive climate mitigation and adaptation investments. In relation to harnessing synergies between CSA, REDD+ and Energy+, a comprehensive understanding of land use patterns is essential because women may lack land rights although they play essential roles in a wide range of agricultural activities (Meinzen-Dick *et al*. 2010). To date there is still a general lack of empirical evidence on the differential effect that CSA, REDD+, and Energy+ have on men and women (e.g. gender study on biofuels, Nhantumbo and Salomão, 2010). Some ongoing initiatives do address gender dimensions of climate change mitigation and adaptation but empirical results are yet to be communicated (CCIAM project in Tanzania). Further related projects at Noragric are examining gendered processes in large scale

transnational land deals in Ghana and Ethiopia (2010-2012) and the EPINAV project 'A gendered analysis of climate change impacts and adaptation in Tanzania' (2011-2014).

The gender differentiated impacts are also related to other community social or cultural values, norms and practices (Mankunike, 2010). These are usually beyond the scope of CSA, REDD+ or Energy+ project goals. Efforts to promote gender equality should also consider the local values and norms, which cannot be changed overnight. Understanding the local context and other motivations related to cultural and social values and norms which mediate human decision making processes would inform future engagement in implementing climate change mitigation and adaptation strategies. Related research work though predominantly so far undertaken in developed countries is the study of human behaviour under different institutional contexts. As implementing and sustaining practices related to CSA, REDD+ and Energy+ will require changing or sometimes enhancing certain practices; understanding human decision making processes will be crucial for sustaining desirable actions.

To meet these challenges, Noragric has, in collaboration with Mekelle and Hawassa Universities in Ethiopia, established the Institute of Environment, Gender and Development Studies. This institute aims to promote capacity building, education and applied research programmes with four proposed project areas: I) Agriculture and Rural Development Problems, and Socioeconomic Consequences; II) Environment/climate change and development; III) Health and health-related problems, gender disparities and development consequences; and IV) Short-term training/role model events.

The Department of Economics and Resource Management has carried out research on gender-related issues in Ethiopia, Malawi, Tanzania, Uganda and Zambia over many years. Particularly the household and farm databases from Ethiopia and Malawi provide a strong basis for analysis of how CSA, REDD+ and Energy+ will affect women. The analyses of gender-specific effects of policy changes such as land tenure reforms, farm input subsidies, new technologies, land management, risk exposure, vulnerability, coping strategies and safety net programmes provide a strong basis for assessing the effects of climate risk, climate changes, increasing resource pressures and the potential of new climate robust agricultural technologies.

4. UMB'S COLLABORATION WITH AFRICAN UNIVERSITIES

Starting in the 1960s, the Norwegian University of Life Sciences (UMB) has had the privilege of supporting agricultural development in Africa through funds from government sources. Livestock development in Madagascar, development of Sokoine University of Agriculture, and rural development in Northern Zambia are three highlights from the early programmes. During the last decade, UMB's agricultural development projects have for the most part been located in Tanzania, Ethiopia, Malawi, Sudan and Mali (Fig. 4). The projects have consisted of university staff development, capacity building, research administration, and field studies. Thematically, the projects have covered studies of livelihoods, land tenure, crop production, plant genetics, conservation agriculture, agronomic microbiology, soil fertility, irrigation, pastoralism, gender, animal husbandry, economic analyses, safety net assessments, carbon sequestration, agroforestry, and various forms of adaptation to climate change.

Fig. 4. Location of UMB's recent, current and planned projects in agricultural development in Africa (each project listed in Table 1 is represented by a red dot).

In recent years, UMB has managed its largest capacity building programmes in support of Bunda College of Agriculture in Malawi and Hawassa University and Mekelle University in Ethiopia. The largest recent, and ongoing research programmes have been, and still are, carried out in support of Sokoine University of Agriculture, Bunda College of Agriculture, Hawassa University and Mekelle University. UMB has established particularly close institutional links with these four universities for capacity building and agricultural research. With Phase 2 of the long-term research project on conservation agriculture in Zambia, to be started early 2012, UMB will also establish close working relations with University of Zambia in Lusaka the Golden Valley Agricultural Research Trust and the Zambia National Farmers Union. Collaboration with University of Juba in South Sudan and University of Bamako in Mali is also well established.

Table 1. Overview of UMB's recent, current and planned projects with African partners in the field of agriculture (more detailed information is presented in Appendix 1).

Country	***Theme***	***Title***	***Institution***	***Norw. Partners***
Ethiopia	University development	Academic partnership for improving the rural livelihood of Ethiopia	Hawassa University Mekelle University	Noragric + depts. at UMB, UiO, UiB and NTNU
	Agronomy	Intensification of cereal crop production in semi-arid highlands of Ethiopia through conservation tillage, micro-fertilising and seed priming	Hawassa University	Noragric/UMB
	Household food security	Household food security in Southern Rift Valley of Ethiopia: A Gendered Analysis	Hawassa University	Noragric/UMB
	Pastoralism, climate	Pastoral pathways: Climate change adaptation lessons	Afar Pastoralist Devel. Assoc.; Ogaden Welfare and Devel. Assoc.	Noragric/UMB, Development Fund
	Gender and land resources	Large land deals in Africa: Gendered processes of tenure insecurity, resource capture and collective action	IFPRP	Noragric/UMB
	Rural safety net	Impacts of productive safety net in Ethiopia	Mekelle Univ., IFPRI	School of Econ. and Business/UMB
	Rural safety net	The Potential of Rainfall Insurance in Ethiopia	CIMMYT	School of Econ. and Busin./UMB
	Economics of irrigation	Impact of Irrigation Investments in Northern Ethiopia	Mekelle Univ., IWMI	School of Econ. and Busin./UMB
	Seeds	Seed Safety Through Diversity, Ethiopia	Mekelle Univ.	IPM/UMB
	Carbon in soils	Carbon sequestration and soil quality-an index of sustainable production in the agroforestry systems of Tigray, Ethiopia	Mekelle Univ., Ohio State Univ.	IPM/UMB
	Soil microbiology	Legumes and rhizobia in southern Ethiopia: Evaluation, management and utilization of biodiversity of the microsymbiont for sustainable agriculture	Hawassa University	IKBM/UMB
	Economics	NOMA MSc Programme in Development and Natural Resource Economics	Mekelle University; Hawassa University	School of Econ. and Busin./UMB
Kenya	Technology transfer	Solar transitions: Transfer of social and technological innovations between India and Kenya	CAMCO (Kenya); Fac. for Interdisc. Studies (IFF), Klagenfurt University	Noragric/UMB; UiO
Madagascar	Agriculture, environment, development	Agriculture, Environment and Development: BSc Field Course	U. of Fianarantsoa	Noragric/UMB
Malawi	Economics	NOMA MSc Programme in Development and Natural Resource	University of Malawi	School of Econ. and Busin./UMB

		Economics		
	Capacity building	Building Capacity for Development and Food Security in Malawi	Bunda College	Noragric/UMB
	Agricultural research	Agricultural Research and Development Fund	Bunda College	Noragric/UMB
	Conservation agriculture	Facilitating the adoption of conservation agriculture by resource-poor smallholder farmers in Malawi	Bunda College	Noragric/UMB
	Food security	Proposal: Climate Change Adaptation for Improved Food Security and Livelihoods in Malawi	Bunda College	Noragric/UMB
	Conservation agriculture	ASWAp-SP (ADP-SP) in Malawi	Bunda College	School of Econ. and Busin./UMB
	Agricultural economics	Impacts of the input subsidy programme in Malawi	Bunda College	School of Econ. and Busin./UMB
	Economics	Impacts of new maize technologies in Malawi and Zambia	Bunda College, CIMMYT, Michigan State Univ.	School of Econ. and Busin./UMB
Mali	Agriculture and climate	Adaptation of agriculture and livestock to climate change in Mali	Institute d'Economie Rurale, Malian NGOs	Noragric/UMB
	Agriculture and climate	Adaptation to climate change in Mali	Institute d'Economie Rurale	Noragric/UMB, Drylands Coord. Grp.
Sudan	Livelihood and environment	Post-war Livelihood and Environmental Studies - NUCOOP project	Juba University	Noragric/UMB
	Agriculture and climate	Adapting agriculture in northern Sudan to climate change	El Obeid Research Institute	Noragric/UMB
	Plant genetic resources	Origins and Survival of Sorghum Genetic Resources in Lafon, Eastern Equatoria, South Sudan	Juba University	Noragric/UMB
	Climate change	Socio-economic consequences of climate change in sub-equatorial Africa		Noragric/UMB, UiO
Tanzania	Climate change	Climate Change Impacts, Adaptation and Mitigation, CCIAM	SUA; UDSM; Ardhi University; Tanzania Meteorolog. Agency	CICERO; NTNU; NILF; UMB
	Livelihood and forest products	Climate change, non-timber forest products and livelihood of forest dependent communities: Impacts, vulnerabil. and adapt. in Tanz.	SUA	Noragric/UMB
	Rural energy	Alternative energy sources and efficient utilization of biomass energy for reduced depletion of carbon sinks and improved livelihoods in rural areas of Tanzania	SUA, International Child Support, Meatu district, Barefoot College India	Noragric/UMB
	Agricultural development	Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-chains, EPINAV	SUA	Noragric/UMB, Veterinary College

	Dairy production	Application of value chain and innovation systems approaches for up-scaling and out-scaling technologies for enhancing integrated dairy production system in Njombe district	SUA	Noragric/UMB, IPM/UMB
	Crop science	Enhancing sunflower production for poverty alleviation in Mvomero and Kilosa districts, Morogoro region	SUA, ARI	Noragric/UMB
	Gender and climate change	A gendered analysis of climate change impacts and adaptation in semi-arid area farming systems and natural resources management	SUA; NGOs in Meatu and Singida district; INADES; ICS; Tumbi Agricultural Research Institute; CBOs; Local Government	Noragric/UMB
	Livelihood and climate change	Integrated livelihood and natural resource management to adapt dryland communities to climate change	SUA, ARI	Noragric/UMB
	Animal husbandry	Increasing market share of locally produced beef through improved cattle husbandry, slaughter operations and meat handling	SUA	IHA/UMB, Noragric/UMB
	Agroforestry	Optimizing production and utilization of lesser known and lesser utilized indigenous agro-forestry timber species	SUA; Tanzania Tree Seed Agency	Noragric/UMB
	Institution building	Institutional evolutions at macro and micro-levels in the management of water catchments and their influences on local community livelihoods under a climate change scenario in Tanzania	SUA; Tanzania Forestry Research Institute (TAFORI); Ardhi University (ARU)	Noragric/UMB
	Greenhouse gases	Can farming in Africa both reduce the GHG emission by using climate/resource friendly and sustainable methods/technologies and improve farmers' livelihood?	UDeS; Ardhi University; Meterol. Agency; SUA	CICERO; UiO; NILF; NUFU; Yara/Syngenta; Green Resources; Noragric/UMB
	Development, environment	Development and Environment in Practice: MSc Field course	SUA	Noragric/UMB
	Development, climate change	Development and Climate Change, Adaptation and Mitigation: BSc Field Course	SUA	Noragric/UMB
	Agroforestry	Enhancing the revival of home-gardens for improved utility and productivity through the use of proven agroforestry technologies in the northern highlands of Tanzania	SUA; ARI; TAFORI	INA/IMB
Uganda	Economics	NOMA MSc Programme in Development and Natural Resource Economics	Makerere University	School of Econ. and Busin./UMB
	Economics	Impacts of new maize technologies	UNZA, CIMMYT,	School of Econ.

Zambia		in Malawi and Zambia	Michigan State Univ.	and Busin./UMB
	Conservation agriculture	Conservation Agriculture in Zambia	NZFA, UNZA, GART	Noragric/UMB
	Conservation agriculture	Reversing household food insecurity through conservation agriculture: Socio-economic impact of conservation farming in Zambia	UNZA	Noragric/UMB
	Conservation agriculture	From maize monocropping to conservation agriculture: a multi-perspective analysis of smallholder conservation agriculture in southern, central and eastern Zambia	UNZA	Noragric/UMB

5. CAPACITY BUILDING AND RESEARCH IN TANZANIA, MALAWI AND ETHIOPIA

TANZANIA

Tanzania has made some effort towards dealing with the threat and anticipated effects of climate change. The government has developed NAPA with assistance from UNEP, The new National Strategy for Growth and Reduction of Poverty (NSGRP II) or its Swahili acronym MKUKUTA has also included climate change as an area of focus and cross cutting issue. To this effect the government is implementing together with some NGOs and its high institutions of higher learning and TMA the REDD+ project, which is fully supported by the Norwegian government.

For Tanzania, involved institutions include the Economic and Social Research Foundation (ESRF), Environmental Protection and Management Services (EPMS), Institute for Resource Assessment-University of Dar es Salaam, Sokoine University of Agriculture. The two projects CCIAM and EPINAV in which UMB is actively involved provide great opportunities as a springboard for launching the smart agriculture concept and later on proceeding to consolidating work done by both projects into one fully fledged coherent programme of its own. This is in keeping in mind the fact that the chance to mainstream the concept into the existing projects has been missed since these projects have already had their first batch of research projects and capacity building activities. However, the concept could still be incorporated into other research activities being undertaken by postgraduate students (MA and PhD) both at UMB and SUA**.** Furthermore, EPINAV has very relevant synergies with the SAGCOT initiative in terms of facilitation with participatory action research whereby the farming communities in the corridor could benefit from practically being involved in the activities of the two initiatives**.** Small-scale farmers in Tanzania, as in many other parts of Africa, lack access to modern inputs, are at risk from climate change and remain locked out of international markets. SAGCOT's intention is to link farmers to modern supply chains and make agriculture a profitable activity, in a country where over 75% of the population is engaged in the sector. EPINAV on the other hand emphasizes scaling up of proven technologies under PANTIL by using an innovation systems approach and value chain approaches in improving communication and dissemination of information and building the capacity of smallholder farmers and other role players (traders, processors, and retailers) to articulate and satisfy their demand for knowledge, technology and other resources. Here value chains are a common denominators for both SAGCOT and EPINAV something that provides an opportunity for collaboration.

MALAWI

The World Bank has identified Malawi as the developing country most at risk from drought arising from global warming (World Bank 2011). Having experienced a number of adverse climatic hazards over the last decades including dry spells, seasonal droughts, intense rainfall and floods, Malawi is taking climate change seriously. Around 85% of the population live in rural areas and the country relies heavily on agriculture for both subsistence and export. Nearly 80% of export earnings come from agriculture, from crops such as tobacco, tea, coffee and sugar. Maize is the staple food of Malawi (Matiya *et al*., 2011) and that is why to address the food security issue, the Malawi government instituted a subsidy programme for maize so as to raise maize productivity.

Like Tanzania, Malawi has developed a NAPA with the GEF assistance which puts emphasis on the Agriculture sector, human health, energy, fisheries, wildlife, water, forestry sectors. Project three of the NAPA focuses on improving agricultural production under erratic and changing climatic conditions. The proposed interventions include: i) improved early warning systems; ii) recommended improved crop varieties; iii) recommended improved livestock breeds; and iv) improved crop and livestock management practices. Project 4 focuses on improving Malawi's preparedness to cope with droughts and floods.

The Farm Input Subsidy Program (FISP) has been the cornerstone in the agricultural policy in Malawi since it was introduced in 2005 to improve household and national food security. It was successful in its objectives and has until recently been praised as a success story and has even been suggested as a model for other African countries and has contributed to substantial rethinking around the use of input subsidies to enhance the welfare of poor smallholders. One of the weaknesses of the programme however, is that the main crop it promotes, maize, is vulnerable to droughts, and the country has not experienced a severe drought after it was introduced. A new programme, first called Agricultural Development Program – Support Project (ADP-SP), and later renamed to Agricultural Sector Wide Approach – Support Project (ASWAp-SP) was introduced since 2009 to enhance the efficiency of FISP by introducing climate smart agricultural technologies such as reduced tillage, agroforestry trees, legumes, and improved maize varieties. The technologies have been disseminated at broad scale through the research and extension system by the Ministry of Agriculture and Food Security with support from the World Bank and the Norwegian Government. Reviews of these on-farm experiments and outreach activities in 2010 and 2011 show very promising adoption rates for several of the new technologies. These new technologies have done particularly well in areas exposed to dry spells during the rainy season due to their moisture conservation impacts. They can also enhance the fertilizer use efficiency and reduce the financial burden of importing fertilizers, one of the most severe problems the country now faces.

While the Ministry of Agriculture and Food Security is in charge of this programme it is evident that its capacity to monitor, evaluate, guide the CSA promotion process through research and impact assessments is very limited. This leads to inadequate learning from the existing programme and limited ability to fine-tune and enhance the efficiency of the programme. Currently some researchers from Chitedze Research Station are involved in the technology assessment but their capacity is also very limited.

For Malawi, most of the projects have been carried out by the Coordination Unit for the Rehabilitation of the Environment (CURE), Civil Society Agriculture Network (CISANET), Malawi Polytechnique and Bunda College (University of Malawi). For Tanzania involved institutions include; the Economic and Social Research Foundation (ESRF), Environmental Protection and Management Services (EPMS), Institute for Resource Assessment-University of Dar es Salaam, Sokoine University of Agriculture.

Two sustainable livelihood projects in Malawi (undertaken by FAO and SCC) and three programmes (Agriculture Research and Development Programme **(**ARDEP**)**, Centre for Agriculture Research and Development (CARD) and National Association of Smallholder Farmers of Malawi (NASFAM)) have been sponsored by the Norwegian government.
These projects and programmes were reviewed in 2007, to ascertain their relevance to adaptation to climate change in Malawi. The review concluded that, since adaptation to climate change was not a project design feature, the relevance of the activities to adaptation to climate change was merely incidental (Bie *et al*., 2008). The review report further recommended that

Malawi's expertise in climate change issues must be significantly strengthened at national level, so as to avoid becoming over dependent on outside expertise. It suggested that the vehicles for this could be through ASWAp-SP, ARDEP and NASFAM, in collaboration with relevant government ministries and international research institutions such as CIMMYT and IFPRI. On specific Norwegian – Malawian bilateral cooperation issues, the Review Team suggested UMB (agriculture and adaptation to climate change), CICERO (climate modelling), and Meteorological Office (weather station experience) and University of Bergen (meteorological sciences) to be institutions that may assist in capacity building in specified Malawian institutions.

UMB is collaborating with Bunda College (soon to be Lilongwe University[3]) in implementing research projects including the Agriculture Research and Development Programme **(**ARDEP**),** where a recent evaluation of the ARDEP programme recommended a further climate change focus for the programme in its coming phase. UMB could strengthen this collaboration by adjusting the programme to take in the climate-smart agriculture concept which consolidates both the food security livelihood focus with climate change aspects. Furthermore, action research or participatory action research could be further emphasized in order to facilitate a process of interactive learning whereby information/ knowledge from different sources and levels is shared and used in effective ways by stakeholders in agricultural to better adapt to climate change. To ensure both scientific quality and better integration of existing programmes, it is essential that research programmes linked to Bunda College of agriculture are also linked to international research programmes such as CIMMYT and existing programmes such as ASWAP-sp promoting climate-smart agriculture.

ETHIOPIA

Whilst most research cooperation between UMB and partners in the South has contained elements of institution building, the long-term collaboration with Mekelle University and Hawassa University in Ethiopia has specifically targeted research and educational capacity for rural development. The collaboration has resulted in a very successful long-term links between the Ethiopian Universities and UMB, and the effects of the support have indeed been immense.

Dating back to 1985 when Ethiopia was severely struck by drought, UMB enhanced the two universities' research, planning and consultancy capacity. Later, this grew to be part of the Norwegian Programme for Development, Research and Education (NUFU) for academic co-operation with emphasis on research-based capacity building and training. Hence, under the NUFU programme many PhD candidates were educated as part of Hawassa's staff development programme.

The Department of Economics and Resource Management has established good longitudinal household-farm baselines of data from the four most populated regions in the highlands. These baselines date back to 1994 and have great potential to be built upon in the climate-smart agenda. A large number of Ethiopian MSc and PhD students have their degrees from the department and have returned to Ethiopia and work in universities there or in international research institutions and other organisations. A large number of new universities have been established in Ethiopia over the last 10 years and there is an extreme shortage of academic competent staff to fill the positions. Yet the country has very few PhD programmes and only very few strong MSc programmes, clearly illustrating the continued need for international

[3] The bill to establish Lilongwe University, in which Bunda College will be the main campus, was passed in June 2011.

support and training of competent staff outside the country. It is therefore inappropriate to think that this problem only can be resolved by educating academic staff within the country. Young universities and departments staffed with only MSc and BSc holders are unable to provide good MSc and PhD programmes.

When the few PhD holders are sucked into heavy university administrative responsibilities they also find very limited time to practice what they learnt during their PhD education. We now see a severe brain-drain from Ethiopian universities because of this and low salaries. A follow-up programme aiming to build university programmes should consider the incentives for completed PhD holders to remain in the universities and draw on their professional expertise there.

UMB has the capacity to take on responsibilities for competence building to meet the needs of Ethiopian universities and focus such training towards the current and future climate and agricultural policy challenges the country is facing. The termination by SIU of the collaborative MSc programme in Development and Natural Resource Economics was an unwise decision and was not based on an assessment of the needs in the universities from the South that were involved in the programme (Mekelle University, Hawassa University, Makerere University, University of Malawi). UMB can contribute research on CSA by building on its strong university linkages in Ethiopia and the linkages to CGIAR organisations such as CIMMYT, IWMI, IFPRI and ILRI that have researchers based in Ethiopia

The SSE programme was phased out in 1996, but the work of the NGOs has continued under the Drylands Coordination Group (DCG). In 1994, NORAD supported Hawassa and Mekelle University through a short-range project for the purchase of academic resources. After this project, regular academic co-operation between UMB was put in place. Then, Formal Norwegian bilateral development co-operation with Ethiopia followed soon and the first Memorandum of Understanding between the two countries was signed in 1995 and resulted in increased involvement of UMB in Ethiopian universities. The cooperation agreement signed earlier with the Ethiopian institutions was further structured and became part of the Grant Agreement that was done between Norway and Ethiopia in June 1996. Capacity building and training was emphasised in the Grant Agreement for institutional contracts between UMB and Hawassa and Mekelle Universities.

Ethiopians constitute the largest proportion of all MNRSA master graduates trained at UMB. By 2009, 63 Ethiopians had been admitted for PhD studies at UMB. Of these 37 have finished and about 20 are in progress. Most of these graduates have taken up high positions in government and non-governmental organisations in Ethiopia.

The NORAD II project was designed and made ready for implementation in November 2002. The project focused on improving research and teaching capacity, supporting graduate studies, enhancing staff development and extension, training in agriculture and health sciences, supporting female students, strengthening library and information centre, and improving administrative and management for better rural livelihood. Accordingly, efforts have been made to implement the activities with far-reaching consequences on the capacities of the universities.

In 2009, a third phase of the collaboration was initiated under the title “Improving the Livelihoods of Communities in the Northern Highlands and Rift Valley Region of Ethiopia

through Development Oriented Research and Education". The project will strengthen the Ethiopian capacity for applied research and teaching relevant to climate-smart agriculture.

6. SYNERGIES WITH REDD+, ENERGY+ AND OTHER NORWEGIAN SUPPORTED CLIMATE INITIATIVES

Reducing emissions from deforestation and forest degradation (REDD+) has attracted considerable global interest, although deforestation and forest degradation continues in many African countries. The limited effectiveness of the current interventions may indicate the knowledge gap and limited understanding of the drivers of deforestation and forest degradation, which accounts for about 20 % of the GHG emissions. Agriculture is one of the major causes of deforestation, particularly in Africa.

Most of the production increases in the agricultural sector in sub-Saharan Africa have derived from area expansion – with only 34% achieved from yield increases (Smith *et al.,* 2010). This results in increasing greenhouse gas emissions. At the same time, agricultural practices can significantly reduce atmospheric greenhouse gas emissions by storing carbon in the soil or above ground biomass (for example in agroforestry or woodlots, or by reducing nitrous oxide or methane emissions). However, despite the greenhouse gas mitigation potential of agricultural production systems, the exclusion of many agricultural mitigation activities from existing compliance driven carbon markets such as the Clean Development Mechanism (CDM) greatly limits opportunities for harnessing synergies between climate change mitigation, adaptation and potential improvements in agricultural productivity, food and livelihood security. Climate-smart agriculture (CSA) requires working across the forestry and agriculture divide and aims at achieving the triple win goals for food security, adaptation and mitigation. CSA is expected to strengthen the impacts of REDD+ (Negra and Wollenberg, 2011).

Adaptation to global change also requires substantial energy saving and development of renewable energy sources. Numerous pilot projects undertaken over the years show that access to energy generated from locally or regionally available sources is a viable and sustainable option, but for this strategy to become reality, well-designed national policies and targeted international technical and financial support for the implementation process are essential (Müller *et al*., 2008). Norway's Energy+ initiative builds on the experiences of its REDD+ funding scheme. The Energy+ initiative aims at increasing access to clean energy and reducing greenhouse gas in developing countries (Reed and Gutman, 2011). The unifying objective of reducing greenhouse gas emissions in REDD+, CSA and Energy+ offers opportunities for harnessing synergies between the three initiatives.

6.1. POSSIBLE ROLE OF UNIVERSITIES IN CLIMATE CHANGE ENGAGEMENT THROUGH SYNERGIES IN CSA, REDD+ AND ENERGY+

The cross-cutting key issues in CSA, REDD+ and Energy+ to which universities can make a substantial contribution, include: i) building the human and institutional capacity required to respond to the challenges presented by a changing climate; ii) establishing and strengthening partnerships for designing, implementing, monitoring, reporting and evaluating outcomes in climate mitigation and adaptation efforts; and iii) providing information (e.g. publishing results in papers and policy briefs) from well-grounded research to guide policy and decision making.

Human and institutional capacity building

There is growing interest in developing and implementing REDD+ projects in Africa. These projects face numerous challenges related to the human and institutional capacity required to secure the triple-win goals of mitigating climate change, securing livelihood benefits (related to food and energy demands) and protecting biodiversity resources. Although the literature evaluating the outcomes from REDD+ initiatives is still limited, pilot carbon projects have marginalized poorer farmers and minority groups including women from decision-making processes and more generally communities have been denied access to resources which constitute an important part of their food and energy security (German *et al.*, 2011; Nakakaawa, 2011). Based on these experiences, some actors especially from civil society and forest dependent minority communities are wary of the development of REDD+ related measures and have, as in Tanzania, already started strongly opposing REDD+ activities (Bryceson, *pers. comm.* 2011).

UMB, in collaboration with various universities in Africa (e.g. Sokoine University of Agriculture and Makerere University) are undertaking REDD+ related research in the Congo Basin, Tanzania and Uganda, working together to collect baseline data and to synthesize vital lessons from the design, implementation and management of pilot REDD+ projects in these countries. Through in-depth case studies of pilot REDD+ projects under different institutional arrangements, the researchers aim at getting a deeper understanding of the actual processes involved in the design and implementation of REDD+ projects and evaluating the outcomes in relation to the intended goals of climate change mitigation and adaptation. The researchers are collecting information on national policies, specific projects and other efforts in these regions that relate to smallholder farmer adaptation to climate change and agriculture related mitigation efforts. They will further analyse these policies and projects through various lenses, and will highlight potential trade-offs and synergies of climate change policies and projects with food security, poverty alleviation and gender equality goals.

By involving research partners (university staff and students) from institutions in the respective host countries, and working with active carbon project developers and managers in design, data collection and analysis, the projects also aim to build their capacity for institutional analysis and design of climate change mitigation and adaptation projects. Having collected baseline data from the various REDD+ project sites, the projects will enable rigorous tracking of changes and impacts over time. Results from these studies will be disseminated through workshops, scientific publications and policy briefs to inform policy makers. The scope of these studies and potential avenues for training could widen to investigate the interplay between REDD+, climate-smart agriculture (CSA) and Energy+ initiatives. These initiatives can then be replicated in other parts of Africa to enhance the role of universities in informing and creating an informed society that is able to cope with and adapt to the changing climate to meet challenges related to food and energy security.

Monitoring, reporting and verification

Successful and meaningful engagement in CSA, REDD+ and Energy+ initiatives will require monitoring, reporting and verification of both intended and unintended outcomes. For REDD+, although remote sensing technology and ground based protocols are currently available, using them requires a processing architecture with sufficient human and material resources, expertise, access and time. Natural resource managers and governments in most of the African countries are greatly constrained. For CSA and REDD+ and Energy+, long term technology

adoption studies could inform climate change mitigation and adaptation processes. Thus, as independent research institutions, with lifetimes exceeding mitigation and adaptation project intervention lifetimes, universities may contribute to independent monitoring, reporting and verification of outcomes in REDD+, Energy+ or CSA projects through their various research (social and biophysical) and training activities. The information generated through independent research will enable policy makers and the various stakeholders to make better informed decisions related to food production, energy use and land use in a changing climate.

Establishing partnerships between public, private and civil society actors

Implementing CSA, REDD+ or Energy+ initiatives will require establishing partnerships between various actors in different sectors and at different operational levels. Through the existing institutional collaboration programmes, Universities have already established several partnerships including private-public partnerships, private and civil society partnerships and private-public and civil society partnerships. These partnerships will be crucial for implementing successful CSA, REDD+ and Energy+ initiatives. The role of the universities will be in strengthening the already existing partnerships and establishing other partnerships that may be required for harnessing synergies between CSA, REDD+ and Energy+ initiatives. The next section draws on Noragric's experience to highlight some opportunities for harnessing synergies.

6.2. OPPORTUNITIES FOR SYNERGIES BETWEEN CSA, REDD+ AND ENERGY+

There are important direct and indirect linkages between energy security, food security and climate change. For instance, the price of food is increasingly driven by global energy prices, notably through biofuels but also through increase in price of other inputs. Biofuel production (especially bioethanol and biodiesel) is taking up more land and has become an important driver of deforestation and higher food prices (Abbott and Borot de Battisti, 2011).

For developing countries, the goals of climate change adaptation and mitigation come in addition to the existing goals of agricultural development, food security, biodiversity protection, and soil and water conservation. Implementing CSA to adapt and mitigate the effects of climate change may involve a combination of innovation (research, development, education), information (extension, markets, weather), more inputs (irrigation, seeds, fertilizer), developing infrastructure (roads, ports, markets), and institutions (farmers organizations, finance, insurance). Considering UMB's project portfolio, there are opportunities for harnessing synergies between CSA, REDD+ and Energy+.

Integrated farming systems in the Sahel

Noragric has undertaken research on the development of integrated farming systems in the drylands of Africa. This research has been organized through the Drylands Coordination Group, a consortium on Norwegian NGOs working in the drylands of Africa. The main objective of the collaboration has been to develop integrated farming systems that can simultaneously increase farmers' income, improve human nutrition and preserve the environment. The approach has been to introduce a new fertilizer application method (microdosing), seed priming, new crops, reduced tillage methods, improved feeding practices and cultivation of nutritious foods such as fruits and leaf vegetables. Yields increased by 50-100 % using seed priming and microdosing and the plant establishment was better implying

that the production is more resistant to climate change (Aune and Ousman, 2011). As yield increases, there will also be more carbon input to the soil through the root system. This shows that it is possible to develop CSA also in marginal areas such as the Sahel.

An additional advantage of micro fertilization is that straw production is increased in the same order as grain production. Straw is a highly valuable fodder resource in all dryland areas and micro fertilization will therefore increase the integration of crop and livestock production. Millet/cowpea intercropping is also integrated in the system, further strengthening the linkages between crop and livestock production. The project also introduced improved fodder rations for fattening sheep by using millet bran and cowpea haulms. As a result of higher grain yield, some farmers have reduced their cultivated areas because the same level of production can be achieved on a smaller area of land. This will contribute to carbon sequestration and reduce pressure on the rangeland. This method has become a part of the official agricultural recommendations in Sudan. The International Fund for Agricultural Development (IFAD) and projects of the Buffet Foundation are using the results in addition to NGOs such as CARE and ADRA. Farmers have started to use the technologies without any support from projects and in some areas in Mali more than 50 % of the farmers are using the methods.

Conservation agriculture

In Zambia, Noragric has been part of a project on conservation agriculture financed by the Norwegian Ministry of Foreign Affairs. The project has since been renewed for a further 4 years (2012-2015). The goals of the project are to increase food security and profitability of agriculture, whilst encouraging environmental regeneration and afforestation through increased adoption of conservation agriculture among targeted small-scale farmers. This project has been led by the Conservation Farming Unit in collaboration with the Golden Valley Agricultural Research Trust (GART). The Department of Economics and Resource Management has long experience with modelling agricultural technology changes in Zambia and how it is affected by market access, risk, and policy changes such as fertilizer subsidies. Zambia is one of the countries with most rapid deforestation in Africa and where extensive agriculture (shifting cultivation) is the main driver of deforestation. Policies that can provide incentives for intensification with CSA have the potential to substantially reduce deforestation rates. The future phase of this project should involve collaboration with the University of Zambia, with capacity-building forming a significant element. Michigan State University in USA is an important partner for this research in Zambia.

The concept of conservation agriculture has included reduced tillage, crop rotation, mulching and integration of trees in the farming systems. CFU has developed two systems for conservation agriculture; one based on hoe cultivation and another based on ripping using animal traction. Yields have more than doubled, particularly for hoe based cultivation, which consists of making planting-basins to which manure and mineral fertiliser can be added. Experiences show that this system will ensure a good yield even in the dry years. Of relevance to REDD and Energy+ initiatives, the *Faidherbia albida* tree has been integrated in the system. This tree will contribute to fuel wood, carbon sequestration and provide fodder for animals (Nair *et al*., 2010; Milder *et al*., 2011). Opportunities for carbon financing have been explored, but due to low carbon price and complicated rules and regulations the idea has not be put into practice.

These examples illustrate opportunities to develop CSA systems which achieve higher food production, adaptation and mitigation of climate change. For African farmers the emphasis

will, however, be on the first two objectives of CSA. Climate-smart agriculture is also relevant for Energy + as a higher biomass production will also mean that more energy will be available. One way to capture this energy is through biogas systems.

Energy+: Biofuels, improved stoves and solar energy

As part of the Energy+ initiatives, biofuel investments could contribute to improving Africa's trade and energy balance and provide African countries with much needed investment capital, while simultaneously contributing to global energy security and rural development.

The critical issue here is that policies promoting Energy+ investments such as the production of biofuels should not undermine long-term food security and the achievement of the Millennium Development Goals (MDGs). The key challenge is that food production and biofuels depend on the same resources (land, water, and energy). As a result, diverse conflicts exist in the use of land, water, energy and other environmental resources for food and biofuel production (Pimentel *et al.,* 2009).

Biofuel investments also present a number of other risks as many African countries do not have comprehensive legal and institutional frameworks in place to regulate this type of land-based investment (Schoneveld *et al.,* 2010). For example (and similar to concerns raised in relation to REDD+ funding contributing to a recentralization of forest governance and restriction of forest resource access [Phelps *et al.,* 2010]), there is emerging concern over the large-scale transfer of valuable land resources from customary land users to large scale commercial enterprises. This would lead to loss of vital livelihood resources for the local poor (Vedeld *et al.,* 2007). Furthermore, the unequal power relations and the differential access to information and resources that characterize the different actors involved in biofuel investments also result in inequitable benefit distribution and elite capture. So far, research has mainly focused on getting the technologies right. Experience from Noragric staff (working on modern energy generation with locally produced biofuel, as well as stove testing, and energy security at the very local level in Tanzania) will be valuable. However, there is still limited empirical research that quantifies the actual impacts on rural livelihoods and development pathways (Nhantumbo and Salomão, 2010). As previously indicated, the study on gendered processes in large scale transnational land deals in Ghana and Ethiopia will also be useful. Similarly, the research on water resources will be invaluable as Energy+ initiatives will also involve use of water resources and there is ample empirical evidence which shows a relationship between biofuel consumption and pressure on water resources (see Gerbens-Leenes *et al.,* 2009 for an overview).

There are particular synergies with Energy+ and climate-smart agriculture in terms of finding ways that local-level power supplies can be enhanced in a manner that promotes renewable (rather than fossil fuel) energy pathways as well as increasing agricultural production and climate change adaptation among the most vulnerable. Noragric is involved in the installation, repair and maintenance of solar systems in Kenya and Tanzania, investigating how access to modern energy through a solar energy centre in a rural village can contribute to adaptation to climate change.

7. POTENTIAL FOR COLLABORATION WITH THE PRIVATE SECTOR IN MOZAMBIQUE AND TANZANIA

The private sector will play a crucial role in securing long term sustainability and scaling up any pilot projects when donor funding is withdrawn. This is particularly important for most African countries with limited government funding. This section presents two cases from Mozambique and Tanzania to illustrate potential avenues for private sector engagement.

7.1. MOZAMBIQUE

The Beira Agricultural Growth Corridor[4] (BAGC) is broadly described and analysed in *Case Study Mozambique* in Noragric Report No. 53 (Kaarhus *et al.*, 2010), commissioned by NORAD under the NORAD-UMB Frame Agreement. The overall objective of BAGC is to exploit and develop the potential for commercial agriculture in the region defined as the 'Beira Corridor', which covers the geographical area of the Mozambican provinces of Sofala, Manica, Tete, and parts of Zambezia.

Since 2010, BAGC has been formally organised into two parts: the BAGC Partnership, which is at present being formally registered as an 'Association' under Mozambican law. YARA is one of the founding members of this BAGC Partnership; other members are Mozambican government institutions (such as CEPAGRI, IIAM – Mozambique National Institute of Agronomic Research), and local private sector companies. The Alliance for Green Revolution in Africa (AGRA), as well as the Norwegian Embassy in Maputo provided initial funding for the BAGC initiative. The BAGC Partnership has now established a secretariat in Maputo.

In addition, a private BAGC Investment Company is being formed to be registered in Mozambique. A major task of this Investment Company is to manage a Catalytic Fund, which has also been set up with funding from the Norwegian Embassy, in addition to DFID. AGRA has committed further funding – aiming to target projects that link small-scale farmers to commercial initiatives. So far, the projects approved under the BAGC have mostly been located in Manica, and ongoing processes have Chimoio as their "local urban centre". While the Investment Company is being formally established and registered by Mozambican authorities, the Fund is being managed by the company AgDevCo (based in the UK), which also developed the original concept paper for the BAGC initiative.

Potentials

In the future it could be possible to provide funding for the BAGC Catalytic Fund with clear and specific conditions attached to target CSA initiatives. This could either be in the form of funding that is specifically targeting CMA projects in the Beira corridor, or to provide an incentive for CSA components within projects basically aiming to develop commercial agriculture. Specific conditions for the fund have to be negotiated, harmonized and agreed with the structures already in place to implement the BAGC initiative.

YARA is at present considering scaling up its involvement with BAGC, after focusing on SAGCOT in Tanzania since the second half of 2010, when YARA's investment plans in Beira Port were put on ice, cf. Noragric Report No. 53, p. 27-28.

[4] CEPAGRI – Centre for Promotion of Agriculture http://www.beiracorridor.com/

7.2. TANZANIA

The Southern Agriculture Growth Corridor of Tanzania (SAGCOT) is what BAGC is for Mozambique. The two countries were identified by the African Union through its New Partnership for Africa's Development (NEPAD) as potential breadbaskets, having the conditions for strong economic development, namely corridors linked to the ports of Beira (Mozambique) and Dar es Salaam (Tanzania). Yara International ASA, a global fertilizer company, has been a partner in the Tanzania Agriculture Partnership since 2006 and has been instrumental to the process leading to the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). Yara has so far initiated an investment blue print which provides USD 20 million for construction of Dar es Salaam harbour fertilizer terminal. SAGCOT is driven by a unique partnership of public, private and donor companies and organizations. YARA has been important for policies that support its work across all key aspects of the African agricultural value chain from seeds, soil health and water to markets and agricultural education. Here again is a striking similarity with the SAGCOT and EPINAV programmes in terms of developing agriculture through value chains. While AGRA works at the regional level and SAGCOT at the zone level, EPINAV works locally at community levels. The value chain approach is crucial to overcome one of the main constraints in African agriculture – poor infrastructure – including storage, transportation and marketing. Some of EPINAV's project sites are located in the corridor area, namely Njombe, Mvomero and Mgeta.

AGRA's objectives on the other hand include, among other things, the scaling up of efforts to transform major staple food value chains in high-potential, change-ready countries through demonstrating successful systemic transformation in a few highly visible breadbaskets, which will help spark a broader green revolution across Africa. AGRA's breadbasket strategy involves three key types of investments including: expanding and intensifying production of major food crops through improved technologies and farm management methods; linking smallholder farmers with the private sector; and improving the various supply chains that affect food production, marketing and consumption. The overall goal of the Breadbasket Strategy is to contribute to increased smallholder food security, incomes and agricultural contribution to the gross domestic product (GDP) in Ghana, Mali, Mozambique and Tanzania by increasing agricultural productivity and production of the following staple crops: maize, rice, and sorghum for cereals and pulses such as soybeans, beans and cowpeas, on a sustainable basis. AGRA's role in the implementation of the Breadbasket Strategy is to drive innovation, fund demonstrations and engage collaboratively with partners to scale up successes across breadbasket areas and countries. AGRA's objectives are very much in line with the Africa Union's CAADP and Tanzania's agricultural sector development strategy. Tanzania's government has launched a green revolution campaign in the name of 'Kilimo Kwanza' ('Agriculture First') where more effort is intended to be put into agriculture for food security. Together with the launch of SAGCOT, the Kilimo Kwanza initiative is set towards boosting agricultural production and promoting food security for the country's people. The investment blueprint in the agriculture sector, launched during the World Economic Forum in Davos, Switzerland in January 2011, is a public-private partnership which aims to boost agricultural productivity in Tanzania and the wider region. USAID has already committed USD 2M to its Catalytic Fund. The goal of SAGCOT is to promote "clusters" of profitable agricultural farming and services businesses, with major benefits for smallholder farmers and local communities.

Potentials

Although the region where the corridors are being established has ample arable land for food production, it has a huge shortage of experts in the agriculture sector. This therefore represents a good opportunity for universities and research institutions in the country such as SUA and UDSM to engage with policy makers and farming communities at making this noble endeavour not only a success but sustainable too, by researching in agricultural systems (the value chain) and their link to climate change in order to design the implementation of these programmes appropriately. Such interrelationships and partnerships among public and private institutions provide a healthy recipe for a successful collaboration in bringing about the shared goal of making the green revolution a reality. These already existing dynamics offer a great opportunity for universities in Tanzania in general, and UMB in particular to collaborate with the government with its private sector partners and farming communities to facilitate successful implementation of projects and programmes such as SAGCOT.

Noragric cooperation with the private sector under CCIAM

Noragric is working in a public private partnership under the CCIAM project:

'Farming in Africa and greenhouse gasses (GHG): Can farming in Africa (subsistence and business) both reduce the GHG emission by using climate/resource friendly and sustainable methods/technologies and improve farmer's livelihood?'

Private partners are Yara, Syngenta, Green Resources and Mulbadaw Farm Ltd., with the first two operating together. The partners' joint vision is to demonstrate and document the effects of intensification/changed farming-practices, i.e. the use of adapted fertilizer and optimum use of herbicides on important parameters such as yield, farmers' income and vulnerability of farming-systems. The outcome will be tested on-farm and later used for modelling purposes. In order to streamline the collaboration, a MoU is under preparation between Yara and SUA. Yara/Syngenta has contributed the following to the project:

- Planning phase
- Inputs to farmers (fertilizer, herbicides, pesticides and fungicides)
- Manpower from their own staff
- Analysis of soil-samples

The project is still in the initial stages. A workshop will be held at SUA to plan for next year activities.

8. POSSIBLE COLLABORATION WITH THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURE RESEARCH (CGIAR)

The CGIAR research programme on *Climate Change, Agriculture and Food Security* (CCAFS) is a 10-year research initiative launched by the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership (ESSP). CCAFS seeks to overcome the threats to agriculture and food security in a changing climate, exploring new ways of helping vulnerable rural communities adjust to global changes in climate. Bruce Campbell at the University of Copenhagen where the secretariat is based, is responsible for CCAFS. The International Center for Tropical Agriculture (CIAT) is the convening centre. Almost all the centres are participating in this programme (except CIFOR). In particular, World Agroforestry (ICRAF) is doing research work on conservation agriculture in Africa.

CCAFS have very well connected regional programme leaders in East Africa (base Nairobi) and West Africa (base Mali), with work and baseline sites in Tanzania, Ethiopia and Mali. They are initiating action research on the ground with partners at the baseline sites, as well as being connected into specific national and regional policy processes. CIAT (and other centres) have ongoing work in CCAFS at the sites. According to the CGIAR CCAFS website (ccafs.cgiar.org): "*CCAFS will define and implement a uniquely innovative and transformative research program that addresses agriculture in the context of climate variability, climate change and uncertainty about future climate conditions. CCAFS is designed to contribute to improved agricultural, natural resource management and food systems. It takes its mandate from the from the CGIAR vision, namely "To reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership, and leadership*".

Impacts are sought in three dimensions:

i) Environmental, in particular related to reducing emissions and improving carbon storage
ii) Enhancing rural livelihoods, by reducing vulnerabilities, increasing adaptive capacity, securing assets and raising incomes
iii) Improving food security

While much of the focus will be on agricultural production, the entire food system will be targeted, as solutions to the challenges posed by climate change have to go beyond agricultural production. These three dimensions correspond to different groups of ultimate beneficiaries. For impact on livelihoods, the ultimate beneficiaries are resource-poor farmers and other members of the rural and peri-urban poor associated with the agricultural sector. These groups will benefit through reduced vulnerability, raised adaptive capacity and higher incomes. For impact on food security, CCAFS seeks to help not only the rural poor but also the urban poor that number among the world's one billion undernourished. For impact on environmental health and carbon storage, there will be both local beneficiaries and global benefits.

Working with national and regional partners, promising adaptation options will be identified and evaluated, and through modelling approaches their efficacy in adapting agricultural systems will be quantified and used to provide detailed adaptation pathways at the national, regional and global levels. CCAFS will generate the knowledge base and toolsets needed to empower farmers, policy makers, researchers and civil society to manage agricultural and food systems successfully so as to strengthen food security, enhance rural livelihoods and improve

environmental health in the context of the challenges arising from current climate variability and progressive climate change. CCAFS will explore and jointly apply approaches and methods that enhance knowledge to action linkages with a wide range of partners at local, regional and global levels. Noragric has made contact with the CCAFS leadership to discuss potential collaboration, and at least two windows for further future collaboration have been identified.

The first task will be to explore in detail the CCAFS programme in the actual countries where UMB has university collaboration, and to share UMBs project portfolio within climate-smart agriculture with CCAFS. It will also be necessary to explore to what degree our partners in East and West Africa have established partnerships with CCAFS and work with similar/complementary challenges. Opportunities for future collaboration have to be explored further based on this initial study of opportunities.

Departments at UMB have, for long period of time, collaborated with many of the CGIAR centres, including CIMMYT, IFPRI, CIFOR, ICRAF, ICRISAT and ILRI and much of this collaboration continues and is not necessarily a part of the new climate programme. It nevertheless focuses on closely related issues such as the collaborative projects that the Department of Economics and Resource Management has entitled *Risk and the Potential of Rainfall Insurance in Ethiopia*, and the project *Impacts of New Maize Varieties in Malawi and Zambia*. Similarly the department has had a close and long-standing collaboration with CIFOR and is conducting ongoing research on REDD+ in Tanzania and Malawi among others. It is, therefore, important to think beyond the new climate programme.

A second and related task would be to identify PhD students in environmentally and social science related, as well as other fields interested in conducting their thesis/postdoc research in connection with any of the programmes, in Africa. Promoting gender analysis research within CGIAR programmes, particularly within CCAFS is of particular interest.

UMB's partner universities in Africa can be involved in the research CCASF is conducting. By using the material produced by CCAFS, utilizing the scientific publications both in their own research and in their teaching, they can 1) make use of the training opportunities that CCAFS provides for their faculty; 2) use scholarship opportunities such as IFAR and AWARD to connect young professionals and female professionals to CCAFS for a period of time; 3) affiliate PhD and Master students to CCAFS; 4) attend workshops organised by CCAFS. Noragric can also represent a bridge in organising contacts between our partners and CCAFS as it did between SUA and ILRI. A constraint to these activities might be funding in the sense that CGIAR CCAFS are not providing much funding for their partners. However, it might be possible that our partners can use some funding from institutional collaboration programmes funded by Norwegian embassies.

A concept note involving Noragric, IDS and CCAFS: '*Supporting flexibility and sustainable adaptation among rural populations in East Africa*', is elaborated on and will be discussed with CCAFS.

Although the Norwegian Ministry of Foreign Affairs and NORAD are channelling CGIAR resources to the CGIAR system, and not to centres or programmes, it may be possible, nevertheless, to tap into bilateral funding through embassies. CCAFS would then be able to find resources coming for research related to the new CGIAR programmes or other sources (Bruce Campbell, *pers. comm.*).

9. FUTURE RESEARCH AGENDA ON CLIMATE-SMART AGRICULTURE

A potential research and training agenda could be divided into technological, policy and action research categories focusing on implementation outcomes. Technological research has taken a centre stage and so far the available technologies could be adapted to fit the varying local conditions in different countries. Acceptability and adoption studies will be necessary to inform any further developments in particular technologies and for purposes of scaling up pilot initiatives.

9.1. CSA-SPECIFIC RESEARCH AND TRAINING

Development of climate-smart agriculture (CSA) is dependent on appropriate technologies and input, market access, institutional development and favourable policies. There is a great variability in these factors in Africa and site-specific solutions must be applied. Climate-smart agriculture aims at achieving triple wins through higher productivity, adaption to climate change and mitigation of climate change. These objectives cannot be achieved without fundamental changes in how farming is practiced in Africa. Yield levels in Africa are often below one ton/ha, and hardly any organic matter is recycled to the soil. Average fertilizer use is still below 10 kg/ha.

There is a solid knowledge base with regard to how agriculture can be developed in a more sustainable way. This knowledge base is found in indigenous knowledge or developed through research. Results show that the yields African farmers are achieving are far below the potential yield. The main reason for this yield gap is low supply of plant nutrients. Plant nutrient supply is in many cases a more limiting factor than water. However, fertilizer recommendations are often based on uniform application rates for the whole country ignoring the high variability that exist in agro-ecological and socioeconomic conditions. Research both in southern Africa and in the Sahel show that small amounts of mineral fertilizer applied in the planting pocket is efficient in increasing yields. This way of fertilizer application is far more profitable than fertilizer application by broadcasting and target application also reduces the losses of nutrients. Even though this principle of fertilizer application is well documented, the fertilizer recommendation in most African countries is still based on rates appropriate for fertilizer broadcasting. There is therefore a need to:

1. Continue research in order to develop recommendations that are suitable for the diverse agro-ecological conditions that exist throughout the tropics.
2. Continue research on different organic methods for soil fertility maintenance. Integration of nitrogen fixing species such as pigeon pea and nitrogen fixing fodder trees such as *Gliricidia sepium* or *Faidherbia albida* can make an important contribution. However, market assess may limit use of nitrogen fixing species and promotion of these species will therefore have to go hand in hand with market development for these crops. In Tanzania the market for pigeon pea is growing due to increasing demand from India.
3. Continue research on conservation agriculture (CA) in Africa. It has been shown that CA can increase yields, but there are still challenges related to labour use, fertilisation and weed control. Research on conservation agriculture has been mainly driven by international research institutes and there is a need to strengthen the African countries own research capacity on conservation agriculture.

4. Continue research on improved livestock management as a part of CSA.

It is well documented particularly in the drylands that mulching can have a key role in increasing yields. Mulching increases the soil water holding capacity and reduces the soil surface temperatures; more water is also infiltrated into the soil if mulching is practiced. However, practicing mulching is very difficult in the drylands as all the residues left on the ground as mulching will be removed by grazing animals. Establishment of trees such as *Faidherbia albida* and natural regeneration is also difficult because of a high grazing pressure. Improved livestock management will therefore have to be part of CSA. This includes improved grazing management, production of fodder of high quality and zero grazing systems. Such an approach will also allow intensification of livestock production. Less use of residues for fodder will reduce the emission from livestock because methane production is higher if fodder is of low quality. In some countries like Ethiopia, the major reason for keeping animals is for providing traction power and a change to CA will reduce the need for keeping oxen for traction power. This will make it possible to change the composition of livestock from animals kept for traction purposes to livestock kept for milk and meat production

Dependence on rainfall for food crops will leave rural populations increasingly food insecure in times of climate change. Crop yields may be secured with relatively small amounts of supplemented water to carry the plants through drought spells during the growth season. UMB's partners in Ethiopia have rich experience with micro dams and closure of catchment areas to provide water for irrigation. However, micro dams tend to fill with sediments within a couple of years after construction. Therefore, many of the dams in Ethiopia serve currently only as diversion dams without significant storage.

Despite difficulties, better water management will be essential for future food security in arid and semi-arid areas. Since the prospects for food security and reforestation are significant, research should focus on developing infrastructure for supplemental irrigation. As a first step, better use of plant nutrients on the best agricultural lands may increase yields three- to four-fold. This may facilitate conversion of marginal cropland in upland areas to forest/bushland and consequently increase the availability of groundwater and surface water for irrigation. Additional water supply may, in turn, facilitate better crop growth resulting in a total of five- to seven-fold yield increase.

Lessons learned from communities where water storage and area closure have been implemented, should be collected and analysed with the aim to transfer and adapt experiences to areas under different conditions. The key target should be crop intensification on flat land and reforestation on sloping land.

The scientific underpinning for such developments is well established, but so far there have been few full-scale tests for these types of integrated agricultural systems. The conservation agriculture programme in Zambia is an example, but this programme is not involving the livestock sector. Farmers practicing conservation agriculture in Zambia has been able to increase yield, but there is no improvement in soil properties because all the crop residues are removed from the fields by grazing animals. There is therefore a need to test a more comprehensive package that also includes livestock production. In such a full-scale test it will be possible to study overall effects on farm productivity, changes in soil properties and emissions of greenhouse gases at landscape level. Such test will have to include whole villages or watersheds. Farmers' perceptions and attitudes will have to be monitored throughout the

project period. Such a study will give important results regarding how to achieve large scale up-scaling of climate-smart agriculture.

The adoption of climate-smart agricultural technologies boils down to what millions of farm households are able to – and find beneficial to – adopt. Adoption, therefore, depends on many factors such as the basic agro-ecological conditions, household resource endowments (including knowledge and skills) and preferences, access to markets and technologies, institutions and policies. The Department of Economics and Resource Management suggests selecting two countries, Ethiopia and Malawi, where food security is a central issue due to climate risk and where we have long experience with collaborating with the local universities through the joint MSc programme, capacity-building of staff and research collaboration. The already ongoing household-farm panel surveys can serve as an extremely valuable database for further studies to assess climate-smart technologies and policy designs that can promote their adoption. The first survey in Tigray Region in 1998 was funded by the project 'Incentives for Conservation', funded by the Research Council of Norway, and this set the appropriate framework for relevant data collection already from the beginning and now has 5 rounds of surveys, the last in 2010. Similarly, in Malawi the department has developed a database dating back to 2006 with 3 rounds of surveys. The challenge in Malawi is to integrate the adoption of conservation agriculture with the Farm Input Subsidy Program in ways that can reduce the overall financial costs and create production systems that are less vulnerable to droughts and that can therefore enhance household and national food security. In addition to working with the local universities, it is necessary to cooperate with the relevant CGIAR institutions, in particular CIMMYT (in both countries) and IWMI (in Ethiopia). In Malawi it is also very important to establish close collaboration with Chitedze Research Station and the ASWAp-SP programme under the Ministry of Agriculture and Food Security. Inclusion of at least two PhD students from each of the universities would be essential to achieve both capacity-building and strong links between UMB and the universities in the South. Further involvement of MSc students and staff from the local universities will also be essential. An important new thing would be to link PhD and MSc students from several relevant disciplines to work in same localities to build a more inter- and multidisciplinary analysis. This could include students in crop science, agro-ecology, soil science, and climate research.

9.2. RESEARCH TO OBTAIN SYNERGIES BETWEEN CSA, REDD+ AND ENERGY+

Implementing CSA, REDD+ and Energy+ will involve collaboration across sectors and a range of actors at multiple spatial and temporal scales. CSA entails the effective agriculture and climate change policies which can also boost green growth, protect the environment and contribute to the eradication of poverty. REDD+ on the other hand is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (UN-REDD.org). Finally, the Energy+ initiative supports developing countries' efforts to transform the energy sector to achieve universal access to sustainable energy and decrease greenhouse gas emissions by scaling-up access to renewable energy sources and increased energy efficiency. All these three initiatives interface with land and forests and in turn affect livelihoods and environmental health. For instance, implementing REDD+ will require addressing drivers of deforestation and forest degradation, many of which are outside the forest sector (including agriculture and energy) and sometimes beyond national jurisdictions.

National governments will therefore require cross-sectoral approaches and will need to undertake research to identify the interplay between the different sectoral specific policies and actor interests in order to reduce and manage conflicts (negative interplay) and to promote synergies (positive interplay). The policy analysis should focus both on the policy design and implementation process and the actual 'rules in use'. This kind of research will be necessary as the success of CSA, REDD+ and Energy+ will depend on harmonizing policies, the different actor interests and actual resource use patterns. Harmonizing policies will allow for information sharing and ease transfer of technologies across nation states with similar conditions which will be necessary for adaptation to inevitable climate related changes.

Reducing emissions from deforestation and forest degradation will require intensifying agricultural production in addition to other measures. Thus, research should identify how to achieve sustainable agricultural intensification. The challenge is to intensify the agriculture production in Africa in a way that also contributes to less emissions of GHG and avoid pollution and degradation of the environment. Implementing CSA will require identifying low carbon agricultural development pathways. Noragric's research on the effects of agricultural intensification in Africa and Nepal provides a good basis for continued research on this topic. Mitigation research should also investigate impacts of CSA, REDD+ and Energy+ initiatives on livelihoods and identify options which deliver multiple goods and services. Aspects to consider include the implication of the initiatives within their institutional frameworks of governance, property and user rights to land, forest and forest carbon. Issues pertaining to governance of the various land tenure and their implication to incidence of benefit and opportunity costs of participation by local communities in CSA, REDD+ and Energy+, should be investigated and understood in order to facilitate successful implementation of these initiatives.

Field evidence on the scale and implications of REDD+ and Energy+ investments is still limited. Further research should contribute to this knowledge gap through detailed case-study analysis of the local, social, and economic impacts of CSA, REDD+ and Energy+ investments in the respective countries. Results from such research will inform the design and implementation of the different initiatives to deliver global and local energy security goals, mitigate climate change while also promoting rural development in the respective countries. Adaptation research should also investigate appropriate coping and innovative insurance schemes to compensate for any losses due to inevitable changes.

In summary, developing synergies between mitigation and adaptation and understanding the impacts of the different initiatives will be necessary. Considering the connected nature of the different productions systems (water, energy, forests, agriculture land etc.), a single policy strategy that relies on providing incentives for CSA, REDD+ or adoption of renewable energy targets and subsidies for energy efficient equipment (Energy+), will not meet the challenges of a changing climate. A systems or landscape approach which considers the whole array of social, economic, ecological, political and institutional factors which influence human actions will be necessary. Universities can contribute to strengthened climate change engagement and search for solutions through research, training and developing, testing and investigating acceptability of different technologies.

9.3. UNDERSTANDING VULNERABILITY CONTEXTS AND POLITICAL DIMENSIONS

Rural populations draw on several sources of flexibility in responding to and adapting to climate variability and change. Their ability to secure a decent life in the face of multiple social and environmental changes, including climate change, is dependent for example on crop and income diversification, pastoral-agropastoral trade and interaction, use of biodiversity (on–farm and forest resources) in farm and income strategies, shifting cropping patterns and seeking off-farm employment seasonally and permanently.

There is a need to identify the types of interventions and measures that can effectively reduce vulnerability in different contexts. In particular, since the particular agricultural technologies required will vary from place to place and over time, there is a need to identify societal features that allow local shifts in practices in response to local contextual factors, and hence facilitate a transition towards a more resilient society. Such an approach draws attention to how institutions (formal and informal) and various policies as well as political change frame and determine local options. Recent research has demonstrated that not every adaptation intervention is a good adaptation. Adaptation policies and development interventions can in fact be maladaptive in terms of increasing vulnerability for some groups (even if increasing adaptive capacity for others) and having negative environmental and equity effects in the long term. As a response to this concern, Eriksen *et al*. (2011) formulated four normative principles of sustainable adaptation: first, recognize the context for vulnerability, including multiple stressors; second, acknowledge that differing values and interests affect adaptation outcomes; third, integrate local knowledge into adaptation responses; and fourth, consider potential feedbacks between local and global processes. These principles can guide critical assessment of how policies or interventions can most effectively support adaptation.

Future research needs will include understanding how production, adaptation and mitigation objectives relate to local vulnerability, poverty and livelihoods. This may require understanding the significance of CSA for softer 'social'-based measures in addition to harder 'technocratic' measures, potential conflicts of interest between mitigation, production and adaptation objectives and understanding limits to CSA in addressing these. Linkages to wider sustainability issues (social equity, justice and environmental integrity) and related terms such as sustainable adaptation and climate compatible development are required.

10. POTENTIAL FUTURE ENGAGEMENTS FOR UMB/CAMPUS ÅS WITH ESTABLISHED PARTNERS IN AFRICA

Norwegian Centre for Climate-Smart Agriculture

UMB/Campus Ås (including Veterinary College) will consider establishing a *Norwegian Centre for Climate-Smart Agriculture* to serve as a stimulating and coordinating agency for both national and international research and education efforts to promote climate adaptation and mitigation in food production. Such a centre would fit well into UMB's Strategy for Food ("*Strategi for matområdet ved UMB*"), which will be finalized in 2012. A potential Centre for Climate-Smart Agriculture may be organized under the planned "FOODglobal" ("*MATglobal*") division under the new strategy. FOODglobal will be able to draw upon expertise at all departments at UMB and surrounding institutes, notably Bioforsk.

UMB School of Economics and Business (UMB-SEB)

How can UMB-SEB contribute to competence building at weaker universities?

1. The UMB School of Economics and Business (UMB-SEB) currently offers a strong MSc-programme in Development and Natural Resource Economics, emphasizing the application of rigorous economic theory and methods to local realities and policy debates. Universities in the South with economics departments would benefit from sending strong candidates to this programme, as many have done in the past: The MSc degrees earned under the programme is a low cost way of strengthening the academic staff for these universities. Scholarships will be required for this as UMB no longer receives quota scholarships for MSc-education and the NOMA-programme has terminated.
2. The UMB-SEB can offer a strong PhD-programme in Development and Natural Resource Economics with focus on Climate-Smart Environmental and Agricultural Policies (outlined in detail below) in which strong candidates from weak universities may be offered scholarships.

How can UMB-SEB's cooperation be linked to NORHED-financing?

UMB-SEB is interested in developing an application to the new NORHED programme in collaboration with partners in the South to build on previous involvement in the NOMA and NUFU programmes. Contingent on proper funding becoming available under NORHED, below is a sketch of a possible collaboration project that is likely to be relevant to the needs in the South. The proposal is of academic interest from a UMB-SEB perspective since it blends well with our existing portfolio of graduate courses and research.

Cooperation with CGIAR and the World Bank

The UMB-SEB thinks it is particularly relevant to cooperate with CIMMYT, CIFOR and IFPRI in relation to our collaboration with universities from the South. Moreover, we believe this can be a particularly valuable triangular relationship to strengthen education programmes in the South and link capacity-building at PhD-level to research frontier research on climate-

smart agriculture and agricultural policies. The UMB-SEB already has very strong links to these three international institutions.

Dynamics of forest and agricultural land use, land rights and policy

The UMB-SEB has strong competence in this area and can contribute to capacity-building, research and research collaboration within this area. We have collaborated for many years with university partners from the South, and already have strong databases in some countries that are very valuable for assessing issues such as technology adoption, land use changes, poverty, vulnerability, responses to climate shocks, impacts of various types of policy interventions such as safety net programmes, agricultural input subsidies, dissemination of improved technologies, etc. (Ethiopia, Uganda, Malawi and to some extent Tanzania). This programme enables expanding these databases, which will have benefits beyond the sketched programme. There are very few such strong programmes at MSc-level in Africa and their capacity to produce strong new candidates falls short of the countries' needs.

At the PhD-level the situation is even more severe. It has become increasingly difficult for African universities to send their staff for such training in western countries because such training capacity has been downscaled as agriculture has had low priority. UMB is one of the few universities that has retained this capacity. The climate, food and energy crisis makes it highly timely to ensure that this capacity is not lost.

A Sketch of a Comprehensive Capacity-building and Research Programme on Climate-Smart Environmental and Agricultural Policies

1. MSc-Programme to be developed as a North-South-South collaborative effort:
    a. A valuable component of the NOMA-DNRE programme was the joint fieldwork that also generated North-South-South learning interactions and network building.
    b. The databases collected can be used to analyse many climate- and agriculture-related development and policy issues as part of MSc-, PhD-theses and other publications and provide valuable policy lessons.
    c. The programme will build on current courses at the master level (which has only changed slightly since the last NOMA student graduated in 2011). The programme received much praise in an external evaluation and from students, and will be developed further with new course offerings related to climate smart agriculture.
2. PhD-programme at UMB-SEB with scholarships (5 year scholarships) for strong candidates from partner universities from the South. A coordinated start-up, for example, one PhD-student from each of the collaborating partner universities in a joint programme, would also strengthen South-South collaboration during the whole process.
    a. PhD-Courses: Basic courses in economic theory and methods, natural resource economics and policy, development economics and policy, behavioural and experimental economics, and impact assessment methods. Issues such as climate risk, vulnerability, adaptation strategies, policy design, technology and welfare impacts, land tenure rights and policies, and political economy, should be core issues.
    b. Research funding for fieldwork (data collection, see next point) in partner countries in the South.

   c. PhD candidates should be teaching in MSc-programmes in partner universities in the South (to strengthen MSc-programmes in these universities). This should be feasible with 5-year scholarships.
   d. Supervision: UMB professors, CGIAR-researchers and lecturers/professors at universities in the South.
   e. Writing of PhD-dissertations of good international standard, with emphasis on international journal publication of dissertation essays.
3. Research funding for research on Climate-Smart Environmental and Agricultural Policies in the countries of partner universities from the South
   a. Focused research on key issues related to developing Climate-Smart Environmental and Agricultural Policies
   b. Building on existing links to CGIAR-institutions, databases, national institutions
   c. Funding for research that involves MSc-students, PhD-students, post-doc research for university staff, CGIAR-researchers and UMB-researchers
   d. Building on the NOMA-DNRE partnerships, experiences and databases. Expanding the databases as a basis for collaborative research.
4. Partner universities in the South:
   a. Mekelle University, Ethiopia
   b. Hawassa University, Ethiopia
   c. University of Malawi, Bunda College of Agriculture (Lilongwe University), Malawi
   d. Makerere University, Uganda
   e. Sokoine University of Agriculture, Tanzania (possible new partner?)
   f. University of Zambia, Zambia (possible new partner?)
   g. Addis Ababa University, Ethiopia (possible new partner that could be a lead university in Ethiopia and in the whole programme).
5. Partner CGIAR-institutions: These will have to be identified for each PhD-student and research project as the most appropriate partner.
   a. CIMMYT (The wheat and maize centre)
   b. CIFOR (The forestry centre)
   c. IFPRI (The food policy centre)
   d. ILRI (The livestock centre)
   e. IWMI (The water management centre)

Department of International Environment and Development Studies (Noragric) in cooperation with Campus Ås

NORHED programme

The new NORHED programme aims to strengthen capacity in higher education and research institutions in LMICs to enable them to provide the public and private sectors with a skilled workforce. The main goal of NORHED is increased higher education and research capacities in LMICs as a means to enhance sustainable development and reduce poverty. The programme is designed to be responsive to the priorities of the partner countries and will encompass support to in-country/regional bachelor's and master's degree programmes, joint research projects including PhD studies, systems for improved knowledge management and information dissemination, as well as institutions' and systems' strengthening.

The NORHED programme offers a good opportunity to collaborate with partner universities in Africa in the field of climate-smart agriculture.

Together with the following (suggested) partners, UMB-Noragric will consider submitting a proposal which includes the following elements:

1. Quality enhancement of bachelor's degree programmes: entrepreneurship and incorporation of climate-smart agriculture in existing agronomy programmes among partner universities, curricula improvement, textbook development.
   Hub: Sokoine University of Agriculture (SUA), Tanzania.
   Partners: University of Zambia, Bunda College of Agriculture (Malawi), Eduardo Mondlane University (Mozambique), University of Fianarantsoa (Madagascar).
2. Master's degree programme in climate-smart agriculture (south-east Africa network)
   Hub: UNZA University of Zambia.
   Partners: Bunda College, SUA, Eduardo Mondlane, University of Fianarantsoa.
3. Master's degree programme in climate-smart agriculture (Horn of Africa network)
   Hub: Mekelle University, Ethiopia.
   Partners: Hawassa University, University of Juba (Sudan), University of Kordofan (Sudan)
4. PhD programme
   Hub: SUA/UMB sandwich programme
   Partners: UNZA, Mekelle University, Hawassa University.

The suggested hubs are tentative. The final decision will be made on the basis of existing – or planned – CAADP Centres of Excellence. CAADP has already suggested making the University of Zambia a Centre of Excellence in the field of conservation agriculture (the plan has not materialized yet due to lack of funding). A NORHED project with UNZA as the hub might be a good start towards a Centre of Excellence.

The proposed master's degree programmes will seek to build upon existing programmes in the partner countries. If deemed necessary, new programmes will be established.

UMB/Campus Ås will contribute among others with guest teachers, research inputs, peer review of publications, academic writing courses and liaison.

After UMB-Noragric hosted a World Bank workshop in October 2011 on tertiary agricultural education in Africa, Noragric enjoys close relations with World Bank partners involved in supporting African universities in this field. Noragric will maintain and utilize this network for the benefit of potential support programmes funded by the Norwegian Government.

South-South collaboration
UMB-Noragric was a collaborating partner in the seminar series *Sustainability, Education and the Management of Change in the Tropics* (SEMCIT) developed by EARTH University (Costa Rica) and the Salzburg Seminar. The purpose of the seminars, which were held in Austria, Costa Rica, Uganda, Thailand and Norway from 1999 to 2003, was to explore the possibilities for establishing tertiary education throughout the tropics built on the principles of EARTH University. The initiative went into a phase of dormancy due to lack of funding of dedicated schools. The ideas, connections and the seminar experiences (such as the Jinja Consensus) are still alive and can be built upon if funding becomes available.

Additional financing sources

UMB-Noragric will continue to seek funding through the Norwegian Research Council to the extent possible under the current thematic programmes. The research funds are, however, limited and very competitive.

REFERENCES

Abbott, P. and Borot de Battisti, A. 2011. Recent Global Food Price Shocks: Causes, Consequences and Lessons for African Governments and Donors, *Journal of African Economies* 20 (1): 12–62.

Aune, J. B. and Ousman, A. 2011. Effect of seed priming and micro-dosing of fertilizer on sorghum and pearl millet in Western Sudan. *Experimental Agriculture*, 47 (3): 419-430.

Bie, S. W., Mkwambisi, D. and Gomani, M. 2008. Climate change and rural livelihoods in Malawi: Review study report of Norwegian support to FAO and SCC in Malawi, with a note on some regional implications. Noragric Report no. 41. Noragric, Ås, Norway.

Campese, J. 2011. Gender and REDD+ in Tanzania: An overview of key issues. Tanzania Natural Resource Forum. 50 pp.

Cline, W.R. 2007. Global warming and agriculture: Impact estimates by country. Washington DC, USA. Peterson Institute.

Eriksen, S. E. H., Aldunce, P., Bahinipati, C. S., Martins, R. D., Molefe, J. I., Nhemachena, C., O'Brien, K., Olorunfemi, F., Park, J., Sygna, L., Ulsrud, K. 2011. When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Climate and Development*, 3 (1): 7-20.

Gerbens-Leenes, W., Hoekstra, A. Y. and Van der Meer, T. H. 2009. The water footprint of bioenergy. *Proceedings of the National Academy of Sciences of the United States of America* 106 (25): 10219-10223.

German, L., Ruhweza, A., Mwesigwa, R. and Kalanzi, C. 2011. Socio-environmental footprints of carbon payments: A case study from Uganda. In: Tacconi, L., Mahanty, S. and Suich, H. (eds), *Payments for environmental services, forest conservation and climate change: Livelihoods in the REDD?* Edward Elgar Publishing, Cheltenham, UK.

Kaarhus, R. 2010. Women's land rights and land tenure reforms in Malawi: What difference does matriliny make? *Forum for Development Studies*, 37 (2): 171-192.

Kaarhus, R., Haug, R., Hella, J. P. and Makindara, J. R. 2010. Agro-investment in Africa – Impact on Land and Livelihoods in Mozambique and Tanzania. Noragric Report no. 53. Ås, Noragric.

Mai, Y. H., Mwangi, E., Wan, M. 2011. Gender Analysis in Forestry Research: Looking Back and thinking ahead. *International Forestry Review*, 13 (2): 245-258.

Mankunike, C. 2010. Large scale agricultural investment in Africa: Points to ponder. In Kugelman, M. and Levenstein, S. (eds.) *Land Grab? The Race for the World's Farmland*, Washington, DC: Woodrow Wilson International Center for Scholars.

Matiya, G., Lunduka, R. and Sikwese, M. 2011. Planning and costing agricultural adaptation to climate change in the small-scale maize production system of Malawi. International Institute for Environment and Development, London, England.

Meinzen-Dick, R., A. Quisumbing, J. Behrman, P. Biermayr-Jenzano, V. Wilde, M. Noordeloos, C. Ragasa, and N. Beintema. 2010. Engendering agricultural research. IFPRI Discussion Paper 973. 76 pp.

Milder, J. C., Majanen, T. and Scherr, S. J. 2011. Performance and potential of conservation agriculture for climate change adaptation and mitigation in Sub-Saharan Africa. Final

Report for the WWF-CARE Alliance's Rural Futures Initiative. *EcoAgriculture Partners*, Washington, DC.

Müller, A., Schmidhuber, J., Hoogeveen, J. and Steduto, P. 2008. Some insights in the effect of growing bio-energy demand on global food security and natural resources. *Water Policy* 10 (1): 83-94.

Nair P. K. R., Nair, V. D., Kumar, B. M., Showalter, J.M. 2010. Carbon sequestration in agroforestry systems. *Advances in Agronomy* 108: 237–307.

Nakakaawa, C. 2011. Potentials, policies and projects on carbon sequestration at national, local and household levels in Uganda. PhD thesis, Noragric, Norwegian University of Life Sciences, Ås, Norway.

Negra, C., and Wollenberg, E. 2011. Lessons from REDD+ for agriculture. CCAFS Report No. 4. CGIAR Research Program, Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. 62 pp.

Nelson, G.C., Rosegrant, M.W., Palazzo, A., Gray, I., Ingersoll, C., Robertson, R., Tokgoz, S., Zhu, T., Sulser, T.B., Ringler, C., Msangi, S. and You, L. 2010. Food security, farming, and climate change to 2050: Scenarios, results, policy options. International Food Policy Research Institute, Washington DC, USA. 131 pp.

Nhantumbo, I., Salomão, A. 2010. Biofuels, land access and rural livelihoods in Mozambique. International Institute for Environment and Development Working Paper. IIED. London. 58 pp.

Nyanga, P. H., Johnsen, F. H., Kalinda, T.H. 2011. Gendered Impacts of Conservation Agriculture among Smallholder Farmers in Zambia. Trends and Future of Sustainable Development Conference, Finland. 9-10 June 2011.

Phelps, J., Webb, E. and Agrawal, A. 2010. Does REDD+ threaten to recentralize forest governance? *Science* 328 (5976): 312–313.

Pimentel, D., Marklein, A., Toth, M. G., Karpoff, M. N, Paul, G. S., McCormack, R., Kyriazis, J., Krueger, T. 2009. Food versus biofuels: Environmental and economic costs. *Human Ecology* 37: 1–12.

Reed, D., Gutman, P. 2011. Energy+: Opportunities, Challenges and Options. Technical Working Group on the International Architecture for Climate Finance. 47 pp.

Schoneveld, G. C., L. A. German, R. Andrade, M. Chin, W. Caroko and O. Romero-Hernández. 2010. The role of national governance systems in biofuel development: a comparative analysis of lessons learned. Info Brief 35. Center for International Forestry Research, Bogor, Indonesia.

Smith, P., Gregory, P. J., van Vuuren, D., Obersteiner, M., Havlík, P., Rounsevell, M., Woods, J., Stehfest, E., Bellarby, J. 2010. Competition for land. *Philosophical Transactions of the Royal Society B*, 365: 2941–2957.

Vedeld. P., Angelsen, A. Bojo, J., Sjaastad E. and B.G. Kobugabe 2007. Forest environmental incomes and the rural poor. *Forest Policy and Economics* 9: 869–879.

World Bank. 2007. Cultivating knowledge and skills to grow African agriculture. Report No. 40997-AFR. The World Bank for Reconstruction and Development, Washington DC, USA. 97 pp.

World Bank. 2011. Vulnerability, risk reduction and adaptation to climate change: Malawi. Climate Risk and Adaptation Country Profile, April 2011. The World Bank for Reconstruction and Development, Washington DC, USA. 16 pp.

APPENDIX 1. INSTITUTIONAL COLLABORATION, PROGRAMMES AND PROJECTS AT UMB RELEVANT TO CLIMATE-SMART AGRICULTURE IN AFRICA (ALPHABETICALLY BY COUNTRY)

ETHIOPIA

Department of International Environment and Development Studies (Noragric)

Institutional Collaboration between Mekelle and Hawassa Universities (Ethiopia) and the Norwegian University of Life Sciences (Norway) (programme)

Period: 2009-2013
Funding: Royal Norwegian Embassy, Addis Ababa
Programme leader: Kjell Esser
Partners: Mekelle University; Hawassa University; NTNU; UiO; UiB

The goal of this programme is to improve the livelihoods of the rural poor communities (particularly farming, pastoral and fishing communities) in the Rift Valley and the arid highlands of Ethiopia through development oriented research, natural resource management, dissemination of findings, and strengthening of the quality of higher education. The programme aims to support development oriented research and dissemination with the establishment of the Institute of Development, Gender and Environmental Studies (at MU and HU) via graduate studies, capacity building, support of female students, university-industry linkage, and the promotion of north-south cooperation. Beneficiaries include farmers and their sectors of the rural community; governmental and non-governmental institutions; the private sector engaged in agricultural development, natural resource and health management; female students and staff at HU and MU and research communities. Indicators of success: development research outputs leading towards achieving livelihood improvement, poverty reduction, natural resource management, technology transfer and food self-sufficiency, generated, disseminated and used by policy makers and rural communities of Northern Highlands and Rift Valley areas of Ethiopia. The programme supports research within a wide range of subjects including environmental law, medical science, economics, business development, social organization and crop production. It represents a very relevant and promising channel for future Norwegian support to climate-smart agriculture. The programme establishes a close collaboration between the two Ethiopian universities and four of Norway's leading universities through, *inter alia*, 15–20 PhD programmes in a broad range of fields that are either directly relevant for climate-smart agriculture or serve supporting roles. Support to female students is specifically stated in the project plan. Research will also target opportunities for female farmers to improve food security for their families.

Intensification of cereal crop production in semi-arid highlands of Ethiopia through conservation tillage, micro-fertilising and seed priming: An eco-farm system approach

Period: 2009-2012
Funding: Royal Norwegian Embassy, Addis Ababa
Project leader: Jens Aune
Partners: Hawassa University; UMB

The project aims to make agriculture in central Ethiopia more productive and adaptive to climate change. It is implemented as a PhD project (Getachew Sime) with involvement of researchers at Hawassa University. The project builds on the concept of conservation agriculture. Major components include tillage methods, seed priming, microdosing and mulching. The project also studies how farmers adopt new technology and how new technology can contribute to increase farmers' incomes. Ploughing by oxen is the principal method for cultivating soil Ethiopia. However, this method leaves the soil unprotected from soil erosion and very low quantities of organic matter are recycled to the soil. Such a farming system is also vulnerable to drought. Additionally, female-headed households are in a very difficult position because it is culturally unacceptable for them to plough the land. Fertiliser use efficiency is improved through changing from broadcasting of fertiliser to microdosing. This method also reduces the risks related to application of mineral fertilisers. Mulching will reduce water loss from the soil and build soil organic matter. The research outcome of this project may strengthen the role of the women on farms, as the new systems developed will be less dependent on the use of oxen.

Pastoral Pathways: Climate change adaptation lessons from Ethiopia

Period: 2010-2011
Funding: Development Fund/Norad
Project leader: Siri Eriksen
Partners: Afar Pastoralist Development Association; Ogaden Welfare and Development Association; UMB; Development Fund

The study investigates what sustainable adaptation means in a local context. Sustainable adaptation is adaptation that contributes to sustainable development pathways in terms of social equity, poverty reduction and environmental integrity. Four normative principles have been developed that can guide policies and interventions towards achieving development pathways that strengthen both social equity and environmental integrity: i) recognise the context of vulnerability, including multiple stressors; ii) acknowledge differing values and interests affecting adaptation outcomes; iii) integrate local knowledge into adaptation responses and iv) consider potential feedbacks between local and global processes. This study examines the practical implications of these principles in an Ethiopian pastoralist context. Hence, pastoral pathways – past, present and future - can provide lessons for the type of societal transformations required to tackle the climate change problem. The analysis is based mainly on interview data collected in two sites in Afar as well as insights from past studies in the region as documented in published literature. In order to understand their significance across contexts, some of the key issues identified for Afar are followed up with a smaller number of interviews in another pastoral area, the neighbouring Somali region. The vulnerability context, multiple stressors and local adaptation strategies are investigated in order to identify the social, environmental and development processes that shape adaptation options in

both areas. A crucial issue is the extent to which the local dynamics – that is, the interaction between local livelihood responses and the multiple changes that they face (including climate variability and change, conflict and development policies) – contribute to more or less sustainable development pathways. The concept of sustainable adaptation has close parallels with climate-smart agriculture and findings from this investigation may help develop the term. There is a potential synergy with carbon sequestration in drylands. Determining sustainable adaptation pathways involves forms of agricultural development that both maintain environmental integrity and contribute to low-carbon development. Adaptation needs and interests often differ between men and women and the way that they can articulate these needs through power relations and decision making processes differs. The project investigates how these processes lead to differentiated vulnerability and adaptation.

Large land deals in Africa: Gendered processes of tenure insecurity, resource capture, and collective action (Ethiopia and Ghana)

Period: 2010–2012
Funding: Research Council of Norway (RCN)
Project leader: Poul Wisborg
Partners: International Food Policy Research Institute (IFPRI), UMB

The objective of this project is to contribute to the knowledge of gendered processes and outcomes of large-scale transnational land deals in Africa, and to develop empirical and theoretical insights into the following sub-issues: i) how the projects involve, affect and empower women and men in different ways; ii) how land and water tenure is recognized and affected by the deals; iii) what specific steps and mechanisms of resource capture are observed; iv) how power relations, diverse sources of power and governance processes promote participation or exclusion; v) whether and how land holders or others engaged in collective action to resist or affect the deals and vi) how actors assess the land deals and how they may be analysed in terms of gender equality and other human rights and capabilities. The project examines cases of large-scale transnational land deals in Ghana (initiated) and Ethiopia (planning stage). One of the land deals was initiated for the purpose of biofuel production for the global market, and was as such partly driven by policies developed to address global climate change. The project studies the way the processes and impact of land appropriation are gendered. Gender relations affect most stages of transnational land deals, from appropriation, to decision-making, implementation, impact and evaluation (Behrman *et al*., 2011). Gender equality is one of the normative references for the research project.

Household Food Security in Southern Rift Valley of Ethiopia: A Gendered Analysis (PhD research)

Period: 2012 – 2015
Funding: Royal Norwegian Embassy, Ethiopia
Project leader: PhD student: Ansha Yesufe Nure; Supervisor: Darley Kjosavik
Partners: Hawassa University; UMB

This project is implemented as a PhD Project (Ansha Yesufe Nure, Hawassa University). The study seeks to understand the recurring food security dilemmas in the Southern Rift Valley of

Ethiopia with a special focus on the gender dimensions. The goal in doing so is to draw attention to the multifaceted dimensions of household food (in) security – Socio-economic, political, ecological and cultural. The Rift valley areas like the other parts of Ethiopia face the problem of food insecurity. Among other things, increasing population pressure has contributed to land scarcity, which is one of the major challenges for the people. This has led to fragmentation of farmlands, reduction of fallow periods, shifts in cropping patterns; reduce time spent in farming, acceleration of land use conflict and competition, and land degradation.

School of Economics and Business, UMB

Impacts of Productive Safety Net in Ethiopia

Period: 2010-2013
Funding: SIU/NOMA, Statens Lånekasse (Kvotestipend)
Project leader: Stein Holden
Partners: IFPRI; Mekelle University; UMB

The project aims to assess the impacts of the Productive Safety Net Program (PSNP) on household welfare and natural resource management in Tigray based on household and farm data collected in the period 1998-2011. The public works component of the programme enhances investments in soil and water conservation, irrigation, tree planting, etc., while households are paid in food or cash for their investment activities. The programme implied that participant households were granted access to such public works for five years (2006-2010) and the project aims to identify the impacts after the first five years of the programme. The strong database and institutional collaboration provides an excellent basis for further studies on the impacts of climate risks, alternative policies and projects. Women have a central role in the PSNP as contributors in the public works, as heads of female-headed households, etc. The PhD student in the project is also a female Ethiopian.

Impact of Irrigation Investments in Northern Ethiopia

Period: 2005-2011
Funding: Norad
Project leader: Stein Holden
Partners: Mekelle University; IWMI; UMB

The project aimed at capacity building (PhD student from Mekelle University) and to assess the benefits from irrigation investments in Tigray region of Ethiopia by collecting data from different types of irrigation projects (with different irrigation technologies) and assessing their contribution to land productivity, food security and household welfare. The PhD was completed in 2009 but papers are still being publishing based on this work. The project was a collaborative project with IWMI. Investment in irrigation to better utilize the scarce water resources in semi-arid climates is an important strategy to make agriculture more climate-robust.

The Potential of Rainfall Insurance in Ethiopia

Period: 2011-2013
Funding: Research Council of Norway
Project leader: Million Tadesse (Postdoc); Stein Holden (Supervisor); Frode Alfnes (Supervisor)
Partners: International Maize and Wheat Improvement Center (CIMMYT); UMB

The project assesses rural households' demand for rainfall insurance and whether rainfall insurance can be an alternative policy instrument to protect people against climate risks. It is too early to say whether this can be something to build on as a policy instrument but the institutional network in Ethiopia and the links to CIMMYT are something that it is possible to build on.

Department of Plant and Environmental Sciences (IPM)

Seed Safety through Diversity, Ethiopia

Period: 2007-2012
Funding: SIU/Norwegian Programme for Development, Research and Education (NUFU)
Project leader: Åsmund Bjørnstad, UMB; Fetien Abay, MU
Partners: Mekelle University; UMB

The project has three main goals: i) develop improved barley varieties for Tigray based on locally adapted diversity using participatory on farm selection methods; ii) institutional capacity building through infrastructure (laboratory) and students (PhD and MSc); iii) empowerment of farmers, especially women, through product development based on improved barley varieties. The key climatic stresses for barley are water logging due to excessive rainfall followed by early termination of rains and drought. The first improved variety for Tigray was officially released in 2011(several previous releases have not been adopted by farmers due to mal-adaption to the variable and stressful conditions). It is tolerant of water logging and represents a major improvement in food quality. New lines that are earlier maturing and also tolerant to drought are in the pipeline, all based on locally adapted barley varieties studied in this research. This has generated a lot of interest; five different local seed businesses have been established through a Dutch side-project. The work has also become part of an EU FP7 project '*Strategies for Organic and Low-input Integrated Breeding and Management*' (SOLIBAM), focusing on low input agriculture. The gender aspect is integrated in the project through the key involvement of women farmers and through the project coordinator, who in 2010 received the national Ethiopian Gender and Development Award for her work. The project coordinator also works on another NUFU project, '*Women in Food Science*'. The commercialization of local roasted barley products is carried out in collaboration with NGOs. Since discovering that groundnuts used in the food had a high contamination with mycotoxins, this subject has become part of the project with the first Ethiopian workshop on mycotoxins taking place in MU in 2010.

Carbon sequestration and soil quality-an index of sustainable production in the agroforestry systems of Tigray, Ethiopia (PhD research)

Period: 2009-1013
Funding: International Foundation of Science (Sweden); Loan Stipend from Norway and the Ohio State University Columbus, USA.
Project leader: Bal Ram Singh
Partners: Mekelle University; Ohio State University, USA

The primary objectives of this study are to investigate the agroforestry systems to resolve the following sub-objectives: i) carbon sequestration potentials and its quality; ii) reducing large-scale soil degradation, prevelent in the region, and iii) validate or develop models to predict carbon sequestration petential and soil qaulity leading to improved soil productivity in dry land ecosystems of Ethiopia and reduced carbon emmissions. The use of agroforestry in cropping systems offers an inexpensive means to enhance carbon sequestration in soils and thus sustain soil fertility at the local level. The results of the study will contribute to the development of best management practice to improve crop yields on farm fields, and to the development of prediction tools for SOC management in the region. It is believed that the project has both regional and local environmental and socioeconomic relevance. Recurrent famine is endemic in the semi-arid regions worldwide, mainly as a result of poor soil fertility and low rainfall. Solar energy is naturally unlimited and carbon dioxide is abundant in the atmosphere. Thus, insufficient soil moisture and low soil fertility are the main factors limiting crop productivity in the region.Therefore, this project helps to decrease atmospheric CO_2 pools that partly account for the increase in global warming at a wider/regional level. The accumulation of soil carbon may improve soil productivity so as to make crop yields sustainable. Agroforestry and soil carbon sequestration, both leading to higher agricultural productivity and moisture storage, have an important role and impact on women's welfare and activities.

Department of Chemistry, Biotechnology and Food Science, (IKBM)

Legumes and rhizobia in southern Ethiopia: Evaluation, management and utilization of biodiversity of the microsymbiont for sustainable agriculture

Period: 2007-2012 (extended until the end of 2012)
Funding: SIU/NUFU
Project leaders: Åsa Frostegård; Endalkachew Wolde-meskel
Partners: University of Hawassa; UMB

The project investigates the indigenous biodiversity of symbiotic, nitrogen fixing bacteria in Ethiopia with the aim of developing efficient inocula for common Ethiopian leguminous crops. Furthermore, nitrogen transformations are analysed under different environmental conditions in order to develop more nitrogen-efficient management methods for agriculture in this area. Intensification of agriculture has led to pH decrease in soils over huge areas globally and is considered imminent in Africa. pH emerges as the major controller of N_2O emissions (with a strong, negative correlation to pH). This project, which is developing efficient nitrogen fixation through amendments with bacterial inocula as an alternative to the much less climate-friendly chemical fertilizers, is at the core of the CSA agenda.

Education

School of Economics and Business, UMB

NOMA MSc Programme in Development and Natural Resource Economics (Ethiopia, Malawi and Uganda)

Period: 2007-2011
Funding: SIU/NOMA
Project leader: Ragnar Øygard
Partners: Mekelle University; Hawassa University; Makerere University; University of Malawi (Bunda College of Agriculture), UMB

A collaborative MSc programme with North-South-South exchange of students, teaching and research experiences, focusing on rural development and natural resource management in Ethiopia, Malawi and Uganda. The programme built databases (household and farm plot level data) by repeatedly surveying the same villages and households. These data (on climate change, adaptation to climate change, land use, deforestation, tree planting, fuel wood use, water conservation, etc.) are used by students and researchers for writing of theses and research papers and are an excellent source to build on for the further study of impacts of climate change and the assessing of adaptation strategies of farm households in the study areas. The institutional collaboration achieved through the programme has also contributed to a good basis for further cooperation. Gender issues have been central in the NOMA programme, both through a high share of female students and through a focus on gender issues in the data collection and research.

KENYA

Department of International Environment and Development Studies (Noragric)

Solar transitions: Transfer of social and technological innovations between India and Kenya

Period: 2009-2012
Funding: Research Council of Norway
Project leader: Karen O'Brien (UiO); Siri Eriksen (UMB)
Partners: CAMCO (Kenya); Faculty for Interdisciplinary Studies (IFF), Klagenfurt University; UiO; UMB

The Noragric project component investigates in particular the role of household access to energy in strengthening adaptation in a rural community, including how access to a renewable energy source interlinks with agricultural activities and forest uses. The focus of the project is energy access in distant rural communities with no access to the national energy grid. The overall project investigates Indian experiences with the implementation and social organisation of village solar power plants in villages in the Sunderban Islands in West Bengal, and their contribution to social and economic development, poverty reduction and climate adaptation. Through action research, the project actively transfers experiences from India to Kenya, both monitoring and influencing the adaptation of the Indian experiences to Kenyan local contexts, and will also create a local power supply project in a Kenyan village. In these ways the project

will contribute to the extension of technological and organizational options available for decentralized, renewable energy supply in Kenya, and is intended to be useful for governments, development agencies, NGO's, village groups, renewable energy actors and others who are involved in the planning and implementation of solar energy and other decentralized energy options in Kenya and elsewhere. Understanding how household level energy access in rural communities contributes to adaptation and enhanced livelihoods and productivity is important in understanding how climate-smart agriculture can be achieved. Rural household energy security addresses adaptation, productivity and mitigation of emission objectives. Gender issues are investigated both in terms of how energy is accessed, the differential role that energy can play in promoting adaptation among men and women (e.g. for domestic uses and income generating purposes, improvement of health and education), and in terms of empowerment of women in the running (and institutional organisation) of the local energy plant.

MADAGASCAR

BSc Field Course: Agriculture, Environment and Development in Madagascar
Period: 2011 -
Funding: Self-financed
Project leader: Kjell Esser
Partners: University of Fianarantsoa, Tombontsoa Agricultural School, Ihosy Rural Development Project, Ifanadiana Rural Development Project, LOVASO Cross-Cultural Conference Centre Antsirabe, Noragric/UMB

The course consists of 1/3 UMB students and 2/3 Malagasy students and staff. Participants visit three ecological zones, the highlands, rainforest and drylands, where they observe and analyse agricultural, environmental and development issues. Interviews and discussions are made with village leaders and villagers. The course is designed as a fact finding mission as part of an exercise to develop a log frame for a rural development project.

MALAWI

Department of International Environment and Development Studies (Noragric)

Building Capacity for Development and Food Security in Malawi (BCDP) (Programme)

Period: 2005-2010
Funding: Norwegian Embassy, Lilongwe, Malawi
Programme leader: Poul Wisborg (2006-2010); Fred Johnsen (2010-2011)
Partners: Bunda College of Agriculture; UMB

The goal of the programme is to enhance the performance of Bunda College as a leading institution in relevant and efficient learning, teaching, research and outreach for the agricultural and natural resource sector of Malawi and to enable the College to play a significant role in the development of the country. The programme has significantly enhanced the capacity of Bunda College to teach, investigate and manage climate-smart agriculture. The enhancement consists of both improved staff competence and university infrastructure.

Agricultural Research and Development Fund (ARDEP) (Programme)

Period: 2006-
Funding: Royal Norwegian Embassy, Lilongwe, Malawi
Programme leader: Poul Wisborg (2006-2010); Fred Johnsen (2010-2011)
Partners: Bunda College of Agriculture; UMB

The goal of the programme is to reduce poverty and vulnerability amongst the poorest groups and improve quality of life and social well-being of Malawians through a powerful, effective and efficient national research and outreach system for the agricultural sector in Malawi. The objectives are i) to promote food security and income generation of small-scale farmers; ii) to facilitate the participation of more women in the economic, agricultural and natural resource development of the country; iii) to contribute to the mitigation of the impacts of HIV/AIDS; and iv) to broaden sources of funding for development programmes. The programme brought together government, research, and implementation and farmer organizations in a joint effort to find ways and means to promote food security among rural poor. According to the midterm review, "*almost all the ARDEP micro projects fit into the climate change impact adaptation strategy, especially when dealing with food security and sustainable development at the household level*". It took some time for the project to bring all partners into a concerted effort, but it succeeded. This experience suggests that established mechanisms for national cooperation are valuable for future development work.

Facilitating the adoption of conservation agriculture by resource-poor smallholder farmers in Malawi (Projects)

Period: 2007-2011
Funding: Royal Norwegian Embassy, Malawi
Project leader: Jens Aune
Partners: Bunda College of Agriculture; University of Malawi; Agriculture Research and Development Programme (ARDEP); UMB

This project focuses on development of conservation agriculture in Malawi through research on tillage methods, integration of legumes in the farming system, mulching systems and adaptation studies. The project is implemented by PhD student Robert Amos Ngwira with Jens Aune as supervisor. The traditional tillage system in Malawi is very labour intensive and yields are very low. Land holdings are small and it is therefore important to develop production systems with high yield. Fuel wood is in limited supply and integration of pigeonpea can provide biomass for fuel whilst at the same supplying fodder. Drought occurs frequently in Malawi and conservation tillage will make farming less vulnerable to climate change. The project will contribute to building soil organic carbon through increased recycling of organic matter. It will deliver research results that can facilitate the tillage operations, something that will particularly benefit women since it is females that carry out most of the hard labour. The increased food production will also be of benefit to women.

New programme:

Proposal: Climate Change Adaptation for Improved Food Security and Livelihoods in Malawi (CCAFL) (Programme)

Period: Proposed for 2012-2016
Funding: Royal Norwegian Embassy, Lilongwe, Malawi
Programme leader: Not yet decided
Partners: Bunda College of Agriculture and other Malawian organisations; UMB

The overall goal of the programme is to contribute to food security and sustainable livelihoods through enhanced capacity for adaptation to climate change. In order to achieve this, the immediate objectives are to: i) understand, develop and promote climate change adaptation strategies for improved food security, natural resources management and livelihoods for smallholder farmers and vulnerable groups, and ii) improve national capacity to participate in climate change initiatives and address the effects of climate change for national development. The programme will be implemented through activities and outputs clustered around research, outreach, advocacy and policy and, capacity building, each with a set of specific objectives, summarised as: i) to analyse and understand existing livelihoods, adaptation strategies, ecosystem services and causes of vulnerability; ii) to develop technologies and systems that will enhance adaptation to climate change for sustainable natural resource management, improved livelihoods and food security; iii) to upscale interventions and technologies that will enhance adaptation to climate change for sustainable natural resource management, improved livelihoods and food security; iv) to develop and implement an effective advocacy and outreach strategy on climate change adaptation and mitigation; v) to analyse and facilitate the strengthening of institutional and policy frameworks for addressing climate change and its impacts; vi) to enhance the capacity of Bunda College and key stakeholders to effectively address climate change and variability problems; and vii) to enhance information access and documentation systems through capacity building and application of ICT in climate change and related subjects. The programme is similar to ARDEP and will bring together government, research, implementation and farmer organizations in a joint effort to increase food security in a changing climate. The proposed programme is a step towards implementing climate-smart agriculture.

School of Economics and Business, UMB

ASWAp-SP (ADP-SP) in Malawi (Programme)

Period: 2010-2011
Funding: Norad/UD
Project leader: Stein Holden
Partners: Norwegian Embassy in Malawi; The World Bank; Ministry of Agriculture and Food Security, Malawi; UMB

This is a Malawian research and extension programme that aims to promote conservation agriculture in Malawi and enhance the efficiency and sustainability of the Farm Input Subsidy Program (FISP). The programme will potentially be very important for promotion of sustainable climate adaptation in Malawi and can contribute to reduced carbon emissions and carbon sequestration in the soils through reduced tillage, reduced erosion, better nutrient

cycling, reduced need for imported fertilizers and less susceptibility to drought.

Impacts of the input subsidy programme in Malawi

Period: 2009-2011
Funding: NoradProject leader: Stein Holden
Partners: University of Malawi (Bunda College of Agriculture); UMB

The project aimed to study the impacts of the input subsidy programme on natural resource management, land productivity, household food security and household welfare including that of poor and vulnerable households. The targeting of input subsidies had a central focus. The natural management issues included assessing how access to cheap inputs affected the demand for organic manure, intercropping, area utilization for maize versus other crops, fertilizer use efficiency and land productivity. The baseline data collected over three years (2006, 2007 and 2009) can serve as an excellent baseline for studying the impacts of introducing new conservation agriculture technologies. The gender focus is central in this research because of the emphasis on targeting of the poor with input subsidies.

Impacts of new maize technologies in Malawi and Zambia

Period: 2011-2013
Funding: SPIA-CGIAR (Gates Foundation)
Project leader: Stein Holden
Partners: CIMMYT; Michigan State University; UMB

The project aims to analyse the food security and welfare effects of the new maize technologies that have been developed by CIMMYT and others for the southern African region. This includes more productive and drought tolerant maize varieties. Survey data and modelling methods will be used to estimate and measure the direct and indirect impacts of the new technologies in the context of how input subsidies affect the access and adoption of the new technologies at a large scale. This requires economy-wide models (among others) to estimate the economy-wide effects through price changes. The models that are developed will become very useful for assessing alternative technologies and their potential impacts under alternative climate scenarios. The modelling can facilitate assessment of new maize technologies in combination with conservation agriculture technologies. Additional funding will be needed for such expansions.

MALI

Department of International Environment and Development Studies (Noragric)

Adaptation of agriculture and livestock to climate change in Mali (Programme)

Period: 2011-2015
Funding: Norwegian Ministry of Foreign Affairs
Programme leaders: Jens Aune; Gry Synnevåg
Partners: Institute d'Economie Rurale (Mali); Malian NGOs; UMB

This programme focuses on adapting agriculture in Mali to climate change. The main components are i) adaption of rain fed agriculture in central Mali to climate change; ii) development of flood recession farming in Lac Faguibine; iii) stabilisation of irrigation canals in Lac Faguibine; and iv) promotion of milk production from camels in Kidal. The programme is conducted in close collaboration with Institute d'Economie Rurale, the government of Mali and various NGOs. The crops and livestock systems in central regions are very vulnerable to climate change. The rain-fed agricultural component of the programme focuses on development of improved methods for crop establishment through seed priming, microdosing, target application of organic fertilisers, mulching and integration of trees into the farming system. These methods will also contribute to increased productivity in the driest years and sequester soil carbon through more recycling of soil organic matter. Assisted natural regeneration of trees will also be part of the programme. The programme's component on rain-fed agriculture has many similarities with conservation agriculture, though is not promoted under this label. Lac Faguibine was previously considered the 'grain basket' of Mali, but the irrigation canals have been filled with sand since the 1970s. These irrigation canals have now been re-established and the programme is conducting research on how to stabilise them as well as on the development of flood recession farming in Lac Faguibine. The programme uses indigenous farming methods as the starting point; flood recession farming in Lac Faguibine can make an important contribution to adaption agriculture to climate change in northern Mali as this system is only dependent on rainfall to a limited degree. Milk production in camels is a key economic activity in Kidal. The programme studies methods for increasing production and processing methods for camel milk. This may secure a source of income in difficult years.

Adaptation to climate change in Mali

Period: 2010-2012
Funding: Drylands Coordination Group (DCG)
Project leader: Jens Aune
Partners: Institute d'Economie Rurale (Mali); Drylands Coordination Group (DCG); UMB

The project focuses on the development of rain fed agriculture in central and southern Mali through improved fertilisation, mulching, planting of multi-purpose trees, improved fodder production and improved land management. The project is implemented in close collaboration with members of the Drylands Coordination Group in Mali. The project builds on the previous Ecofarm project in Mali, aiming to improve the synergies between crop and livestock production through these activities. The development of mulching methods will be an important component in making the cropping system more resistant to climate change. The project also focuses on the establishment of land-use committees for improved management of common agriculture and grazing land. The project will reduce emission of GHG through improving the quality of fodder (methane) and by sequestering carbon through increased biomass production and mulching, and will also make more energy available for energy purposes.

SUDAN

Department of International Environment and Development Studies (Noragric)

Post-war Livelihood and Environmental Studies.

Period: 2008-2012
Funding: The Norwegian University Cooperation Programme for Capacity Development in Sudan (NUCOOP) through the Norwegian Centre for International Cooperation in Higher Education (SIU)
Programme leader: Trygve Berg
Partners: Juba University (South Sudan); UMB

The collaborating universities are carrying out joint research to build capacity and invest in institutional development in the Sudan. Revival of the food producing sectors remains a major post-war priority in the Southern Sudan. Most of the people are farmers and/or pastoralists and have access to abundant land resources, but local food supply is still inadequate and all the major towns depend on imported food. Factors that could explain the situation include disruption of the social structure, collapse of markets and degradation of natural resources. The complexity of the situation calls for a comprehensive study of farming communities (both men and women) to document the situation, identify constraints, and find strategic areas of intervention. Such studies will be undertaken in agrarian communities and in pastoral areas. Environment studies are particularly geared toward the health of wetlands. Capacity building is achieved through including two PhD- and four MSc students from each of the universities in the Sudan. Laboratory technicians and librarians will be trained and investments in libraries and laboratories will be made. The forest management component is relevant for the CSA agenda. The project has established good working relations between the partners that can be continued and expanded.

Adapting agriculture in northern Sudan to climate change

Period: 2011-2014
Funding: Norad
Project leader: Jens Aune
Partners: El Obeid Research Institute; International Fund for Agricultural Development; Drylands Coordination Group (DCG)

The project focuses on the development of rain fed agriculture in northern Sudan through improved microdosing, mulching, planting of multipurpose trees, improved fodder production and improved land management. This project incorporates all three of the key challenges addressed by the climate-smart agriculture agenda: increased production, adaptation to climate change and mitigation of climate change. Mitigation is improved through improved fodder quality, soil carbon sequestration and increased forest biomass. These methods will produce a yield even under very difficult conditions.

Origins and Survival of Sorghum Genetic Resources in Lafon, Eastern Equatoria, South Sudan
Period: 2010-2012

Funding: Norad/SIU
Project leader: Trygve Berg
Partners: Juba University (South Sudan); UMB

The project involves the evolution of sorghum under climate change comparing the DNA profile of 1983 collections with current samples of genetic resources. The project is important for the CSA agenda in that it provides the genetic material needed to breed sorghum varieties that are better adapted to climatic changes that are expected in South Sudan. Gender issues are included in terms of on-farm seed management.

Socio-economic consequences of climate change in sub-equatorial Africa (SoCoCA)

Period: 2009-2013
Funding: Norwegian Research Council
Project leader: Trygve Berg
Partners: UiO, UMB

SoCoCA will improve and spatially refine the projections of climate change in the region. The consequences of these changes in key parameters, such as temperature, precipitation, evaporation, etc., will be assessed in terms of changes in water resources and in agricultural productivity. The next task will be to address a wide range of societal challenges linked to adaptation to climate change. The CSA agenda can build on the knowledge generated from the project.

TANZANIA

Department of International Environment and Development Studies (Noragric)

Climate Change Impacts, Adaptation and Mitigation (CCIAM) (Programme)

Period: 2010-2015
Funding: Royal Norwegian Embassy, Dar es Salaam, Ministry of Foreign Affairs
Partners: Sokoine University of Agriculture; University of Dar es Salaam; Ardhi University; Tanzania Meteorological Agency; CICERO; Norwegian University of Science and Technology; Norwegian Agricultural Economics Research Institute; UMB

The programme includes research, capacity building and student exchange and is orchestrated by Sokoine University of Agriculture (SUA) with UMB as the main Norwegian partner, for which Noragric is the main Norwegian coordinator. The programme follows a pledge by the Norwegian Prime Minister Jens Stoltenberg on a visit to Tanzania in 2008 granting NOK 500 million to the country for a five- year partnership agreement to strengthen forest and climate efforts, of which 94 million is intended for research. The goal of the programme is better management of natural resources and the environment through appropriate adaptation and mitigation strategies and participation in climate change initiatives. The purpose is to develop

and sustain adequacy in national capacity to participate in climate change initiatives and address the effects and challenges of climate change. For further information, refer to Noragric's CCIAM webpage[5].

Climate change, non-timber forest products and livelihood of forest dependent communities: Impacts, vulnerability and adaptation in Tanzania

Period: 2010-2015
Funding: Climate Change Impacts, Adaptation and Mitigation Programme; Royal Norwegian Embassy, Dar es Salaam; Norwegian Ministry of Foreign Affairs
Project leader: Siri Eriksen
Partners: Sokoine University of Agriculture; UMB

Over 20 million Tanzanians depend on non-timber forest products (NTFPs) for livelihood, but the extent to which NTFPs and community livelihoods are vulnerable to the changing climate including the coping strategies is not well established. This project seeks to develop, enhance and provide an understanding of the ability of forest dependent communities to respond to the changing climate. The aim is to carry this out with a view to reducing livelihood threats and forest degradation through vulnerability and adaptation assessments within the NTFPs context, as part of the ecosystem services. The project will contribute relevant information to policy makers, particularly in the current implementation of climate change mitigation and adaptation through REDD initiatives in Tanzania. The expected outputs will contribute towards efforts to adapt to the impact of climate change whilst ensuring sustainability of livelihoods and forest resources. NTFPs form part of the agricultural system in many areas, both in terms of on-farm conservation of indigenous plants and trees and because farmers collect various NTFPs in forested areas as part of their livelihoods. NTFPs are an important part of resilient agricultural systems, and access and control over their management is particularly important as part of the safety net of the poorest in the face of climate stress (diversifying livelihoods). The use of trees on farm/agroforestry systems can also form part of enhancing productivity of agriculture (and of farmer households) in a low-carbon (low in external inputs) manner. These insights regarding the role of NTFPs can support efforts to form transitions to more sustainable, climate-smart agriculture. Gender issues are relevant to the project as the use of and access to NTFPs is often gendered; in particular, the way that women use NTFPs to adapt to climate stresses is highly gendered. Women often engage in collection of NTFPs for alternative sources of food or incomes when harvests fail, as part of or in addition to domestic chores. Meanwhile some of the larger scale commercially more profitable NTFP activities are carried out by men as they have more labour power to devote to this and because they may have connections to markets or de facto rights of access that most women do not have.

Alternative energy sources and efficient utilization of biomass energy for reduced depletion of carbon sinks and improved livelihoods in rural areas of Tanzania

Period: 2010-2012
Funding: CCIAM; Royal Norwegian Embassy, Dar es Salaam; Norwegian Ministry of Foreign Affairs; High Commission of India; ITEC programme

[5] http://www.umb.no/noragric/article/climate-change-impacts-adaptation-and-mitigation-cciam-programme-in-tanzania

Project leaders: Amini Kweka; Gry Synnevåg
Partners: Sokoine University of Agriculture; ICS (International Child Support), Meatu district; Barefoot College India; UMB

Research shows a strong link between access to energy and rural development. Only 1% of rural households in Tanzania have access to electricity, and there is high dependency on kerosene and firewood for lighting and cooking. Increasing fuel prices and deforestation make households increasingly vulnerable, particularly women responsible for firewood collection and use of fossil fuel for domestic purposes. The main goal is to improve livelihoods by solar electrification of poor rural households, to analyse impacts across socioeconomic groups and gender and explore economic and social sustainable ways of introduction and use. The pilot project aims at documenting the processes of building local capacity, control and ownership of the technology in order to make communities independent of outside assistance. Solar electrification of 450 households in two villages in Meatu district was carried out. Two women from each village were trained as solar engineers at the Barefoot College in India, equipping them to take responsibility for installation, repair and maintenance. A training centre is under construction. A baseline study was conducted, documenting impact on the environment, education, health, income generation, entrepreneurship opportunities, communication and empowerment of women. The project will contribute to the extension of technological and organizational options available for a decentralized, renewable energy supply in Tanzania, and is intended to be useful for governments, development agencies, NGO's, village groups, renewable energy actors and others who are involved in the planning and implementation of solar energy and other decentralized energy options in Tanzania and elsewhere. Understanding how household-level energy access in rural communities contributes to adaptation and enhances livelihoods and productivity is important in understanding how climate-smart agriculture can be achieved. Rural household energy security addresses adaptation, productivity and mitigation of emission objectives. Women are central actors in the project, as they are trained as solar engineers and are also master trainers to scale out the project.

Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-chains (EPINAV) (Programme)

Period: 2011-2014
Funding: MFA
Partners: Sokoine University of Agriculture; Norwegian School of Veterinary Science (NVH); UMB

Launched in February 2011, the principal objective of the EPINAV programme is to address the up-scaling of proven technologies and promote adaptation of agriculture and natural resources to the effects of climate change. EPINAV's mission statement is "*to enhance productivity, livelihood security and human capacity of target communities to utilize pro-poor and climate change adapted innovations in agriculture and natural resources value chains*". The programme contains four main themes: Theme I: Innovation systems research to address key knowledge gaps required to spur agricultural productivity and livelihood improvements of poor farmers. This theme will involve the following three categories of research: a) gender-sensitive action research involving smallholder farmers, commercial farmers, industrialists and other actors as co-researchers; b) applied research for validation of new knowledge and development of new products and processes, and c) basic research critical for generation of new knowledge on key aspects of our agriculture such as application of modern tools for

genetic improvement and conservation. Theme II: Adaptation of agriculture and natural resources to climate change. This theme will address gender specific adaptation pathways for smallholder farmers including conservation agriculture in the arid and semi-arid areas of Tanzania to address the problem of recurrent food insecurity and vulnerability. Theme III: Innovative communication and knowledge dissemination pathways. Theme IV: Policy Research Analysis and Governance.

To qualify for funding under EPINAV, research must not only enhance frontiers of knowledge but be applied and useful to end users, who are mainly smallholder farmers and other value chain actors. The budget frame is 72 million NOK over a four-year-period. Similar to the set-up for the PANTIL and CCIAM-programmes, approximately 20 % of the budget will be allocated to Norwegian partners (including five departments at UMB). Activities funded include programme coordination, impact assessment, student training, exchange programmes and institutional compensation for involvement of researchers. For further information, refer to Noragric's EPINAV webpage[6].)

Application of value chain and innovation systems approaches for up-scaling and out-scaling technologies for enhancing integrated dairy production system in Njombe district

Period: 2011-2015
Funding: MFA
Project leaders: R.H. Mdegela; Bal Ram Singh; Frik Sundstøl; Lars Olav Eik
Partners: Sokoine University of Agriculture; Norwegian School of Veterinary Science; UMB

The purpose of this project is to improve livelihood and food security and equip farmers with increased capacity to fully utilize resources and opportunities in agriculture through value chain analysis and innovation systems approaches. Such approaches include the utilization of manure as fertilizers and for biogas production, thus reducing need for fuel wood and charcoal in households. Studies carried out in Njombe under TARP II SUA and elsewhere focused to a large extent on a single commodity such as raising the level of milk production through improved feeding, and other improved animal husbandry practices. Additional inputs into the integrated systems were brought in under the PANTIL Programme through improved milking hygiene, control of mastitis, processing of milk into different products, utilization of manure and biogas production. The latter led to a reduction of workload, particularly for women. Such practices protect the environment through reduction of the use of firewood. Improving the utilization of manure for fertilizer and for biogas production has elements of fuel wood saving and provides cleaner energy for the rural poor, leading to increased agricultural productivity and reduced forest degradation for fuel wood. This work has thus a direct link to REDD+ and Energy+ initiatives.

[6] http://www.umb.no/noragric/article/enhancing-pro-poor-innovations-in-natural-resources-and-agricultural-value-chains-epinav

Enhancing sunflower production for poverty alleviation in Mvomero and Kilosa districts, Morogoro region

Period: 2012-2015
Funding: MFA
Project leaders: A.Z. Mattee (SUA); Randi Kaarhus – contribution to gender and land rights component
Partners: Sokoine University of Agriculture; Agricultural Research Institute (ARI); UMB

This project aims to develop a value chain for increasing the productivity and incomes of sunflower farmers in Mvomero and Kilosa districts and thereby contribute to poverty reduction among small-scale farmers. The focus of the project is increasing production of sunflower, but also installing small- and medium-scale oil processing equipment/structures. In the agronomic component of the project, there is potential for the development of CSA, in on-farms trials and via the training of farmers.

A gendered analysis of climate change impacts and adaptation in semi-arid area farming systems and natural resources management

Period: 2011-2014
Funding: MFA
Project leader: J.K. Urassa (SUA); Gry Synnevåg
Partners: Sokoine University of Agriculture; NGOs in Meatu and Singida district; INADES; ICS; Tumbi Agricultural Research Institute; CBOs; Local Government; UMB

Climate change affects women, the poor and vulnerable, more than their counterparts. It is generally acknowledged that interventions to strengthen livelihoods and food security against the effects of climate change and other vulnerabilities are more efficient and effective when gender differences are properly understood and addressed. However, research and policy-making have so far failed to examine extensively the gender aspects of vulnerability and adaptation to climate change. Though there are many studies which have documented vulnerability and climate change impacts on rural livelihoods, these studies have not dealt with the disaggregation of these impacts based on gender and/or other vulnerable social groups. This study intends to bridge this gap by evaluating gendered impacts and adaptation of climate change and other stresses on rural livelihoods in semi-arid areas of Tanzania. Gender disaggregated information generated from this study will help in informing adaptation and resilience intervention plans and policies, important in poverty reduction. Gender disaggregated data will be gathered from agricultural production systems. Changes in food security and availability of food over time at a household level, and the reasons for any changes will be analysed. Local adaptation pathways towards a more resilient and climate-robust crop and livestock system will be explored.

Integrated livelihood and natural resource management to adapt dryland communities to climate change

Period: 2011 – 2014
Funding: MFA
Project leaders: E.J. Mtengeti (SUA); Frik Sundstøl (UMB)
Partners: Sokoine University of Agriculture; Agricultural Research Institute (ARI); UMB

This project aims to reduce vulnerability of dryland communities to climate change through an integrated participatory natural resources management approach (See 'A gendered analysis of climate change impacts and adaptation in semi-arid area farming systems and natural resources management' on p. 24 for overlapping details).

Increasing market share of locally produced beef through improved cattle husbandry, slaughter operations and meat handling

Period: 2011-2014
Funding: MFA
Project leaders: E.N. Kimbita (SUA); Lars Olav Eik; T. Steine (UMB)
Partners: SUA; UMB

The project aims to increase the contribution of the beef industry to household incomes through increased competitiveness of locally produced beef in the market, with an expected increase in the efficiency of pastoral systems. Various approaches will be tested.

Optimizing production and utilization of lesser known and lesser utilized indigenous agro-forestry timber species

Period: 2011-2014
Funding: MFA
Project leaders: F.B.S. Makonda (SUA); Siri Eriksen
Partners: Sokoine University of Agriculture; Tanzania Tree Seed Agency; UMB

The overall objective is to establish how best lesser known and lesser utilized IAGTS can be optimally produced and sustainably applied to improving income of rural communities while mitigating the effects of climate change. The specific objectives are: i) to identify other suitable lesser known and lesser utilized IAGTS that are available for establishment in the study areas; ii) to determine and document the properties of available lesser known and lesser utilized IAGTS and compare with well-known timbers; iii) to relate the properties of lesser known and lesser utilized IAGTS timber to different uses; and iv) to identify other species which can be grouped together with lesser known and lesser utilized IAGTS for market promotion to different timber stakeholders. This research project will be confined to either Kilosa or Kilolo District in the Morogoro and Iringa regions. Its focus on indigenous agro-forestry timber species is relevant to understanding how local biodiversity and adaptive agricultural systems may be achieved (or not achieved) through REDD+. This project will enhance the understanding of the role of indigenous species in agricultural production, which contributes to reaching both production and adaptation objectives, with particular focus on the poor and value chains within agriculture. These are important linkages in understanding what CSA may mean

in a local context, in particular how it can effectively contribute to adaptation among poor rural populations as well as maintain forest access and environmental integrity. With relation to gender issues, men and women use timber species differently and the role of IAGTS in adaptation of poor populations differ according to the needs and activities of men and women.

Institutional evolutions at macro and micro-levels in the management of water catchments and their influences on local community livelihoods under a climate change scenario in Tanzania

Period: 2011-2015
Funding: MFA
Project leader: G.C. Kajembe (SUA); Paul Vedeld (UMB)
Partners: Sokoine University of Agriculture; Tanzania Forestry Research Institute (TAFORI); Ardhi University (ARU); UMB

This project will assess technical innovations and institutional evolutions at macro and micro-levels in the management of water catchments and their influences on local community livelihoods under a climate change scenario. The reality of climate change and its effects is becoming more apparent globally and locally. As a result land-based production systems have become quite unreliable due to possible shifts in weather patterns adversely affecting livelihoods. The main sectors impacted by climate change include agriculture, forestry, water and fisheries, which are the main means of livelihoods providing food, energy and income. Due to impacts of climate change, local communities, national and international organizations have introduced institutional structures to guide interactions of people with natural resources in order to reduce these impacts. However, the compatibility of policies and local practices from gender perspectives and the outcome of the implemented policies on ground are not known. This research project will use the concept of institutional bricolage in understanding the manner in which the introduced policies in the management of water catchments are borrowed, adapted and combined with existing local institutions in the processes of solving resource management problems by collective action. The objective of this research is to assess the institutional evolutions at micro level in the management of water catchments and their influences on local community livelihoods under climate change scenario. The study will be carried out in Morogoro and Iringa Regions because the important water catchment areas for agriculture and hydropower production are located in these regions. This project will use policy analysis framework and actor oriented approaches as theoretical foundations for understanding institutional development and local community livelihoods in the management of water catchments under climate change scenarios. Regarding the CSA agenda, irrigation as a tool in reducing drought vulnerability is crucial; this project aims to improve the performance of irrigation systems through a focus on irrigation schemes as resource management regimes. Improving water management and increasing hydropower production and performance has elements of fuel-wood saving and fuel-switching elements and thus have rather direct REDD and energy+ dimensions. In addition, increased agricultural productivity may impact on land-clearing for agriculture. Regarding gender issues, there is an explorative gender research component in the project with attempts to study in more detail women's role in irrigation scheme establishment, management, and maintenance.

Farming in Africa and greenhouse gasses (GHG). Can farming in Africa (subsistence and business) both reduce the GHG emission by using climate/resource friendly and sustainable methods/technologies and improve farmers' livelihood?

Period: 2010-2014
Funding: MFA
Project leaders: E. Mtengeti (SUA); J. Abdallah (SUA); Lars Olav Eik (UMB)
Partners: University of Dar es Salaam; Ardhi University; Meteorological Agency; Sokoine University of Agriculture; CICERO; UiO; NILF; NUFU; Yara/Syngenta; Green Resources; UMB

In Tanzania outside the national parks, small-scale farmers are keepers of the land and reduced emission of greenhouse gasses can only take place if farmers find it of benefit. It has been observed that there is a willingness of farmers to intensify their agriculture and plant farm forests if compensated for the latter. Tanzanian agriculture is characterized by lack of inputs resulting in low yields of crops and animals and the wealth of the country is grossly under-utilized. For example, water that could be stored for aquaculture and irrigation runs freely to the sea during rainy seasons, valuable feed from food crops are not stored for times of need and large number of cattle and goats are kept at maintenance level resulting in minimum production. The technologies tested to counter these problems will be new to some of the farming communities, though all (improved soil management, crop cultivation, dairy cattle and goats, aquaculture, fruit and fodder trees and farm forest) have been tried successfully at one or several of the project sites. These strategies will now be tested for their adaption both into on-farm models and further aggravations into community and country levels. Such models have been developed over decades by NILF and more recently by Cicero at the University of Oslo. The main hypothesises to be tested in this study is: *Due to their biological efficiency and proven on-ground-adaptation-rate, agroforestry/farm-forest-based integrated farming systems will improve livelihood and reduce emission of green-house-gasses in Tanzania*. To test the hypothesis, it is suggested that value-chain projects, (based on best-practises from previous PANTIL and Focal projects on food crops such as maize and rice, aquaculture, dairy goats and cattle) will be carried out in addition to some other promising interventions. There is a high potential for building on this project in support of the CSA agenda due to close collaboration with private sector (Yara, Syngenta, Green Resources) as well as a broad-based research group.

Education

MSc Field course, Tanzania: Development and Environment in Practice

Period: 2011-
Funding: Self-financed
Project leader: Lars Olav Eik; Gry Synnevåg
Partners: Sokoine University of Agriculture; UMB

The course EDS 384 is intended for students registered both at UMB and SUA. The aim of the course is that students will i) understand and critically apply concepts and practices of development in the context of natural resource management, and ii) test key concepts in development and resource management in the context of Tanzania. It is expected that some of

the students will also join in some of the research programmes that are undertaken jointly by the two universities, either 'Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-Chains (EPINAV)' or 'Climate Change Impacts, Adaptation and Mitigation in Tanzania (CCIAM)'. Students may join project teams where, under the supervision of scientists from both countries, they can gather their own data for their thesis. Funds for student support are provided by both programmes

---

BSc Field Course, Tanzania: Development and Climate Change, Adaptation and Mitigation

Period: 2012-
Funding: Self-financed
Project leader: Lars Olav Eik
Partners: Sokoine University of Agriculture; CARE; UMB

Students will get the opportunity to understand core issues related to climate change adaptation and mitigation in Tanzania, combining case studies in the field with theory and policy insights. Visits to institutions and presentations by aid and development experts in the start of the course aim to prepare the students for the work with case studies. The course provides i) an introduction to policy and research approaches to climate change in Tanzania; ii) visits to crucial institutions and talks given by aid/development experts and to researchers involved in the CCIAM and EPINAV programmes; iii) a case study of a research based project regarding agriculture and climate change adaptation and mitigation, and iv) learning from the REDD project on Zanzibar regarding mitigating climate change through community forest management and participatory approaches to development. The case studies will give the students a chance to meet, learn from and discuss with researchers and communities directly involved in the projects. Field visits will be complemented with lectures by experts and researchers linked to the projects and institutions involved.

Department of Ecology and Natural Resource Management (INA)

Enhancing the revival of home gardens for improved utility and productivity through the use of proven agroforestry technologies in the northern highlands of Tanzania

Period: 2011-2014
Funding: MFA
Project leaders: P.K.T. Munishi (SUA); Stein Moe (UMB)
Partners: Sokoine University of Agriculture; Tanzania Forestry Research Institute (TAFORI); Agricultural Research Institute (ARI); Open University of Tanzania (OUT); UMB

This project aims to revive, enhance and improve the productivity and wide adoption of appropriate agroforestry technologies in home gardens for increased food security, improved livelihoods and conservation of the natural resource base in the northern highland of Tanzania.

ZAMBIA

Department of International Environment and Development Studies (Noragric)

Conservation Agriculture in Zambia (Programme)

Period: 2011-2015
Funding: MFA
Programme leader: Kjell Esser
Partners: Conservation Farming Unit of the Zambia National Farmers Union; Golden Valley Agricultural Research Trust; University of Zambia; Ministry of Agriculture (Zambia); Bioforsk; UMB

The goal of this project is to contribute to the reduction of rural poverty and environmental stability. The purpose is to provide knowledge to: i) improve the agronomic practices of conservation farming; ii) determine the socio-economic impact of conservation farming; and iii) determine the environmental impact of conservation farming. The programme has resulted in scientific publications in peer-reviewed international journals. This programme coincides with the long-term goals of climate-smart agriculture; it provides knowledge to the large-scale implementation programme under the leadership of Conservation Farming Unit. The programme is a continuation of the programme under the same title that began in 2007. The current programme is aclose research collaboration between key partner institutions within the field of climate-smart agriculture.

Reversing household food insecurity through conservation agriculture: Socio-economic impact of conservation farming in Zambia (PhD Research)

Period: 2008-2012
Funding: UMB
Project leader: PhD student - Progress Hanzwida Nyanga; Supervisor - Jens Aune
Partners: University of Zambia; UMB

This PhD study focuses on the adoption process of conservation agriculture in Zambia. Studies are conducted on the categories of farmers that are adopting CA, the ways in which CA is adopted, why farmers are adopting or not adopting CA and the impact of CA on food security. The research is undertaken through a household study involving 400 farmers, monitoring conservation agriculture in Zambia. One component of the study examines the gender implication of CA. The labour demand in CA system is studied and the use of pesticides in CA is also assessed. This study will generate knowledge with regard to how it is possible to develop CA systems that can benefit different segments of the population.

From maize mono-cropping to conservation agriculture: a multi-perspective analysis of smallholder conservation agriculture in southern, central and eastern Zambia (PhD research)

Period: 2008-2011
Funding: UMB
Project leader: PhD student - Bridget Bwalya Umar; Supervisor - Jens Aune

Partners: University of Zambia; UMB

This PhD study focuses on the environmental and production benefits of CA. The effects of CA on soil properties are studied in plots that have utilized CA for a long period. The study also assesses the economic benefits of CA and compares the economic return of CA with that of conventional agriculture. A system approach is used in order study the total productivity of CA systems. Regarding gender issues, labour use is studied, providing some important information as to how it is possible to develop CA systems that are suitable for women. There are still uncertainties with regard to the production and environmental benefits of conservation agriculture and it is hoped that this project will provide further important information on this.

APPENDIX 2. LIST OF PUBLICATIONS BY UMB STAFF AND STUDENTS RELEVANT TO CLIMATE-SMART AGRICULTURE

Articles in peer-reviewed journals

Abebe, M. H., Oba, G., Angassa, A. and Weladji, R. B. (2006). The role of area enclosures and fallow age in the restoration of plant diversity in northern Ethiopia. *African Journal of Ecology*, 44 (4): 507-514.

Angassa, A. (2005). The ecological impact of bush encroachment on the yield of grasses in Borana rangeland ecosystem. *African Journal of Ecology*, 43 (1): 14-20.

Angassa, A. and Oba, G. (2007). Relating long-term rainfall variability to cattle population dynamics in communal rangelands and a government ranch in southern Ethiopia. *Agricultural Systems*, 94 (3): 715-725.

Angassa, A. and Oba, G. (2008). Herder perceptions on impacts of range enclosures, crop farming, fire ban and bush encroachment on the rangelands of Borana, Southern Ethiopia. *Human Ecology*, 36 (2): 201-215.

Angassa, A. and Oba, G. (2009). Bush encroachment control demonstrations in southern Ethiopia: 1. Woody species survival strategies with implications for herder land management. *African Journal of Ecology*, 47 (1): 63-76.

Angassa, A. and Oba, G. (2010). Effects of grazing pressure, age of enclosures and seasonality on bush cover dynamics and vegetation composition in southern Ethiopia. *Journal of Arid Environments*, 74 (1): 111-120.

Angassa, A., Tolera, A. and Belayneh, A. (2006). The effect of physical environment on the condition of rangelands in Borana. *Tropical grasslands*, 40: 33-39.

Aune, J. B., Alemu, A. and Gautam, K. (2005). Carbon sequestration in rural communities: Is it worth the effort? *Journal of Sustainable Forestry*, 21 (1): 69-79.

Aune, J. B., Doumbia, M. D. and Berthe, A. (2007). Microfertilizing sorghum and pearl millet in Mali - Agronomic, economic and social feasibility. *Outlook on Agriculture*, 36 (3): 199-203.

Aune, J. B. and Bationo, A. (2008). Agricultural intensification in the Sahel - The ladder approach. *Agricultural Systems*, 98 (2): 119-125.

Aune, J. B. and Ousman, A. (2011). Effect of seed priming and micro-dosing of fertilizer on sorghum and pearl millet in Western Sudan. *Experimental Agriculture*, 47 (3): 419-430.

Balesh, T., Zapata, F. and Aune, J. B. (2005). Evaluation of mustard meal as organic fertilizer on tef (*Eragrostis tef* (Zucc) trotter) under field and greenhouse conditions. *Nutrient Cycling in Agroecosystems*, 73 (1): 49-57.

Benjaminsen, T. A., Rohde, R., Sjaastad, E., Wisborg, P. and Lebert, T. (2006). Land reform, range ecology, and carrying capacities in Namaqualand, South Africa. *Annals of the Association of American Geographers*, 96 (3): 524-540.

Benjaminsen, T. A., Derman, B. and Sjaastad, E. (2007). Exploring new understandings of resource tenure and reform in the context of globalisation. *Land Use Policy*, 24 (4): 611-612.

Benjaminsen, T. A. (2008). Savannas and dry forests. Linking people with nature. *Human*

Ecology, 36 (1): 135-136.

Benjaminsen, T. A., Kepe, T. and Brathen, S. (2008). Between global interests and local needs: Conservation and land reform in Namaqualand, South Africa. *Africa*, 78 (2): 223-244.

Benjaminsen, T. A., Aune, J. B. and Sidibe, D. (2010). A critical political ecology of cotton and soil fertility in Mali. *Geoforum*, 41 (4): 647-656.

Berg, T. (2009). Landraces and folk varieties: a conceptual reappraisal of terminology. *Euphytica*, 166 (3): 423-430.

Berge, G. (2009). Internasjonalt miljøsamarbeid og lokale prosesser: om jusens og økonomiens dominerende rolle i multilaterale miljøforhandlinger / Prescription and standardization: on the dominant role of law and economy in multilateral environmental negotiations. *Norsk Antropologisk Tidsskrift*, 20 (1-2): 79-94.

Bezu, S. and Holden, S. T. (2008). Can food-for-work encourage agricultural production? *Food Policy* 33(5): 541-549.

Bukenya, M., Johnsen, F. H. and Gombya-Ssembajjwe, W. (2009). Environmental and Exchange Entitlements from Eucalyptus Woodlots: The case of Mukono district in Uganda. *Forests, Trees and Livelihoods*, 19 (1): 3-17.

Derman, B. and Hellum, A. (2007). Livelihood rights perspective on water reform: Reflections on rural Zimbabwe. *Land Use Policy*, 24 (4): 664-673.

Derman, W. and Hellum, A. (2010). The making and unmaking of unequal property relations between men and women: shifting policy trajectories in South Africa's Land Resolution Process. *Nordic Journal of Human Rights*, 28 (2): 203-229.

Divon, S. A. and Bergstrøm, C. E. (2009). Unintended consequences of development interventions may lead to increased risk for acquisition of diarrheal diseases - a study from the Millennium Villages Project, Ruhiira, Uganda. *Tropical Medicine and International Health*, 14: 105-105.

Eik, L. O., Kifaro, G. C., Kiango, S. M., Nordhagen, Ø. M., Safari, J. and Mtenga, L. A. (2008). Productivity of goats and their contribution to household food security in high potential areas of East Africa: A case of Mgeta, Tanzania. *African Journal of Food Agriculture and Development*, 8 (3): 278-290.

Eriksen, S. E. H., Aldunce, P., Bahinipati, C. S., Martins, R. D., Molefe, J. I., Nhemachena, C., O'Brien, K., Olorunfemi, F., Park, J., Sygna, L., Ulsrud, K. (2011). When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Climate and Development*, 3 (1): 7-20.

Gachathi, F. N. and Eriksen, S. E. H. (2011). Gums and resins: The potential for supporting sustainable adaptation in Kenya's drylands. *Climate and Development*, 3: 59-70.

Gebregziabher, G. and Holden, S. T. (2011). Does irrigation enhance and food deficits discourage fertilizer adoption in a risky environment? Evidence from Tigray, Ethiopia. *Journal of Development and Agricultural Economics* 3(10), 514-528.

Gebregziabher, G. and Holden, S. T. (2011). Distress Rentals and the Land Rental Market as a Safety Net: Evidence from Tigray, Ethiopia. *Agricultural Economics* 42, 45-60.

Glomsrod, S., Wei, T. Y., Liu, G. and Aune, J. B. (2011). How well do tree plantations comply with the twin targets of the Clean Development Mechanism? The case of tree plantations in Tanzania. *Ecological Economics*, 70 (6): 1066-1074.

Habtemichial, K. H., Singh, B. R. and Aune, J. B. (2007). Wheat response to N-2 fixed by faba

bean (*Vicia faba* L.) as affected by sulfur fertilization and rhizobial inoculation in semi-arid Northern Ethiopia. *Journal of Plant Nutrition and Soil Science-Zeitschrift Fur Pflanzenernahrung Und Bodenkunde*, 170 (3): 412-418.

Haddis, A. and Berg, T. (2006). Selectors and non-selectors: agricultural and socio-economic implications of on-farm seed selection in Ethiopia. *Plant Genetic Resources Newsletter* (145): 1-10.

Haug, A., Christophersen, O.A., Kinabo, J., Kaunda, W., Eik, L. O. (2010). Use of dried Kapenta (*Limnothrissa miodon* and *Stolothrissa tanganicae*) and other products based on whole fish for complementing maize-based diets. *African Journal of Food Agriculture, Nutrition and Development*, 10 (5): Electronic journal.

Hella, J. P., Haug, R. and Kamile, I. M. (2011). High global food prices - crisis or opportunity for smallholder farmers in Tanzania? *Development in Practice*, 21 (4-5): 652-665.

Holden, S. T., Barrett, C. and Hagos, F. (2006). Food-for-Work for Poverty Reduction and Promotion of Sustainable Land Use: Can it Work? *Environment and Development Economics* 11: 15-38.

Holden, S. T., Deininger, K. and Ghebru, H. (2011). Tenure Insecurity, Gender, Low-cost Land Certification and Land Rental Market Participation. *Journal of Development Studies* 47(1), 31-47.

Holden, S. T. and Lunduka, R. (In press). Do Fertilizer Subsidies Crowd Out Organic Manures? The Case of Malawi. *Agricultural Economics. In press*

Kamanga, P., Vedeld, P. and Sjaastad, E. (2009). Forest incomes and rural livelihoods in Chiradzulu District, Malawi. *Ecological Economics*, 68 (3): 613-624.

Kaarhus, R. (2010). Women's land rights and land tenure reforms in Malawi: What difference does matriliny make? *Forum for Development Studies*, 37 (2): 171-192.

Lund, T., Nyborg, I., Sæthre, M., Coulibaly, O. and Rahman, M. H. (2010). Farmer field school-IPM impacts on urban and peri-urban vegetable producers in Cotonou, Benin. *International Journal of Tropical Insect Science*, 30 (1): 19-31.

Mamo, G., Sjaastad, E. and Vedeld, P. (2007). Economic dependence on forest resources: A case from Dendi district, Ethiopia. *Forest Policy and Economics*, 9 (8): 916-927.

Mo, M., Weiby, K. V., Urio, N. A., Mtengeti, E. J., Eik, L. O., Sundstøl, F. and Safari, J. (2009). Trends in upgrading crop residues for ruminant feeding. *Tanzania Journal of Agricultural Sciences*, In Press.

Mushi, D. E., Mtenga, L.A., Eik, L.O. (2007). Some factors affecting the quality of meat from ruminants and their relevance to the Tanzanian meat industry – review. *Tanzania Journal of Agricultural Sciences*, 8 (2):173-192.

Mushi, D.E., Safari, J., Mtenga, L. A., Kifaro, G. C., Eik, L. O. (2009). Growth and distribution of non-carcass components of Small East African and F1 Norwegian crossbred goats under concentrate diets. *Livestock Science*, 126: 80-86.

Mushi, D.E., Safari, J., Mtenga, L. A., Kifaro, G. C., Eik, L. O. (2009). Effects of concentrate levels on fattening performance, carcass and meat quality attributes of Small East African x Norwegian crossbred goats fed low quality grass hay. *Livestock Science*, 124: 148-155.

Mushi, D.E., Thomassen, M. S., Kifaro, G. C., Eik, L. O. (2010). Fatty acids composition of minced meat, longissimus muscle and omental fat from Small East African goats

finished on different levels of concentrate supplementation. *Meat Science*, 86:337-342.

Musumali, M. M., Larsen, T. S. and Kaltenborn, B. P. (2007). An impasse in community based natural resource management implementation: the case of Zambia and Botswana. *Oryx*, 41 (3): 306-313.

Mwaseba, D. L., Kaarhus, R., Johnsen, F. H., Mvena, Z. S. K. and Mattee, A. Z. (2006). Beyond adoption/rejection of agricultural innovations - Empirical evidence from smallholder rice farmers in Tanzania. *Outlook on Agriculture*, 35 (4): 263-272.

Mwaseba, D. L., Kaarhus, R., Johnsen, F. H., Mattee, A. Z. and Mvena, Z. S. K. (2007). Rice for food and income - Assessing the impact of rice research on food security in the Kyela and Kilombero districts of Tanzania. *Outlook on Agriculture*, 36 (4): 231-236.

Nakakaawa, C., Aune, J. and Vedeld, P. (2010). Changes in carbon stocks and tree diversity in agro-ecosystems in south western Uganda: what role for carbon sequestration payments? *New Forests*, 40 (1): 19-44.

Nakakaawa, C. A., Vedeld, P. O. and Aune, J. B. (2011). Spatial and temporal land use and carbon stock changes in Uganda: implications for a future REDD strategy. *Mitigation and Adaptation Strategies for Global Change*, 16 (1): 25-62.

Njanja, J. C. and Oba, G. (2010). The Turkana camel breed in north-western Kenya: lactation characteristics. *Outlook on Agriculture*, 39 (1): 49-55.

Nurfeta, A., Tolera, A., Eik, L. O. and Sundstøl, F. (2008). The supplementary value of different parts of enset (*Ensete ventricosum*) to sheep fed wheat straw and *Desmodium intortum* hay. *Livestock Science*, 119 (1-3): 22-30.

Nurfeta, A., Tolera, A., Eik, L. O. and Sundstøl, F. (2008). Yield and mineral content of ten enset (*Ensete ventricosum*) varieties. *Tropical Animal Health and Production*, 40 (4): 299-309.

Nurfeta, A., Tolera, A., Eik, L. O. and Sundstøl, F. (2009). Effect of enset (*Ensete ventricosum*) leaf supplementation on feed intake, digestibility, nitrogen utilization and body weight gain of sheep fed untreated or urea and calcium oxide-treated wheat straw. *Livestock Science*, 122 (2-3): 134-142.

Nurfeta, A., Tolera, A., Eik, L. O. and Sundstøl, F. (2009). Feeding value of enset (*Ensete ventricosum*), *Desmodium intortum* hay and untreated or urea and calcium oxide treated wheat straw for sheep. *Journal of Animal Physiology and Animal Nutrition*, 93 (1): 94-104.

Nyanga, P. H., Johnsen, F. H., Aune, J. B. and Kalinda, T. H. (2011). Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia. *Journal of Sustainable Development*, 4 (4): 73-85.

Nyombi, K., Esser, K. B. and Zake, J. Y. K. (2006). Efforts by small-scale farmers to maintain soil fertility and their impacts on soil properties, Luwero district, Uganda. *Journal of Sustainable Agriculture*, 27 (4): 5-23.

Oba, G. and Kaitira, L. M. (2006). Herder knowledge of landscape assessments in arid rangelands in northern Tanzania. *Journal of Arid Environments*, 66 (1): 168-186.

Oba, G., Byakagaba, P. and Angassa, A. (2008). Participatory monitoring of biodiversity in East African grazing lands. *Land Degradation and Development*, 19 (6): 636-648.

Oba, G., Sjaastad, E. and Roba, H. G. (2008). Framework for participatory assessments and implementation of global environmental conventions at the community level. *Land*

Degradation and Development, 19 (1): 65-76.

Oba, G., Weladji, R. B., Msangameno, D. J., Kaitira, L. M. and Stave, J. (2008). Scaling effects of proximate desertification drivers on soil nutrients in northeastern Tanzania. *Journal of Arid Environments*, 72 (10): 1820-1829.

Ousman, A. and Aune, J. B. (2011). Effect of seed priming and micro-dosing of fertilizer on groundnut, sesame and cowpea in western Sudan. *Experimental Agriculture*, 47 (3): 431-443.

Pedersen, J. and Benjaminsen, T. A. (2008). One leg or two? Food security and pastoralism in the northern Sahel. *Human Ecology*, 36 (1): 43-57.

Roba, H. G. and Oba, G. (2008). Integration of herder knowledge and ecological methods for land degradation assessment around sedentary settlements in a sub-humid zone in northern Kenya. *International Journal of Sustainable Development and World Ecology*, 15 (3): 251-264.

Roba, H. G. and Oba, G. (2009). Community participatory landscape classification and biodiversity assessment and monitoring of grazing lands in northern Kenya. *Journal of Environmental Management*, 90 (2): 673-682.

Roba, H. G. and Oba, G. (2009). Efficacy of integrating herder knowledge and ecological methods for monitoring rangeland degradation in northern Kenya. *Human Ecology*, 37 (5): 589-612.

Safari, J., Mtenga, L. A., Eik, L. O., Sundstøl, F. and Johnsen, F. H. (2008). Analysis of three goat production systems and their contribution to food security in semiarid areas of Morogoro, Tanzania. *Livestock Research for Rural Development*, 20 (5): 741-746.

Safari, J., Mushi, D. E., Mtenga, L. A., Kifaro, G. C. and Eik, L. O. (2009). Carcass composition and meat quality attributes of Small East African goats and Red Maasai sheep fed wheat straw-based diets. *Journal of Livestock Science*, Under review.

Safari, J., Mushi, D. E., Mtenga, L. A., Kifaro, G. C. and Eik, L. O. (2009). Effects of concentrate supplementation on carcass and meat quality attributes of feedlot finished Small East African goats. *Livestock Science.* 125: 266-274.

Safari, J., Mushi, D. E., Mtenga, L. A., Kifaro, G. C., Eik, L. O. (2011). Growth, carcass and meat quality parameters of Red Maasai sheep fed wheat straw- based diets. *Tropical Animal Production and Health*, 43 (1): 87-89.

Safari, J., Mushi, D. E., Mtenga, L. A., Kifaro, G. C., Eik, L. O. (2011). Growth, carcass and meat quality parameters of Small East African goats fed wheat straw-based diets. *Livestock Science*, 135 (2): 168 - 176.

Safari, J., Mushi, D. E., Kifaro, G. C., Mtenga, L. A., Eik, L. O. (2011). Seasonal variation in chemical composition of native forages, grazing behaviour and some blood metabolites of Small East African goats in a semi-arid area of Tanzania. *Animal Feed Science and Technology*, 164 (1-2): 62.

Schreinemachers, P., Berger, T. and Aune, J. B. (2007). Simulating soil fertility and poverty dynamics in Uganda: A bio-economic multi-agent systems approach. *Ecological Economics*, 64 (2): 387-401.

Sheuyange, A., Oba, G. and Weladji, R. B. (2005). Effects of anthropogenic fire history on savanna vegetation in northeastern Namibia. *Journal of Environmental Management*, 75 (3): 189-198.

Stave, J., Oba, G., Eriksen, A. B., Nordal, I. and Stenseth, N. C. (2005). Seedling growth of *Acacia tortilis* and *Faidherbia albida* in response to simulated groundwater tables. *Forest Ecology and Management*, 212 (1-3): 367-375.

Stave, J., Oba, G., Nordal, I. and Stenseth, N. C. (2006). Seedling establishment of *Acacia tortilis* and *Hyphaene compressa* in the Turkwel riverine forest, Kenya. *African Journal of Ecology*, 44 (2): 178-185.

Talle, S. B., Chenyabuga, W. S., Fimland, E., Syrstad, O., Meuwissen, T. and Klungland, H. (2005). Use of DNA technologies for the conservation of animal genetic resources: A review. *Acta Agriculturae Scandinavica Section a-Animal Science*, 55 (1): 1-8.

Tarimo, A. J. P., Johnsen, F. H., Nchimbi-Msolla, S., Mbaga, S. H., Kilima, F. T. M., Sesabo, J. K., Abdallah, J. M. and Iranga, G. M. (2007). The capacity of on-farm research in reducing poverty: experiences from twenty seven projects in Tanzania. *Tanzania Journal of Agricultural Sciences*, 8 (2): 103-114.

Tiki, W., Oba, G. and Tvedt, T. (2011). Human stewardship or ruining cultural landscapes of the ancient Tula wells, southern Ethiopia. *Geographical Journal*, 177: 62-78.

Tolera, A., Tsegaye, B. and Berg, T. (2008). Effects of variety, cropping year, location and fertilizer application on nutritive value of durum wheat straw. *Journal of Animal Physiology and Animal Nutrition*, 92 (2): 121-130.

Tsegaye, B. and Berg, T. (2007). Utilization of durum wheat landraces in East Shewa, central Ethiopia: Are home uses an incentive for on-farm conservation? *Agriculture and Human Values*, 24 (2): 219-230.

Tsegaye, B., Tolera, A. and Berg, T. (2008). Livestock production and feed resource constraints in Akaki and Lume districts, central Ethiopia. *Outlook on Agriculture*, 37 (1): 15-21.

Tsegaye, D., Moe, S. R., Vedeld, P. and Aynekulu, E. (2010). Land-use/cover dynamics in Northern Afar rangelands, Ethiopia. *Agriculture Ecosystems and Environment*, 139 (1-2): 174-180.

Tsehaye, Y., Berg, T., Tsegaye, B. and Tanto, T. (2006). Farmers' management of finger millet (*Eleusine coracana* L.) diversity in Tigray, Ethiopia and implications for on-farm conservation. *Biodiversity and Conservation*, 15 (13): 4289-4308.

Tulema, B., Aune, J. B. and Breland, T. A. (2007). Availability of organic nutrient sources and their effects on yield and nutrient recovery of tef *Eragrostis tef* (Zucc.) Trotter and on soil properties. *Journal of Plant Nutrition and Soil Science*, 170 (4): 543-550.

Tulema, B., Aune, J. B., Johnsen, F. H. and Vanlauwe, B. (2008). The prospects of reduced tillage in tef (*Eragrostis tef* Zucca) in Gare Arera, West Shawa Zone of Oromiya, Ethiopia. *Soil and Tillage Research*, 99 (1): 58-65.

Vedeld. P., Angelsen, A. Bojo, J., Sjaastad E. and B.G. Kobugabe (2007). Forest environmental incomes and the rural poor. *Forest Policy and Economics* 9: 869–879.

Weiby, K. V., Mo, M., Mtengeti, E. J., Urio, N. A., Eik, L. O. and Safari, J. (2009). A combination of urea and lime as agent for straw treatment in Tanzania. *Tanzania Journal of Agricultural Sciences*, In Press.

Books and book chapters

Aune, J. B., Berthe, A. and Doumbia, M. D. (2005). Conservation agriculture as an approach to agricultural development in dryland areas of Mali. In Omanya, G. O. and Pasternak, D. (eds) *Sustainable agriculture systems for the drylands: proceedings of the International Symposium for Sustainable Dryland Agriculture System*s*:* 2 -5 December 2003 Niamay, Niger, pp. 239-248. Patancheru, India: ICRISAT.

Aune, J. B. (ed.) IIRR and ACT. (2005). *Conservation agriculture: a manual for farmers and extension workers in Africa. Nairobi: International Institute of Rural Reconstruction*; African Conservation Tillage Network, Harare. 251 pp.

Aune, J. B., Asrat, R., Teklehaimanot, D. and Tulema, B. (2006). Zero Tillage or Reduced Tillage: The Key to Intensification of the Crop? Livestock System in Ethiopia. In Pender, J., Place, F. and Ehui, S. (eds) *Strategies for Sustainable Land Management in the East African Highlands*, pp. 309-318. Washington DC: International Food Policy Research Institute.

Barrett, C., Holden, S. and Clay, D. (2005). Can Food-For-Work Programs Reduce Vulnerability? In S. Dercon, (ed.), *Insurance Against Poverty*. Oxford University Press, Oxford.

Coulibaly, A., Aune, J. B. and Doumbia, M. D. (2007). Agricultural development in the drylands of West Africa. In Nærstad, A. (ed.) *Africa can feed itself*, pp. 131-138. Oslo: Utviklingsfondet.

Ebei, A. P., Oba, G. and Akuja, T. (2008). Long-term impacts of droughts on pastoral production and trends in poverty in north-western Kenya: An evaluation of 14-year drought early warning data series. In Sánchez, J. M. (ed.) *Droughts: Causes, Effects and Predictions*, pp. 103-138: Nova Science Publishers, Inc.

Hagos, F. and Holden, S. T. (2011). Fertilizer Use by Smallholder Households in Northern Ethiopia: Does Risk Aversion Matter? In R. A. Bluffstone and G. Köhlin (eds.) *Agricultural Investment and Productivity. Building Sustainability in East Africa.* RFF Press, Washington, DC and London.

Holden, S. T. and Bezabih, M. (2008). Gender and Land Productivity on Rented Out Land: Evidence from Ethiopia. In Holden, S. T., Otsuka, K. and Place, F. (Eds.). *The Emergence of Land Markets in Africa: Impacts on Poverty and Efficiency*. Resources For the Future Press, Washington D.C.

Holden, S. T., Shiferaw, B. and Pender, J. (2006). Policies for Poverty Reduction, Sustainable Land Management and Food Security – A Bio-economic Model with Market Imperfections. In J. Pender, F. Place and S. Ehui (eds.), *Strategies for Sustainable Land Management in the East African Highlands*. International Food Policy Research Institute, Washington, D. C.

Oba, G. (2007). Challenges and opportunities for pastoralism in Africa: degrading rangelands or maintaining resilience. In Rosati, A., Tewolde, A. and C, M. (eds) *Animal Production and Animal Science Worldwide* pp. 317-328. Wageningen: Wageningen Academic Publishers.

Roba, H. G. and Oba, G. (2010). Framework for integrating indigenous knowledge and ecological methods for implementation of Desertification Convention. In Runas, J. and

Dahlgren, T. (eds) *Grassland Biodiversity: Habitat Types, Ecological Processes and Environmental Impacts*, pp. 135-177. New York: Nova Science Publishers.

Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007: Agriculture. In Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A. (eds) *Climate Change 2007. Mitigation. Contribution of 31 Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge

Vatn, A. and Angelsen, A. (2009). Options for a national REDD+ architecture. In Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W. D. and Wertz-Kanounnikoff, S. (eds) *Realising REDD+: National strategy and policy options*, pp. 57-74. Bogor, Indonesia: CIFOR.

Reports and conference proceedings

Aune, J. B. and Berg, T. (2009). The environment and development link in BN-funded projects, 9788299412797. Oslo: Norsk Misjons Bistandsnemd. 58 pp.

Aune, J. B. (2007). Best development techniques and approaches for agricultural improvement in the Sahel. Oslo: Drylands Coordination Group. 34 pp.

Aune, J. B. (2008). Adapting dryland agriculture in Mali to climate change. A report for the Norwegian Ministry of Environment. Ås: Noragric. Bayu, W., Bayissa, M., Manjur, K., Yeshanew, A., Agdo, E., Sime, G., Tolera, A., Belay, T., Aune, J. B. and Ayele, A. A. (2010). Results of Ecofarm Action Research Activities in Three Project Areas in Ethiopia. *DCG report*. Oslo: Drylands Coordination Group. 54 pp.

Behrman, J., Meinzen-Dick, R. and Quisumbing, A. (2011). The gender implications of large-scale land deals. *IFPRI Discussion Paper 01056*. Washington, DC: International Food Policy Research Institute.

Betru, N., Nyborg, I. and Ali, J. (2005). Exploring ecological and socio-economic issues for the improvement of area enclosure management: a case study from Ethiopia. *DCG report*. Ås: Drylands Coordination Group. 55 pp.

Bezabih, M. and Holden, S. T. (2006). Tenure insecurity, transaction costs in the land lease market and their implications for gendered productivity differentials. 26th International Conference of the International Agricultural Economics Association, Brisbane, Australia, 12-18. August, 2006.

Bie, S. W. and Lang, T. (2006). NASFAM: National Smallholder Farmers' Association of Malawi. Evaluation of Norwegian support to NASFAM's Strategic Development Programme 2003-2006: Appraisal of programme document for support to NASFAM's Strategic Development Programme 2007-2011. Noragric Report 38. Ås: Noragric.

Bie, S. W. (2009). The Establishment of a Centre of Excellence in Natural Resource Management at the University of Zambia. Noragric Report 46. Ås: Noragric. 39 pp.

Bie, S. W., Kuntashula, E. and Mughogho, L. K. (2009). Community Markets for Conservation Programme (COMACO) Phase II. Appraisal of the proposal to the Royal Norwegian Embassy, Lusaka, Zambia. Noragric Report 49. Ås: Noragric. 37pp.

Bie, S. W., Mkwambisi, D. and Gomani, M. (2008). Climate change and rural livelihoods in Malawi: Review study report of Norwegian support to FAO and SCC in Malawi, with a

note on some regional implications. Noragric Report 41. Ås: Noragric. 40 pp.

Bie, S. W. and Phiri, S. (2010). Mid-term review of the Strategic Development Programme 2006-2011 (SDP2) of the National Smallholder Farmers' Association of Malawi. Noragric Report 56. Ås: Noragric. 36 pp.

Coulibaly, A., Aune, J. B. and Sissoko, P. (2010). Etablissement des cultures vivrières dans les zones sahélienne et soudano sahélienne du Mali. GCoZA Report 60. Oslo: Drylands Coordination Group. 65 pp.

Doumbia, M. D., Berthe, A. and Aune, J. B. (2005). Integrated Plant Nutrition Management in Mali. Summary Report 1998-2004. *DCG Report*. Oslo: Drylands Coordination Group.

Eriksen, S. and Marin, A. (2011). Pastoral pathways: Climate change adaptation lessons from Ethiopia. Oslo: The Development Fund/Utviklingsfondet. 51 pp.

Haug, R., Tessema, W., Lemma, T., Berg, T., Phiri, A. R., Banda, J. W., Kaunda, E., Hella, J., Kamile, I. and Schulz, C.E. (2009). High global food prices: crisis or opportunity for smallholder farmers in Ethiopia, Malawi and Tanzania. Noragric Report 48. Ås: Noragric. 186 pp.

Holden, S. T. and Lunduka, R. (2010). Impacts of the fertilizer subsidy program in Malawi: Targeting, household perceptions and preferences. Report to NORAD. Department of Economics and Resource Management, Norwegian University of Life Sciences, Ås.

Holden, S. T. and Lunduka, R. (2010). The Political Economy of Targeted Input Subsidies in Malawi. Paper presented at the NFU conference, Oslo, 25-26.November, 2010. Revised and submitted to Forum for Development Studies

Holden, S. T. and Lunduka, R. (2010). Too Poor to be Efficient? Impacts of the Targeted Fertilizer Subsidy Program in Malawi on Farm Plot Level Input Use, Crop Choice and Land Productivity. Report to NORAD. Department of Economics and Resource Management, Norwegian University of Life Sciences, Ås.

Holden, S. T. and Lunduka, R. (2010). Yara, the Fertilizer Industry and the Impacts on Small Farmers in Malawi. Understanding the Issues 1/2010. Norwegian Church Aid, Lilongwe and Oslo.

Holden, S. T. and Lunduka, R. (2011). Cash Constraints and Sticky Input Expenditures: Experimental Evidence from Malawi. Paper presented at the Annual Conference of Norwegian Economists at Handelshøgskolen, Bergen, January 5-7, 2011. Revised and submitted to American Journal of Agricultural Economics.

Holden, S. T. and Sietchiping, R. (2010). Land, Environment and Climate Change. Challenges, Responses and Tools. Global Land Tools Network, UN-HABITAT, Nairobi.

Holden, S. T. and Tefera, T. (2008). From Being the Property of Men to Becoming Equal Owners? Early Impacts of Land Registration and Certification on Women in Southern Ethiopia. Final Research Report submitted to UN-HABITAT, Shelter Branch, Land Tenure and Property Administration Section. Nairobi.

Holden, S. T. and Tefera, T. (2008). Early Impacts of Land Registration and Certification on Women in Southern Ethiopia. Summary Report, UN-HABITAT, Shelter Branch, Land Tenure and Property Administration Section. Nairobi.

Holden, S. T., Kaarhus, R. and Lunduka, R. (2006). Land policy reform: the role of land markets and women's land rights in Malawi. Noragric Report No. 36. Ås: Noragric.

Holden, S. T., Shiferaw, B. and Pender, J. (2005). *Policy Analysis for Sustainable Land*

Management and Food Security – A Bio-economic Model with Market Imperfections. Research Report 140. International Food Policy Research Institute, Washington D. C.

Ikdahl, I., Hellum, A., Kaarhus, R. and Benjaminsen, T. A. (2005). Human rights, formalization and women's land rights in southern and eastern Africa. Noragric Report 26. Ås: Noragric. 120 pp.

Johnsen, F. H., Mbaga, S. H., Nchimbi-Msolla, S., Bakari, A. and Iranga, G. M. (2006). Improving livelihoods through agricultural and natural resources research: baseline data survey report 9987640338. Morogoro: PANTIL, Programme for Agricultural and Natural Resources Transformation for Improved Livelihoods, Sokoine University of Agriculture. 80 pp.

Johnsen, F. H., Mwaseba, D. and Mombo, F. (2009). Farmer perspectives on the usefulness of technologies introduced by on-farm research. The case of the TARP II - SUA programme. Noragric Report 50. Ås: Noragric. 72 pp.

Kaarhus, R. and Nyirenda, R. (2006). Decentralization in the agricultural sector in Malawi: policies, processes and community linkages. A status report. Noragric Report 32 Ås: Noragric. 56 pp.

Kaarhus, R., Haug, R., Hella, J. P. and Makindara, J. R. (2010) Agro-investment in Africa – Impact on Land and Livelihoods in Mozambique and Tanzania. Noragric Report No. 53. Ås: Noragric.

Kaunda, E., Wisborg, P., Masangano, C., Siambi, M. and Madzonga, O. (2007). A study of lessons learned from the Shire Highlands Sustainable Livelihoods Programme for possible application to the Malawi Lake Basin Programme. Lilongwe: Bunda College, Noragric and ICRISAT. 74 pp.

Kinabo, L., Batamuzi, E. K., Tarimo, A. K. P. R., Lyimo-Macha, J., Malimbwi, R. E., Makungu, P. J., Nyaki, A. S., Madata, C. and Johnsen, F. H. (2005). Final report of the project Food security and household income for smallholder farmers in Tanzania: Applied research with emphasis on women, under the Tanzania Agricultural Research Project Phase Two (TARP II). Morogoro: Sokoine University of Agriculture, TARP II SUA Project. 58 pp.

Lwesya, A. H. and Vedeld, P. (2008). Step by Step! Livelihoods, Social Institutions and Treadle Pump Adoption, Kasungu District, Malawi. Noragric Working Paper 43. Ås: Noragric. 47 pp.

Maliondo, S. M. S., Larsen, T. S. and Boddens Hosang, J. A. A. (2010). Developing the science, economics and governance of ecosystem service payments in climate-prone socio-economies in Africa - getting scholars and practitioners together for research and capacity building that matters: a contribution to Norway's support of REDD. *Noragric Report 52*. Ås: Noragric. 56 pp.

Nyanga, P. H., Johnsen, F. H., Kalinda, T.H. (2011). Gendered Impacts of Conservation Agriculture among Smallholder Farmers in Zambia. Trends and Future of Sustainable Development Conference, Finland. 9-10 June 2011.

Vatn, A. and Vedeld, P. (2011). Getting Ready! A Study of National Governance Structures for REDD+. *Noragric report* 59. Ås: Noragric. 43 pp.

Vatn, A., Vedeld, P., Petursson, J. G. and Stenslie, E. (2009). The REDD direction: the potential for reduced forest carbon emissions, biodiversity protection and enhanced

development: a desk study with special focus on Tanzania and Uganda. *Noragric report* 51. Ås: Noragric. 148 pp.

Vedeld, P. and Kengera, Z. A. (2006). The fast track initiative: an assessment of a public-private partnership process on developing the fertilizer value chain in Tanzania. *Noragric report 37.* Ås: Noragric. 74 pp.

Master and PhD Theses at UMB/NLH

Abbas, D. (2009). *Land access and livelihood security in expropriated areas: the Newmont Ghana Gold approach*. Ås. 137 pp.

Aemun, P. E. (2006). *Re-evaluation of Drought Early Warning System (EWS) time-series data and the role of indigenous knowledge for drought management in Turkana District, Kenya*. Ås. 95 pp.

Angassa, A. (2007). *The dynamics of savanna ecosystems and management in Borana, southern Ethiopia*. Noragric.

Athuman, K. Y. (2006). *Social and ecological resilience of mangrove ecosystems: lessons from integrated coastal management interventions in Dar es Salaam, Tanzania*. Ås. 58 pp.

Batgerel, M. (2006). *Comparative socio-economic analysis of nomadic and agro-pastoralist households in the Central Province of Mongolia*. Ås. 58 pp.

Borge, E. S. (2010). *Conservation farming in the Central and Southern provinces of Zambia: a study of the characteristics of cf and the reasons for adoption*. Ås.70 pp.

Buke, W. T. (2006). *Adoption of farming among the Obbu Borana of Northern Kenya*. Ås. 79 pp.

Buseth, J. T. (2009). *Conflicting livelihoods and resource scarcity in 'the time of global warming': the political ecology of a farmer-herder conflict in Mopti, Mali*. Ås. 116 pp.

Byakagaba, P. (2005). *The Banyarwanda pastoralists herder knowledge of range management in Kiboga district, Uganda*. Ås. 35 pp.

Chaltu Dula, B. (2006). *Effects of traditional and project water ponds and herder perceptions on the vegetation changes in Borana rangelands of Southern Oromia, Ethiopia*. Ås. 42 pp.

Chande, M. (2010). *Artisanal fishery of octopus in relation to local livelihoods: in Mafia District, Tanzania*. Ås.53 pp.

Chinangwa, L. L. R. (2006). *Adoption of soil fertility improvement technologies among smallholder farmers in Southern Malawi*. Ås. 67 pp.

Compaore, M. N. (2005). *Gender roles in decision-making on allocation of household resources in Lungwena, Malawi*. Ås. 97 pp.

Dabasso, B. H. (2006). *Herder knowledge of landscape scale biodiversity monitoring in Marsabit central, Northern Kenya*. Ås. 48 pp.

Dembele, A. (2006). *Stakeholders' perception of land degradation and the management in Bamba, Mali*. Ås. 37 pp.

Dembélé, Y. (2006). *Land degradation and its impact on livelihood on Malian semi-arid zone, Nara*. Ås. 41 pp.

Doti, A. T. (2005). *Rural ties and urban opportunities among Borana labour migrants to Nairobi, Kenya*. Ås. 90 pp.

Doumbia, D. (2006). *An integrated herder knowledge and ecological methods for assessment*

of rangeland in Nara, north-western Mali. Ås. 36 pp.

Ellingseter, M. (2006). *The politics of poverty reduction: power relations in the making of Ugands's PRSP*. Ås. 100 pp.

Elmakki, O. A. O. (2006). *Challenges and possibilities of drip and canal irrigation in Northern Sudan*. Ås. 65 pp.

Fongoro, S. (2006). *Response of biodiversity to radial distances from traditional wells in Haoussa, Mali*. Ås. 33 pp.

Freim, L. O. (2008). *How will small-scale farmers in Zambia benefit from growing of Jatropha?* Ås. 90 pp.

Gambare, S. L. (2006). *Understanding the potential of indigenous knowledge and information management system: a comparative study between the Ariaal and Rendille pastoralist of Northern Kenya*. Ås.

Gizachew Kebede, B. (2008). *Agricultural extension and its impact on food crop diversity and the livelihood of farmers in Guduru, Eastern Wollega, Ethiopia*. Ås. 74 pp.

Gyasi, K. M. (2009). *Impact of Jatropha production on access to land, food security and livelihoods in the Yendi District of Ghana*. Ås. 64 pp.

Habimana, D. (2008). *Drylands ecofarming: an analysis on ecological farming prototypes in two Sahelian zones: Koro and Bankass in Mali*. Ås. 75 pp.

Kagona, J. D. Z. (2008). *The incidence of Bacterial wilt (Ralstonia solanacearum) in informal potato planting material used by farmers in Dedzaand Ntcheu districts of Malawi*. Ås.73 pp.

Kamanga, P. (2005). *Forest environmental incomes and rural livelihoods in Chiradzulu district, Malawi*. Ås. 78 pp.

Kebede, E. Y. (2010). *Micro and small enterprise (MSE) development: challenges and opportunities: the case of MSE programs in the city of Addis Ababa, Ethiopia*. Ås. 71 pp.

Kgosikoma, O. E. (2006). *Effects of climate variability on livestock population dynamics and community drought management in Kgalagadi, Botswana*. Ås. 57 pp.

Khalif, Z. K. (2010). *Pastoral transformation: Shifta-war, livelihood, and gender perspectives among the Waso Borana in Northern Kenya.* Noragric.

Khwarae, G. M. (2006). *Community perceptions of rangeland degradation and management systems in Loologane and Shadishadi, Kweneng North, Botswana*. Ås. 55 pp.

Kistler, S. B. (2009). *The political ecology of community based forest management in Suledo, Tanzania*. Ås. 100 pp.

Leutlwetse, C. (2006). *Farmers' perception of socio-economic constraints and coping strategies in crop production in Mopipi, Botswana*. Ås. 60 pp.

Lund, T. (2007). *Impact of an integrated pest management project on urban and peri-urban vegetable producers in Cotonou, Benin*. Ås. 176 pp.

Marta Tesfaye, T. (2009). *Impact of commercial vegetable production on the household livelihoods in Guder (Indris watershed), Ethiopia*. Ås. 87 pp.

Meskerem Tadesse, B. (2008). *Analysis of rural poverty and its determinants in Wegera district, Northwestern Ethiopia*. Ås. 45 pp.

Minwary, M. Y. (2009). *Politics of participatory wildlife management in Enduimet WMA, Tanzania*. Ås. 61 pp.

Mugerwa, N. (2005). *Wetland management and oil palm growing in Lake Nabugabo Wetland System, Uganda*. Ås. 65 pp.

Musumali, M. M. (2005). *Comparing community based natural resource management regimes and local attitude towards them in Zambia and Botswana*. Ås. 65 pp.

Mwaseba, D. (2005). *Impact of agricultural research: a study of on-farm development effects of agricultural research in Southern Highlands and Eastern Zones of Tanzania*. Noragric.

Nakakaawa, C. 2011. Potentials, policies and projects on carbon sequestration at national, local and household levels in Uganda. PhD thesis, Noragric, Norwegian University of Life Sciences, Ås, Norway.

Nansubuga, F. (2005). *Biomass accumulation, carbon sequestration potential and profitability of plantation forests in Uganda*. Ås. 45 pp.

Nilsen, L. H. (2009). *Institutions and illusions: community-based wildlife management in Kilosa District, Tanzania*. Ås. 73 pp.

Nyanga, P. H. (2006). *Impact of agricultural policy changes on household food security among small-scale farmers in Southern Zambia: master thesis*. Ås. 98 pp.

Omer, T. E. (2005). *Farming in the desert: institutions and mechanisms that make agriculture as a living possible for the Hawawir pastoralists in Northern Sudan*. Ås. 85 pp.

Patel, S. (2009). *Evolution of water management, institutions and livelihood adaptation on Usangu plains of Tanzania*. Ås. 153 pp.

Petursson, J. G. (2011). *Transboundary protected area governance: An institutional approach. The case of Mt. Elgon, Uganda and Kenya*, 29: UMB.

Refseth, T. H. D. (2010). *Norwegian carbon plantations in Tanzania: towards sustainable development?* Ås. 113 pp.

Safari, J. (2005). *Aspects of goat farming in Eastern zone of Tanzania*. Ås. 52 pp.

Saini, I. M. (2008). *Survey of virus incidence in farmers' self-supply informal potato planting materials in Dedza and Ntcheu districts of Malawi*. Ås. 62 pp.

Selam Ataklt, H. (2005). *Vulnerable livelihoods of female-headed households in northern Ethiopia, Tigray*. Ås. 72 pp.

Selemon Asefa, N. (2009). *The twin objectives of clean development mechanism: are they really conflicting?* Ås. 60 pp.

Stene, R. (2007). *Potential for soil carbon sequestration through rehabilitation of degraded lands in the Baringo district, Kenya*. Ås. 33 pp.

Stenslie, E. (2010). *The role of carbon offsets in reducing emissions and contributing towards sustainable development: can REDD as a market based carbon offset mechanism generate carbon emission reduction projects with biodiversity and livelihood benefits?* Ås. 110 pp.

Tache, B. (2008). *Pastoralism under stress: resources, institutions and poverty among the Borana Oromo in Southern Ethiopia*, 2008:33:00: Universitetet for miljø- og biovitenskap.

Tayor, M. N. (2008). *Challenges of traditional irrigation in Nkongle, Cameroon*. Ås. 57 pp.

Teshome Hunduma, M. (2006). *Local group genetic resource utilization and management in Gindeberet, west central Ethiopia*. Ås. 113 pp.

Tessema, A. J. (2008). *Livelihood adaptation, risks and vulnerability in rural Wolaita,*

Ethiopia. Noragric.

Tewodros Firdissa, D. (2007). *Livelihood dependence on urban agriculture in Addis Ababa, Ethiopia*. Ås. 79 pp.

Thorkildsen, K. (2006). *Socio-economic and ecological analysis of a privately managed marine protected area: Chumbe Island Coral Park, Zanzibar*. Ås. 74 pp.

Tsegaye, B. (2005). *Incentives for on-farm conservation in a centre of diversity: a case study of durum wheat (Triticum turgidum L.) landraces from East Shewa, central Ethiopia*. Noragric.

Tulema, B. (2005). *Integrated plant nutrient management in crop production in the Central Ethiopian Highlands.* Noragric.

Tumusiime, D. M. (2006). *Dependence on environmental income by households around Rwenzori Mountain National Park, Western Uganda*. Ås.

Wapalila, G. J. (2008). *Protected areas, local people livelihoods and conflicts: a case study of Mikumi National Park in Tanzania*. Ås. 98 pp.

Wariro, M. D. (2008). *Food, culture and gender: men's and women's knowledge and perception and their influence on food production, consumption, and storage in Magubike village, Northern highland of Tanzania*. Ås. 86 pp.

Wisborg, P. (2006). *'It is our land': human rights and land tenure reform in Namaqualand, South Africa.* Noragric.