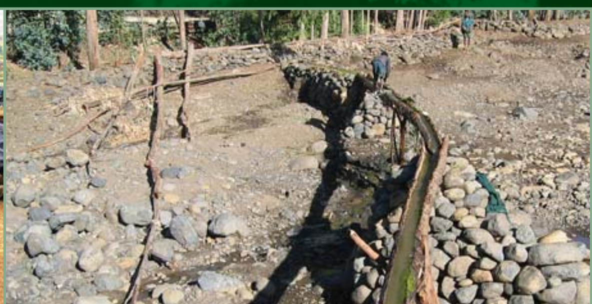
Strengthening Capacity for Climate Change Adaptation in the Agriculture Sector in Ethiopia

Proceedings from National Workshop held in Nazreth, Ethiopia



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ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

ENVIRONMENT [CLIMATE CHANGE] BIOENERGY MONITORING AND ASSESSMENT

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ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER
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ENVIRONMENT [CLIMATE CHANGE] BIOENERGY MONITORING AND ASSESSMENT

Strengthening Capacity for Climate Change Adaptation in the Agriculture Sector in Ethiopia

Proceedings from National Workshop held in Nazreth, Ethiopia 5-6 July 2010

ORGANIZERS:
Climate, Energy and Tenure Division
Natural Resources Management and Environment Department
Food and Agriculture Organization of the United Nations, Rome

Climate Change Forum (Ethiopia)

Sida

CCF-E
Climate Change Forum-Ethiopia

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The task of preparing the proceedings on the basis of several contributors in various formats and styles has been a very challenging one. I am most thankful for the substantive contributions of Meshack Malo (FAO Subregional Office for East Africa), Gebru Jember (Climate Change Forum - Ethiopia) and Ann Woodfine. The editorial contribution of Stephanie Robinson has been most valuable in finalizing this publication and am grateful for her assistance. I am also thankful for the support of Joanne Morgante (Designer), Trina Hershkovitz and Ane Louise Gaudert.

This national workshop ***Strengthening Capacity for Climate Change Adaptation in the Agriculture Sector in Ethiopia*** and the publication of these proceedings were supported through the fund provided by the Swedish International Development Authority (Sida) to FAO. The climate change adaptation activities in East Africa (notably in Ethiopia and Kenya), aims to strengthen capacity and build resilience of the smallholder sector, which is most vulnerable to climate related risks. We express our gratitude to Sida for support to these efforts.

Alemneh Dejene
Team Leader, Environment and Climate Change Adaptation
Climate, Energy and Tenure Division
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Food and Agriculture Organization of the UN
Rome, Italy

CONCEPT NOTE AND SUMMARY

Proceedings of the National Workshop on Strengthening Capacity for Climate Change Adaptation in the Agriculture Sector in Ethiopia[1]

5-6 July 2010 – Venue: Rift Valley Hotel, Nazreth - Ethiopia

Alemneh Dejene, Mashack Malo (FAO)

Gebru Jember (Climate Change Forum - Ethiopia)

BACKGROUND

The (IPPC, 2007) highlighted that Africa will be one of the continents that will be hard hit by the impact of climate change due to a increased temperature and water scarcity. Yet Africa represents only 3.6 percent of emissions. The IPCC Report pointed out that there is "very high confidence" that agricultural production and food security in many African countries could be severely affected by climate change and variability. The Report projected that yields of crops in some countries could be reduced as much as 50 percent by 2020, with smallholders being the most affected.[2]

Climate change is already having profound impacts in developing countries, especially in sub-Saharan Africa (SSA), with the increasing frequency and intensity of climate-related disasters, notably recurrent droughts, floods and erratic rainfall. Africa's vulnerability to climate change is also exacerbated by the multiple other stresses it faces such as natural resources degradation, high dependence on rainfed agriculture and inadequate infrastructure, also low levels of technology, widespread poverty, weak governance and thus low level of adaptive capacity to climate variability and change.

Climate change impacts on water demand are predicted to be highly significant in Africa. The number of people facing water scarcity due to unreliable rainfall and dryingup of springs and rivers is expected to be between 75 to 250 million people by 2025. Furthermore, this is likely to have severe impacts on crop yields, as the majority of the African population (over 85 percent in the case of Ethiopia) depend on rainfed agriculture.

Smallholders in many parts sub-Saharan Africa (SSA) generally face widespread problems related to inappropriate cultivation, overgrazing and deforestation, resulting soil erosion and soil fertility decline, also water scarcity, lack of pasture and livestock feed and the fuel wood crisis. According to the Millennium Hunger Project Task Force (2005) half of the world's hungry people are smallholders unable to meet their food requirements and most live in high-risk environments. SSA has 18 of the 26 countries worldwide where more than 35 percent of the population are undernourished and in nearly half of these countries, the proportion of malnourished has been increasing since 1990. This re-enforcing cycle of "poverty, food insecurity and natural resources degradation trap" will be exacerbated by increasing climate variability and change, requiring urgent action and different approaches,

[1] Sponsored by the United Nations Food and Agriculture Organization (FAO), Natural Resource Management and Environment Department, Climate, Energy and Tenure Division, Natural Resource Management and Environment Department and the Climate Change Forum, Ethiopia (National NGO).

[2] IPCC (2007). "Climate Change 2007, the Fourth Assessment Report.

notably in many parts of the drylands and some of highland areas in Eastern Africa and Ethiopia.

The significance and urgency of African countries to adapt to climate change was highlighted by the African leaders at the Fifteenth Session of the Conference of Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC), held in Copenhagen from 7 to 18 December 2009. One of the outcomes of Copenhagen underscored the need to establish a comprehensive adaptation programme including international support and agreed that developed countries shall provide adequate, predictable and sustainable financial resources, technology and capacity building to support adaptation action aimed at reducing vulnerability and building resilience in developing countries, notably in Least Developed Countries (LDCs) and Africa. However, the Copenhagen Climate Summit was not seen by many stakeholders as being successful in delivering an effective and fair climate change deal capable of safeguarding the livelihoods of vulnerable communities. This Workshop includes speakers who examined the international climate change negotiation processes and its implications for development agenda of Ethiopia in formulating the short-term and long-term strategies and agenda for the post-Copenhagen engagement.

WORKSHOP AGENDA AND PARTICIPANTS

In this context, FAO and the Climate Change Forum (CCF-E), a national NGO, organized a technical workshop which took place on 5 and 6 July 2010 in Nazreth, Ethiopia (see agenda). The overarching goal was to improve the knowledge–base and raise national and local preparedness to address the impacts of climate change and its associated variability on agricultural-based livelihood system (i.e. smallholders with rainfed agriculture, herders and agropastoralists, forest-dependent people) as well as on best practices and options to increase awareness and preparedness for adaptation to climate change. The Workshop participants, representing various government agencies, UN agencies and NGOs, highlighted and shared their experience and lessons learned on good practices, options and policies to assist in building the resilience of the rural poor and smallholders to cope with climate risks. Improving resilience and reducing the vulnerability of smallholder farming systems to future climate change and associated variability requires an integrated approach, encompassing natural resource management, livelihood alternatives guided by early warning and improved availability of weather and climate information at local level.

The State Minister of MOAGRD, Dr Abera Deressa, opened the Workshop underlying the Government of Ethiopia's commitment to address the devastating impact of climate change both globally and nationally. He stressed that strengthening capacity for adaptation in agriculture is highest priority for Ethiopia and invited the partnership of bilateral agencies, UN agencies and NGOs in this effort.

As a co-sponsor of the Workshop, Dr. Girma Balcha, Executive Director of the Climate Change Forum-Ethiopia (CCF-E), welcomed all the participants and emphasized the importance of capacity-building in averting the already visible impacts of climate change and variability in the East Africa Region in general and Ethiopia in particular.

The first part of day one was dedicated to the implications of the ongoing climate change negotiation at national level and action being taken at national and local levels to respond to this global level dialogue. The rest of the session comprised presentation of research findings and ongoing field work on adaptation practices and options for crops, livestock, land, water and forest management and related issues.

Over 50 participants, consisting of policy-makers and technical experts from the Ministry of Agriculture and Rural Development, Ministry of Environment and Ministry of Water Resources, professors and researchers from major universities, UN agencies and representatives of other major donors agencies in Ethiopia participated in the meeting.

MAIN OBJECTIVES OF THE WORKSHOP

- Discuss the implications of the ongoing climate negotiations to Africa and Ethiopia in particular and national actions to be taken to facilitate the development agenda.
- Create awareness and promote action on innovative adaptation strategies and practices to improve food security and the build resilience of vulnerable communities and people.
- Share the experiences and lessons learned from ongoing programmes and projects on adaptation, focusing on agriculture and food security.
- Explore possible ways of integrating climate change issues into national development policies and poverty reduction, including the recommendations on the implementation of NAPA priorities identified for Ethiopia.

WORKSHOP OUTPUTS

(i) Prioritization of adaptation strategies and practices for vulnerable agriculture systems, which will enhance productivity and food security while reducing climate related risks in smallholder and vulnerable food production systems.

(ii) Documentation and synthesis of adaptation practices, options and coping mechanism, including the synergies with mitigating the impacts of climate change.

(iii) Dissemination of the result of the workshop to policy-makers and all relevant stakeholders.

MAIN RECOMMENDATION OF THE WORKSHOP

One of the major recommendations of the Workshop is that the Ethiopian NAPA is a very important venue in addressing climate related risks, but it needs to be revisited and obtain the endorsement of the Council of Ministers. Participants also called for the Federal Environmental Protection Authority, the newly appointed focal point for the NAPA, to actively involve all the major sectoral ministries and NGOs in assessing the NAPA priority options and any adaptation or mitigation projects that may recommended for fast track funding under the current climate negotiation.

The total amount of land covered by major ecological zones (notably drylands) were intensely debated and it was recommended that this needs to be revisited and assessed under the leadership of the MOAGRD and involving all the major research institutions and stakeholders.

Participants also noted the gender dimension of climate change and suggested for more effort to attract professional women to participate in future national and regional workshop related to climate change and agriculture and rural development.

ORGANIZERS

The Workshop was sponsored by the Climate Change Forum, Ethiopia (National NGO) and the Natural Resource Management and Environment Department, Climate, Energy and Tenure Division of the Food and Agriculture Organization of the United Nations (FAO). There was also close collaboration with the Federal Ministry of Agriculture and Rural Development and Oxfam America. The Workshop was also made possible by the Swedish International Development Authority (Sida) trust fund support made available through FAO.

WELCOME AND KEYNOTE ADDRESS

National Workshop on Strengthening Capacity for Climate Change Adaptation in the Agricultural Sector in Ethiopia

By Girma Balcha, Ph.D
Director, Climate Change Forum–Ethiopia (CCF-E)
Adama, 5 July 2010

H.E. Dr Abera Deresa
State Minister - Ministry of Agriculture and Rural Development

H.E Mr. Chipeta Mafa,
Coordinator
FAO Sub-regional for East Africa

H.E Ato Abera Tola,
Director - Oxfam East Africa
Executive Director - Oxfam America
Board Chair – the Climate Change Forum – Ethiopia

and

Ladies and Gentlemen,

I would like to welcome you all to this very relevant Workshop on 'Strengthening Capacity for Climate Change Adaptation in the Agricultural Sector in Ethiopia', jointly sponsored by the Food and Agriculture Organization of the UN (FAO) and CCF-E. We have reached the crucial moment when climate change is not only the issue of academicians and researchers but the concern of humanity at large. The effects of climate change are particularly felt in areas subject to land degradation and ecosystem fragmentation. Smallholder farmers comprise the largest population in Africa; their livelihoods, dependent on agriculture, are most susceptible to the impacts of climate change and variability.

The multiple challenges the world is facing in terms of ecosystem degradation, climate change and food insecurity requires an integrated response and there is an urgent need to reverse the situation.

In this regard, the magnitude of Africa's problem is immense as the continent is hard hit by the impacts of climate change - although its contribution to the cause is insignificant. Current and previous African GHG emission levels are negligible due to its low level of development and industrialization. At the same time, Africa is among the continents most vulnerable to climate change on ecosystem and humanity. The entire continent is estimated to be responsible for less than 7 percent global emissions and only about 4 percent CO_2. In many African countries, the agriculture sector has stagnated without transforming its potential to a palatable economic form. Economic growth has not yet reached the level to achieve broad-based poverty reduction and food security.

Poverty has its own negative effect on ecosystems. People who are affected resort to unsustainable use of natural resources and natural resource-denuded areas do not have resilience capacity to climate variability. The base-lines for climate adaptation are natural resources, biodiversity, smart-agricultural practices, traditional knowledge, clean development, and appropriate technology to increase production and productivity. Ecosystems that are already affected by various factors such as deforestation, land degradation, pollution etc. not only have poor-resilience capacity but trigger negative effects on the lives and livelihoods of those communities. The challenge now is that, on the one hand, we need land and water for agriculture, forests, biodiversity and ecosystem for the very survival, and energy for growth and development etc., while seeking to reduce greenhouse gases on the other. These two are competing challenges that can be solved by agreement on good policies, strategies and actions without delay.

At a global level, there has been a concerted effort to place the issue of climate change on the political agenda. This effort has been mirrored in Ethiopia within several institutions whose responsibilities are related to climate change.

However, the hard work being done by many organizations in Ethiopia has suffered in the past. It was undocumented or poorly articulated, with low levels of information sharing, uptake and action and, in some cases, overlapping responsibilities and inefficient duplication of efforts. In part this was caused by lack of awareness, financial resources and capacity, but a truly effective response to climate change has been incapacitated by poor communication, collaboration and coordination. In 2008 it became apparent to leaders within government and civil society that a national collaborative forum which could articulate the impacts of climate change and galvanize an effective response was needed. They responded to this need - to identify and steer research efforts, nurture and collate knowledge and institutional learning, and to communicate and coordinate on policy development, capacity building, planning, funding and action – by establishing the Climate Change Forum - Ethiopia (CCF-E, formerly the National Climate Change Forum). The CCF-E, a registered NGO, is a genuinely multisectoral, broad-based partnership which set out to complement national, regional and global efforts and to offer support to policy-makers and stakeholders on mainstreaming climate change.

Ethiopia had been actively participating in the negotiations and was elected by the African Leaders to lead the African group at a political level. Hence, PM Meles Zenawi negotiated on behalf of Africa during COP 15 at Copenhagen, Denmark and will continue its leadership until COP 17. In addition, PM Meles Zenawi was elected by UN Secretary-General Mr. Ban Ki Moon to co-chair the High Level Advisory Group on CC Financing (AGF). The Forum has also been involved in these negotiations.

Adaptation is an integrated development process that requires coordination and communication among key stakeholders. The main objectives of the Forum are to:

- Create forums for awareness creation and knowledge-base.
- Serve as information centre by creating Web sites and other.
- Coordinate capacity building efforts for effective and efficient adaptation and mitigation efforts.
- Facilitate and support policy advocacy and lobbying.
- Facilitate and support climate change research.
- Mobilize resources for climate change adaptation and mitigation works.

At the moment, the Forum is drafting its own strategy. On behalf of Climate Change Forum-Ethiopia, my appreciation is extended to Oxfam America, the Food and Agriculture Organization of the UN (FAO), World Food Programme (WFP) and the Horn of Africa Research and Environmental Network for their support of our endeavour.

I thank you very much!

OPENING STATEMENT

National Workshop on Strengthening Capacity for Climate Change Adaptation in the Agricultural Sector in Ethiopia

H.E. Abera Deresa Ph.D,
State Minster
Ministry of Agriculture and Rural Development
Adama, 5th July 2010

Dear Representatives of Government sectors, Academia, International and Local NGOs, UN Agencies represented by the Food and Agriculture Organization of the UN, the World Food Programme (WFP) and United Nations Development Programme (UNDP).
Participants,
Ladies and Gentlemen,

It is my great pleasure and honour to present the opening statement of this Workshop on the important and timely issue of capacity building for climate change adaptation in the Agriculture sector in eastern Africa.

As you all know, agriculture is the cornerstone of Africa's economy, contributing immensely to GDP of the country of the region. In Ethiopia, about 45 percent of the Gross Domestic Product (GDP) is derived directly from the agriculture sector. Today, 85 percent of the foreign currency flow into Ethiopia is generated from agriculture-related activities, employing about 83 percent of the total population of Ethiopia. Furthermore, for many industries agriculture is the main sources of raw materials.

Distinguished guests
Ladies and Gentlemen,

The Ethiopian highlands are the major source of water and harbour rich biodiversity resources, however trends in regional and global climate change are posing threats to agriculture and socio-economic development of the regions and countries at large. With the agricultural sector in Eastern Africa dominated by the vulnerable smallholder sector, land, water, forest and livestock, biodiversity practices are highly affected by the impacts of climate change and variability, such as floods and recurrent droughts.

To tackle this challenge, concerted efforts are needed at continental, regional and national levels from an array of partners and experts. Thus, the programme of this Workshop, that I see brings together a number of national and international experts and participants presenting a wide range of experiences relating to crops, livestock, sustainable land management, watershed management, forestry and agroforestry, small scale irrigation, agriculture research, agrometrology, among others, is encouraging.

I view this Workshop as a classic example of the collaborative efforts needed from stakeholders in assisting the efforts of national governments (notably the Ministry of Agriculture and Rural Development) to strengthen capacity for adapting agriculture to the formidable challenge of climate change and variability. Governments in the region need to build capacity in order to effectively respond to the changing climate, specifically in the agriculture sector; this Workshop is a welcome and most-needed contribution to those efforts.

The issue is not that of climate change as we know it, but the current pace of change will render the traditional coping mechanisms insufficient to effective response to the sudden climatic shocks and expected medium- to long-term impacts of climate change. Increased investment is needed in the development and dissemination of innovative technologies related to crops, livestock, land and water management and forestry and strengthening institutional capacity for adaptation. This will also eventually have synergy to mitigating climate.

I look forward to the successful completion of this Workshop and the conference outcome. I wish much success in your deliberations. I hereby declare the Workshop officially opened.

Thank you very much for your attention.

PAPER 1

THE PRIORITY FOR CLIMATE CHANGE ADAPTATION IN AFRICA: THE ROLE OF THE NATIONAL ADAPTATION PROGRAMME OF ACTION (NAPA)

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Team Leader, Environment and Climate Change Adaptation,
Climate Change, Energy and Tenure Division
Natural Resources Management and Environment Department
FAO, Rome

INTRODUCTION

Climate Change (CC) has emerged as one of the most important environmental and international development challenges of the twenty-first century. The recently published Intergovernmental Panel on Climate Change Report (IPCC, 2007) unequivocally concludes that there is "very high confidence" that increased emissions of Greenhouse Gases (GHG) are of human origin[1]. Carbon dioxide (CO_2) accounts for approximately 80 percent of total greenhouse gas emissions – 57 percent from fossil fuel use and 20 percent from deforestation and other activities. Methane, primarily from agriculture, is the next largest category of emissions (14 percent), followed by nitrous oxide (8 percent).[2] Least Developed Countries (LDC), of which a significant number are in Africa, are most vulnerable to the impact of climate change and bear the highest risks to their socio-economic development. Climate change and related variability is critically jeopardizing some of the progress made over recent years in overcoming hunger and poverty reduction in many parts of Africa.

The IPPC Report underscored that Africa is one of the regions that will be hard hit by the impact of climate change due to increased temperatures and water scarcity, yet Africa contributes the smallest amount of the total carbon dioxide (CO_2) emissions (3.6 percent) per year when compared to other continents. The IPCC Report pointed

[1] IPCC (2007). "Climate Change 2007, the Fourth Assessment Report. Volume 1: The Physical Science Basis" concludes: "The understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report (TAR), leading to very high confidence [*at least a nine-out-of-ten chance of being correct*] that the globally averaged net effect of human activities since 1750 has been one of warming".

[2] IPCC (2007). "Climate Change 2007, the Fourth Assessment Report", Summary for Policy Makers, Figure SPM 3.

out that agricultural production and food security (including access to food) in many African countries could be severely affected by climate change and variability. The Report projected that yields of crops in some countries could be reduced by as much as 50 percent by 2020, with smallholders being the most affected.[3] The impacts of climate change already reduce the length of growing seasons in some parts of Africa and these effects are expected to get worse.[4]

There is much concern that the fragile African ecosystems (mountains, drylands and coastal areas) will undergo noticeable changes under future climate scenarios. The predicted reduction in moisture in dry mountain regions of Africa could have disastrous impacts on downstream users, who entirely depend on this water for consumption and agriculture, as well as increasing the risk of forest fires. Climate change and weather extremes are expected to increase the extent of the arid and semi-arid areas in Africa, further marginalizing potential cultivable and range lands. This could also adversely impact tourism, as a large part of the protected areas and national parks are characterized as drylands and are fragile. There is also high probability that climate change could have a destructive impact on coastal areas (including mangroves, fisheries and coral reefs which support a large human population).[5] In many of the sub-Saharan African countries (including Ethiopia) there are ‘hotspots’ of food insecurity, which will face severe consequence in terms of productivity unless urgent steps are taken to adapt to predicted climate changes.[6]

THE CASE FOR CLIMATE CHANGE ADAPTATION

Agriculture (consisting of crops, livestock and forest-based livelihood system) results in at least a third of all GHG emissions. In reducing levels of these emissions, mitigation has been a well-recognized avenue by the United Nations Framework Convention on Climate Change (UNFCCC). Under the UNFCCC, the Kyoto Protocol (that came into force in 2005) commits the industrialized countries to reducing GHG emission under the principle of “common but differentiated responsibilities”. The Kyoto Protocol offers industrialized countries opportunities to invest in emission-reducing projects in developing countries to meet their emission targets though market-based mechanisms, one of which is the Clean Development Mechanism (CDM). The CDM, however, considers only afforestation and reforestation as acceptable sequestration activities and consequently poor countries with little forest resources cannot benefit. The major beneficiaries have been Brazil, China, India and South Korea.

At the UNFCC Conference of Parties meeting in Copenhagen (COP-15), there was recognition of the need to broaden the scope of CDM. At COP-15 African countries took a common position to make adaptation the highest priority for Africa and LDC. The

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3 Ibidem (footnote 3).

4 Thornton, P., Jones, P., Alagarswamy,G., and Andresen, J. (2009), spatial variation of crop yield response to climate change in East Africa. Global Environment Change, 19:54-65.

5 IPPC (2007), Working Group 2. Fourth Assessment Report, Africa.

6 Liu, J., Fritz, S., van Wesenbeck, C., Fuchs, M., You, L., Obersteiner, M., and Yang, H. (2008) A spatially explicit assessment of current and future hotspots of hunger in Sub-Saharan Africa in the context of global change. *Global and Planetary Change* 64: 222-235.

Copenhagen Accord (2009), a political statement (not binding on any country), stressed the need to establish a comprehensive adaptation programme (including international support) and agreed that developed countries shall provide adequate, predictable and sustainable financial resources, technology and capacity building to support adaptation action (aimed at reducing vulnerability and building resilience) in developing countries, especially LDCs, Small Island Developing States (SIDS) and Africa. Developed countries pledged to provide new and additional resources, including for forestry and investments through international institutions, approaching US$30 billion for the period 2010-2012 (fast start), with balanced allocation for adaptation and mitigation.

There is also now greater recognition that post-Kyoto regimes (2012) should provide increased resources and commitment to climate change adaptation, which in the past has often been associated with a weakening commitment to reducing GHG emission. The IPPC defines adaptation as "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". A more familiar definition to the development community is: "Adaptation is about reducing the risks posed by climate change to people's lives and livelihoods".[7] In-built adaptation ("autonomous adaptation") in the agricultural and ecological system can no longer cope with the effects of enhanced GHG emission, as African rural communities already face multiple stresses due to poverty, food insecurity, natural resources degradation, high population growth and poor social services. For this reason, the most recent IPCC findings have stressed "planned adaptation", based on deliberate policy decisions which aim to create or strengthen the adaptive capacity to adjust or cope with climate change impacts (IPCC, 2007).

Climate change adaptation is a continuous process requiring location-specific response. However, much of the documented information on impact of climate change and its associated variability is at the global level. There is an increasing need for a more organized body of information and knowledge at local and community levels on the location-specific impacts of climate change and variability on the agricultural-based livelihood systems (i.e. smallholder rainfed agriculture, herders and agropastoralists, forest-dependent people) as well as on best practices and options to increase awareness and preparedness for adaptation to climate change.

Climate change adaptation (particularly when community-based) offers an opportunity for a multidisciplinary and integrated approach to address climate-related risks which are predicted to impose severe constraints on production in the agriculture sector (i.e. dryland and highland areas) in many parts of Africa. In addition, adaptation does not necessarily require a stand-alone project or programme, it can be carried-out under ongoing nationally driven programmes/projects such as food security, land and water management, crop, livestock and forestry improvement.

Adaptation should enable agricultural systems to be more resilient to the consequences of climate change. Mitigation addresses its root causes, thereby over time limiting the

[7] Department for International Development (DFID), 2006.

extent and cost of adaptation, as well as the onset of catastrophic changes. Both are needed and a number of agricultural management practices can do both[8], while helping to meet development and food security requirements. Adaptation is an integrated, flexible process and integrating adaptation with development planning and actions can exploit the complementarities to advance both adaptation and development goals.

Another important post-Copenhagen development that has highlighted the importance of adaptation is the Global Donor Platform for Rural Development (GDPRD), which is strategic alliance of donor nations and international agencies which aims to support policies and implementation of programmes for agriculture and rural development. The GDPRD (co-chaired by Germany and FAO) recommended a two-track approach to bring agriculture at the centre of climate negotiation post 2012 agreement. At the global level, it emphasized securing text of the common vision under the Ad-hoc Working Group on Long-term Cooperative Action (AWG-LCA) that explicitly mentions food security and agriculture and recognizes the needs of developing countries and smallholder farmers. At the national level, the need is stressed to disseminate best practices of agriculture programmes which have demonstrated mitigation and adaptation benefits, and delivered more secure livelihoods and food security. Also, it should ensure that Nationally Appropriate Mitigation Actions (NAMAs) are coherent with NAPAs and poverty reduction strategies.[9]

THE ROLE NATIONAL ADAPTATION PROGRAMMES OF ACTION FOR CLIMATE CHANGE

The UNFCC has established a mechanism for the Least Developed Countries to prepare the National Adaptation Programmes of Action (NAPA), in order to identify priority activities that respond to the immediate need to adapt to climate change and to serve as a window to access possible funds for adaptation. A number of African countries have already prepared NAPAs and identified priority options for implementation. However, major challenges remain in terms of resources, technical and institutional capacity in the implementation of the NAPAs and the initiative will also try to assist in this regard.

The NAPA is an important but often neglected entry point to address the challenge of adaptation to the impacts of climate change in Africa. The guiding force behind the NAPA was the UNFCCC decision (Decision 28/CP.7) to communicate the urgent and immediate needs of LDC to adapt to adverse effects of climate change in LDCs. Clear guidelines and processes for development of NAPAs have been drawnup by the UNFCCC LDC Expert Group in order to identify priority activities that respond to the immediate need to adapt to climate change and to serve as a window to access possible funds for adaptation.[10]

The process of preparing NAPAs involves each country in identifying priority activities that respond to their urgent and immediate needs to adapt to climate change. The steps for

[8] TerrAfrica (2009) http://www.nepad-caadp.net/pdf/Using percent20SLM percent20Practices percent20to percent20Adapt percent20and percent20Mitigate percent20Climate percent20Change.pdf

[9] GDPRD, 2010, Beyond Copenhagen, Issue Paper 9. http://www.donorplatform.org/content/view/436/2682

[10] UNFCC, 2002. Annotated guidelines for the preparation of national adaptation programmes of action. Least Developed Countries Expert Group.

the preparation of the NAPAs, as indicated in the guideline, includes a synthesis of existing information, participatory assessment of vulnerability to current climate variability, extreme events and of areas where risks would increase due to climate change, identification of key adaptation measures as well as criteria for prioritizing activities, and selection of a prioritized short list of activities. The UNFCC guideline also stipulates that all NAPAs should apply key criteria, *inter alia*: (a) loss of life and livelihood; (b) human health; (c) food security and agriculture; (d) water availability, quality and accessibility; (e) essential infrastructure; (f) cultural heritage; (g) biological diversity; (h) land-use management and forestry; (i) other environmental amenities; (j) coastal zones, and associated loss of land. The process involves all major stakeholder groups in the country and the selection of the NAPA priority actions are guided by the above selection criteria and finally judged by the National Steering Committee (that also involves UNEP and UNDP).

The main content of NAPAs is a list of ranked priority adaptation activities and projects, as well as short profiles of each activity or project, designed to facilitate the development of proposals for implementation of the NAPA. NAPAs are therefore action-oriented, country-driven and flexible, based on national circumstances. As of June 2010, 48 LDC have prepared and submitted their NAPA, of which 33 are in Africa.

LESSONS IN NAPA FORMULATION AND IMPLEMENTATION

Some preliminary analyses of the NAPAs show that the quality of the NAPA documents varies from one country to the other. However, all countries have, to large extent, executed the UNFCC guidelines on preparation of the NAPA set by LDC Expert Group. The NAPA process is rigorous and involves all major stakeholders. Thus, some of the general remarks voiced against the NAPA as being “wish list” or “shopping list” is not accurate and distracts from the some legitimate and major weaknesses of NAPA, which need to be addressed. In most cases, NAPAs in Africa have put emphasis on rural communities, the use of traditional knowledge about coping strategies and bottom-up process, in order to capture the most important vulnerabilities of stakeholders. This is in direct contrast to countries’ National Communications, which are top-down obligations for parties to communicate their emissions and plans for mitigation.

NAPA priority projects have been sectoral and this is one of the constraints not only in formulation but also in implementation, including securing outside assistance for the NAPA. However, in moving forward with NAPA, additional efforts will be required to take an integrated and community-based approach which could be more flexible and responsive to help farmers and communities to manage their production risks associated with changing climate. There have been weaknesses in the formulation of NAPAs, a major one being that they have taken a sectoral approach and this has, to some extent, adversely affected implementation.

In the NAPA formulation phase, some flaws have been observed in ranking the priority activities. For example, the Lesotho NAPA options do not include forest/agroforestry practices in reducing vulnerability to climate risk in the major livelihood zone. Yet, Lesotho has less than 1 percent of forest cover and this is closely attributed to high demand by humans and livestock. Furthermore, Lesotho relies on its water resources (from the mountain regions) as a significant source of revenue from the sale of water to South Africa and for hydropower generation. Similarly, serious concern was raised during the Adaptation Workshop held in Nazreth (5 - 6 July 2010) on crop insurance programme being the number one NAPA priority project in Ethiopia. There was strong recommendation for re-examining and fine tuning the NAPA priority options in Ethiopia.

Institutional set-up and coordination issues are also constraints in implementation of NAPAs. The Ministry of Environment (and the Metrological Services) have, in most cases, been a focal point for NAPA. However, many of the priority options are to be implemented by the other sectoral ministries, notably the Ministry of Agriculture, Forestry and Water Resources. There were cases where the NAPA options submitted to UNFCC were not cleared by the sectoral ministries and corrective measures are needed before going ahead with implementation.

There is also a gap between the NAPA process and Poverty Reduction Strategy (PRS) and National Development Strategy (NDS). PRS/NDS play a vital role in facilitating access to concessional funding and concerted efforts are needed to achieve synergy between the NAPA and PRS/NDS process.[11] A good example of linking NAPA and PRS is presented in Box 1.

OVERCOMING MAJOR OBSTACLES AND ACCELERATING THE IMPLEMENTATION OF NAPA

NAPA implementation has been extremely slow or in many cases non-existent for many reasons, including those highlighted above. Without going into details about past weakness, this section will focus on the opportunities that may arise for African countries from the current climate change negotiation, which could facilitate the implementation of a reformed NAPA.

Adaptation needs sufficient and sustained funding in order that countries can plan for and implement adaptation. Article 4.4 of the UNFCCC Support for adaptation in developing countries states that “Developed countries shall assist the developing countries in meeting costs of adaptation to Climate Change”. But NAPA implementation cannot be entirely financed by outside sources and African countries must also commit their own resources. This said, as of July 2009, UNFCC indicated that total cost of over 400 projects submitted for funding globally under NAPA was close to US$2 billion and only US$176 million has been pledged mainly through the LDC Adaptation Fund (LDCF) managed by Global Environment Facility (GEF).

The LDCF was established to finance concrete adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol. The Adaptation Fund is to be financed with a share of proceeds from Clean Development Mechanism (i.e. 2 percent

[11] Overseas Development Institute (2009) Closing the gap between climate adaptation and poverty reduction frameworks. Project Briefing 21, ODI, London, UK. Available from: http://www.fao.org/fileadmin/user_upload/rome2007/docs/Climate_adaptation_and_poverty_reduction.pdf

BOX 1

GOOD PRACTICE IN LINKING NAPAS AND POVERTY REDUCTION STRATEGIES[12]

The NAPAs in Tanzania, Mali and Malawi link poverty and adaptation agendas. The Tanzanian NAPA makes a concerted effort to link climate change adaptation to key development concerns – such as food security, reducing morbidity, and increasing agricultural productivity – through linkages with the National Strategy for Growth and Reduction of Poverty (NSGRP/ Mkukuta-Mkuza), and the National Poverty Eradication Strategy. Given that poverty is highest in rural areas, the NAPA highlights the links between poverty and food security, particularly how changing agro-ecological performance will change patterns of food crop production, trade and purchase across different social groups. This emphasis on increasing agricultural productivity is reflected in projects prioritized in the NAPA, such as improving food security in drought-prone areas and improving water availability to drought-stricken communities. The challenge remains to link the NAPA fully with the NSGRP, including links between NAPA priority projects and the mainstream government/donor funded sector programmes.

In Mali, the multiple references to the Cadre Stratégique pour la Croissance et la Réduction de la Pauvreté (CSCRP) suggest substantial adaptation-poverty linkages. Climate change is recognized as one of the main factors in poverty and ill health.

Similarly, the Malawian NAPA highlights not only the impact of climate change on the mainstay of the economy and poor people's livelihoods – agriculture – but also the links that need to be made with key development-policy frameworks: Vision 2020, the Malawi Poverty Reduction Strategy, and the Malawi Economic Growth Strategy.

of certified emission reductions issued for a CDM project activity) and some funds from other sources. The funds available from LDCF are very small and largely depend on carbon market. The approval process is heavy and time consuming. At present it cannot be seen a viable financing mechanism for NAPA and required major reform.

There is now a growing movement in both developed and developing countries for increased support for climate change adaptation for post-Kyoto regimes (2012). Delaying adaptation would be costly as indicated in the Stern Report[13]. This also means that post-2012 climate financing regimes should recognize the eligibility of carbon sinks to include all land use systems (i.e. cropland, rangeland, forest land, agricultural soils, good agricultural practices, improved land and water management practices, watershed management, restoration of degraded land and agroforestry practices). Many of these

[12] Overseas Development Institute (2009)

[13] Stern, N. (2007) *The Economics of Climate Change: the Stern Review*. Cambridge University Press, Cambridge, UK.

practices are incorporated in NAPA priority options as it addresses the most vulnerable communities. If selected and implemented judicially, NAPA priority options could bring multiple benefits in enhancing productivity and ecosystem resilience as well as mitigating climate related risks.

Parties to the UNFCCC have already highlighted the most important elements that might be part of an enhanced multilateral response to climate change up to and beyond 2012. Under the UNFCC negotiating process for post-2012 response, adaptation was identified as one of the five key building blocks (shared vision, mitigation, adaptation, finance and technology) of a future climate change deal. Countries have made progress in defining a comprehensive framework for strengthened action on adaptation, capable of addressing the needs of developing countries for scaled-up financial support, technology and capacity-building.[14]

The specific elements that would constitute such a framework are not yet known and will be negotiated further at COP 16 in Cancun, Mexico and COP 17 in South Africa. It would be vital for least developed African countries to make a reformed NAPA one of the elements of such a framework, requiring fast-track support which can be pursued along with mitigation effort, provided there are sufficient funds and appropriate technology.

Achieving a post-2012 climate deal is essential. This should also involve moving towards a more inclusive and fairer agenda of adaptation, where revised and reformed NAPAs and similar country-driven adaptation activities will also be given serious consideration for using some of the funds that would be made available for Africa.

[14] text from UNFCCC website - http://unfccc.int/press/fact_sheets/items/4985.php

PAPER 2

CLIMATE RISK MANAGEMENT AND DATA NEEDS FOR AGRICULTURE IN ETHIOPIA

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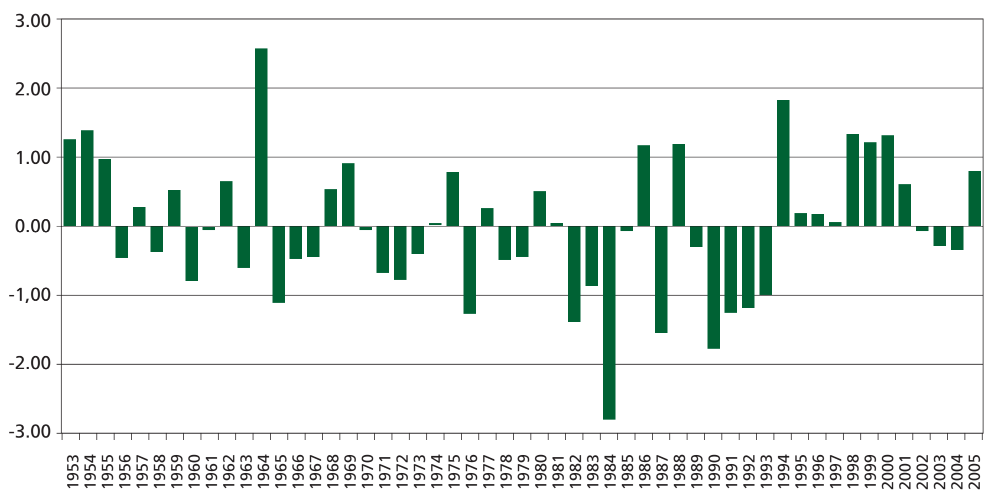
CLIMATE VARIABILITY AND ITS IMPACTS IN ETHIOPIA

The atmosphere fluctuates across different time-scales, which may range from daily weather to long-term climate change. Climate variability refers to time-scales ranging from months to decades. Climate is extremely variable particularly over the arid and semi-arid parts of Ethiopia. The annual rainfall variation is mostly associated with variation in sea surface temperature (SST) over the tropical Pacific. Warm SST (El Niño) leads to reduction in the summer rains, while the cold phase (La Niña) has the opposite effect. Figure 1 shows an example for Combolcha station in north-eastern Ethiopia, a region frequented by droughts. The major droughts of the 1970s, 1980s, and 1990s demonstrate the extreme climate fluctuations over this part of the country.

FIGURE 1

Standardized anomaly of June to August rainfall for Combolcha (NE Ethiopia). Negative values show dry years while positive values represent wet years.



Data source: National Meteorological Agency (NMA).

Climate variability also means fluctuation in crop production, whether this is due to drought or flooding. As a result, climate extremes have their most profound impact on agricultural production, which have been a big hindrance to the country's economic development. In addition to the seasonal rainfall totals and their season-to-season variability, the distribution of the rainfall within a season is also very critical to agriculture. The occurrence of droughts and floods has been found to reduce Ethiopia's annual growth potential by more than one third (Grey and Sadoff, 2006). It is estimated that the 1984-85 drought reduced Ethiopia's agricultural production by 21 percent, which led to a 9.7 percent fall in the GDP (World Bank, 2006). Crop and livestock losses over North-Eastern Ethiopia, associated with droughts during 1998-2000, were estimated at US$266 per household, which is greater than the average annual income for 75 percent of the households in this region (Carter *et al*., cited in Stern, 2007). Fig. 2 (OECD, 2006) shows the impact of drought on GDP growth during 1998 and 2002, while Fig. 3 depicts the impact on agriculture relative to the other economic sectors. The effect of climate variability is, of course, felt more at household levels. This is particularly true for the very poor, whose livelihood depends totally on rainfall as the sole source of moisture for crop or pasture growth. For such communities, variability in seasonal rainfall will inevitably result in highly variable production levels.

The impact of climate variability includes *ex ante* (before onset of the event) and *ex post* (after the event) impacts. *Ex ante* impacts are the opportunity costs associated with conservative strategies that farmers might employ to buffer themselves against climatic extremes at the expense of lower average productivity and profitability, also inefficient resource use. This may include avoidance of improved production technology, selection of less risky but less profitable crops, under-use of fertilizers, shifting household labour away from farming enterprises and shifting from productive to non-productive but more liquid assets as precautionary savings (Hansen *et al*., 2004, and references therein). As a result, the poor farmer may suffer from the impact of climate variability even in the years when climate conditions are favourable. On the other hand, *ex post* impacts are direct results of a climate shocks such as droughts and floods. These may include decreased yields or crop failure due to total or partial destruction of crops, livestock, infrastructure and other assets. These direct and indirect impacts of climate variability may contribute to both transitory and chronic poverty.

CLIMATE RISK MANAGEMENT

Sustainable development in Ethiopia needs to take the challenge of climate variability and change into account. There should be interventions to reduce the sensitivity of the systems (household to national) to climate variability and/or improve the capacities of households and the country to cope with this impact on development. Climate risk management (CRM) is a useful approach for dealing with the effects of climate variability today, while building capacity for adaptation to climate change (e.g., Hansel *et al.*, 2007; Cooper *et al*., 2008). CRM informs decision-making through the application of climate knowledge and information. Effective CRM deals with the full range of variability, balancing hazard

FIGURE 2

Real GDP Growth and Per Capita GDP (Sources: OECD, 2006)

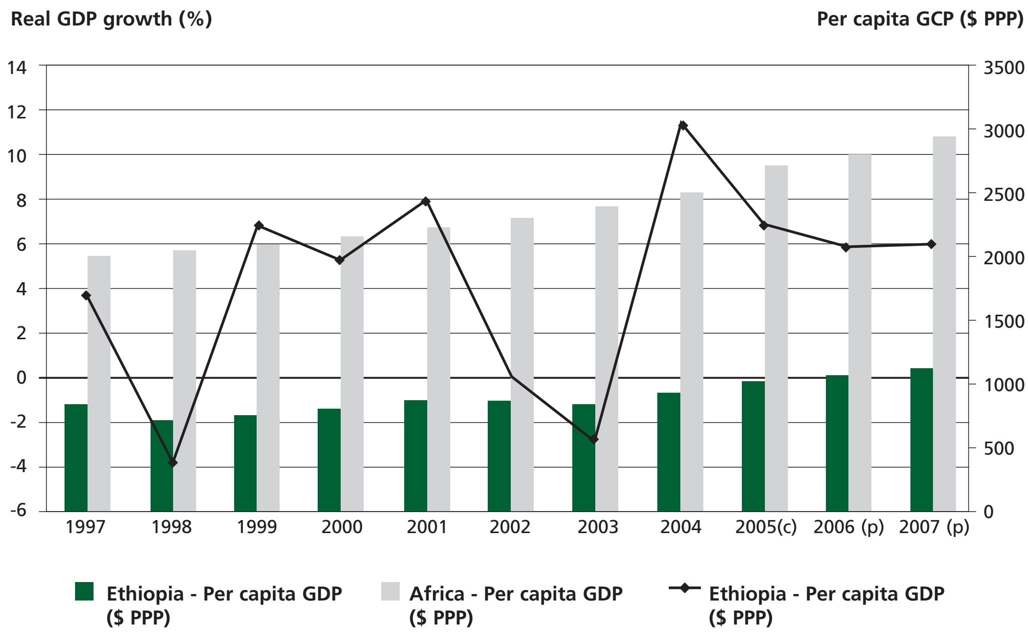
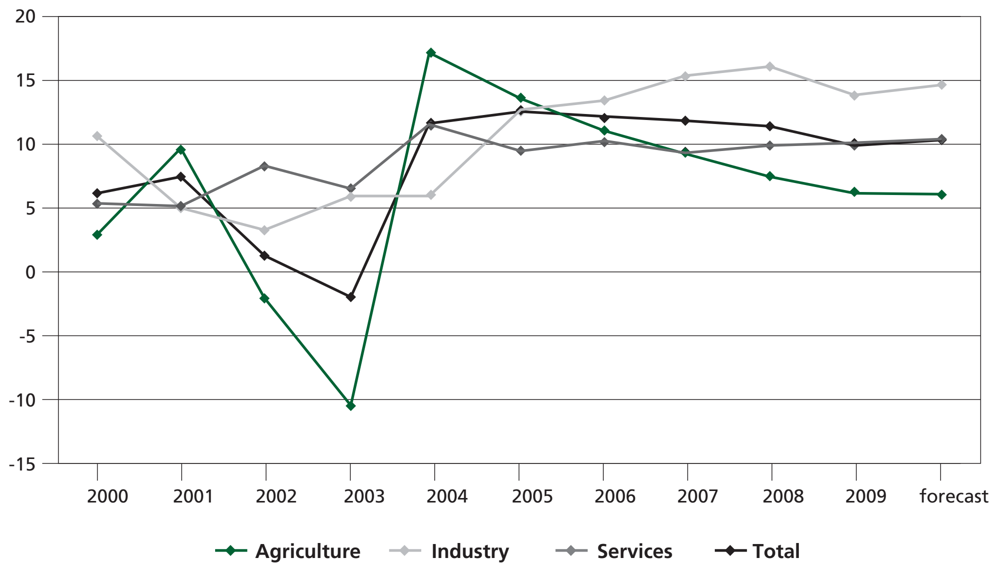


FIGURE 3

GDP growth rate for Ethiopia during 1999 to 2009.



Data obtained from Ministry of Finance and Economic Development (MoFED), Ethiopia.

management with efforts to capitalize on opportunities (Hansen *et al.* 2007). CRM thereby increases resilience to short-term climate variability while increasing adaptive capacity to deal with the longer-term climate change.

Hansen *et al*. (2007) describe three components of CRM:

- Effective rural climate information services that will enable farmers to adopt technology, intensify production and invest in more profitable livelihoods when conditions are favourable; to protect families and farms against the long-term consequences of adverse extremes. Systematic use of the climate information will help to reduce the uncertainty that impacts planning and decision-making.
- Information and decision support systems synthesize historic, monitored and forecast climate information into forms that are directly relevant to institutional decisions (planning, trade, food crisis response) that impact farmer livelihoods. This information may be used to develop climate-informed technologies that reduce vulnerability to climate variability (e.g., crop diversification, water harvesting, irrigation, and improved water use efficiency, breeding for heat or drought tolerance).
- Innovations in index-based insurance and credit to overcome some of the limitations of traditional insurance and are being applied to pre-financing food crisis response and to removing credit constraints to adopting improved technology. These market-based interventions can transfer some part of risk away from vulnerable rural populations.

Cooper *et al.* (2008) recommend that development agendas need to integrate three key aspects of climate risk management:

- Decision-support frameworks that provide a medium-term strategic understanding of the temporal and spatial distribution of climatic variability and its impact on the probability of success of existing and innovative agricultural practices.
- Short-term seasonal climate and agricultural forecasting to enable farmers and other stakeholders to 'fine tune' medium-term strategies in the context of the approaching season and thus to plan tactically and farm more effectively in context of the variable weather.
- Longer-term information on the current and future extent of the impact on climate change, on the nature of climate variability and the implications for rainfed farming systems and their future development and productivity.

DATA NEEDS

Climate information is a critical input for effective CRM. Long-term, temporally homogeneous time series of climate data are of great importance in a number of applications that include:

- Calibration of crop yield models and preparation crop suitability maps.
- Characterization of the nature of the climate risks over a different locations.
- Planning and optimizing investments.
- Understanding trends, deriving statistics of interest, and placing current observations into historical context.
- Timely interventions for food security, flood and major climate sensitive diseases such as malaria.
- Designating and implementing weather index insurance.
- Providing a basis for measuring and understanding climate variability and change.

The conventional source of climate data is meteorological stations. However, availability of climate information, particularly throughout rural areas of Ethiopia, is very limited. The available stations are unevenly distributed. The density of stations is relatively good over the central highlands, while there are very few stations over the lowland areas (Fig. 4). Almost all stations are located in cities and towns along main roads. The number of stations with long time series is even much less (Fig. 4). This imposes severe limitations to availability of climate data on the farms and rangelands, where the data are needed most.

A project underway at the National Meteorology Agency (NMA), in collaboration with the International Research Institute for Climate and Society (IRI), aims to address the data problem. The main objective of the project is to produce and disseminate better climate information. The project optimally combines the excellent spatial coverage of satellite climate proxies, such as satellite rainfall estimates, with the point accuracy of station measurements. This involves rigorous quality check, gridding the station data to regular grids and blending station data with satellite estimates. The gridded station data and the blended products will be in a format that is easier to import into GIS software and could easily be combined with other data of interest. The outputs would be high-resolution (10 km and ten-daily) gridded data sets that can be used to characterize observed recent climate variability and trends and that can be routinely updated to provide real-time monitoring and verification. The gridded data will include thirty-year time-series of:

- Gridded station rainfall.
- Satellite estimated rainfall.
- Merged gauge-satellite rainfall.
- Gridded minimum and maximum temperatures, strengthened with satellite data.
- Other climate variables such as RH are also being considered.

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PAPER 3

CLIMATE CHANGE, VARIABILITY, TRENDS AND POTENTIAL IMPACTS AND RISKS IN MAJOR AGRO-ECOLOGICAL ZONES IN OROMIYA REGION, ETHIOPIA

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INTRODUCTION

Ethiopia is located in the Eastern Africa region. It extends from latitudes 3 °N to 15 °N and longitudes 32 °E to 48 °E, with an area of 1.02 million sq. km. Ethiopia is a country of great geographical diversity with high and low rugged mountains, flat topped plateaus, and deep gorges, incised river valleys and rolling plains. In altitude contrast, it ranges from the highest peak, Ras Dashen (4 553 m a.s.l.) to the deepest depression of the Dalol (120 m b.s.l.). Most of the country consists of high plateaus and mountain ranges, with precipitation edges dissected by numerous streams, which are the tributaries of the major rivers, notably the Abay (Blue Nile), Tekeze, Awash, Omo, Wabi Shebele and Baro-Akabo.

Like many other countries of Africa, the country's economy is mainly dependent on agriculture, which relies heavily on climate. Ethiopia's climate varies from humid to semi-arid with abundant and scarce soil/air moisture. Moreover, extreme variations in rainfall occur from season to season and year-to-year. This interseasonal and interannual rainfall variability imposes severe impacts on agriculture, water resources, health and other socio-economic activities of the country. The pre dicted impacts of climate change include changes in the frequency and intensity of extreme rainfall. It is important to consider how the impacts of these effects can be minimized.

The seasonal classification of the region, especially over Ethiopia, is, from February to May, June to September and October to January, called Belg, Kiremt and Bega, respectively. If the rain gauge network is not too sparse for producing reliable data, extremes can be derived from gauge rainfall using other areal estimates (Korecha *et al.* 2001). Model outputs, such as the Numerical Weather Prediction (NWP) model outputs, can be used to detect extremes (Endalew *et al*. 2007). These include the European Centre for Medium-Range Weather Forecast (ECMWF) data, which is now used in local operational application. The anomalous wet and dry decades, which have been calculated using 1958-2001, mean rainfall from ERA-40 reanalysis data show that for most parts of central, eastern, northeastern Ethiopia for most of the years up to 1970s, the anomaly is positive, especially for July and August which are the peak months of the Kiremt season. It later shows a negative anomaly for most of the years throughout the season (Endalew *et al.* 2007).

The average mean annual minimum temperatures from 40 stations throughout the country for the period 1951-2006 show that there has been a warming trend over the last 55 years, increasing by about 0.37 °C every decade. The mean annual rainfall variability and trend observed over the country in the period 1951-2006 shows that the country has experienced both dry and wet years. The trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country (NAPA, 2007).

Drought is the most important, frequent, climate-related natural hazard the country faces. In Ethiopia, the major causes for vulnerability to climate variability and change include: very high dependence on rainfed agriculture which is very sensitive to climate variability and change; under-development of water resources; low health service coverage; high population growth rate; low economic development level; low adaptive capacity; inadequate road infrastructure in drought prone areas; weak institutions and lack of awareness (NAPA 2007).

Agriculture, water and human health are the sectors most vulnerable to climate variability and change. In terms of the livelihoods approach, smallholder rainfed farmers and pastoralists are found to be the most vulnerable. The arid, semi-arid and the dry subhumid parts of the country are affected most by drought (NAPA 2007).

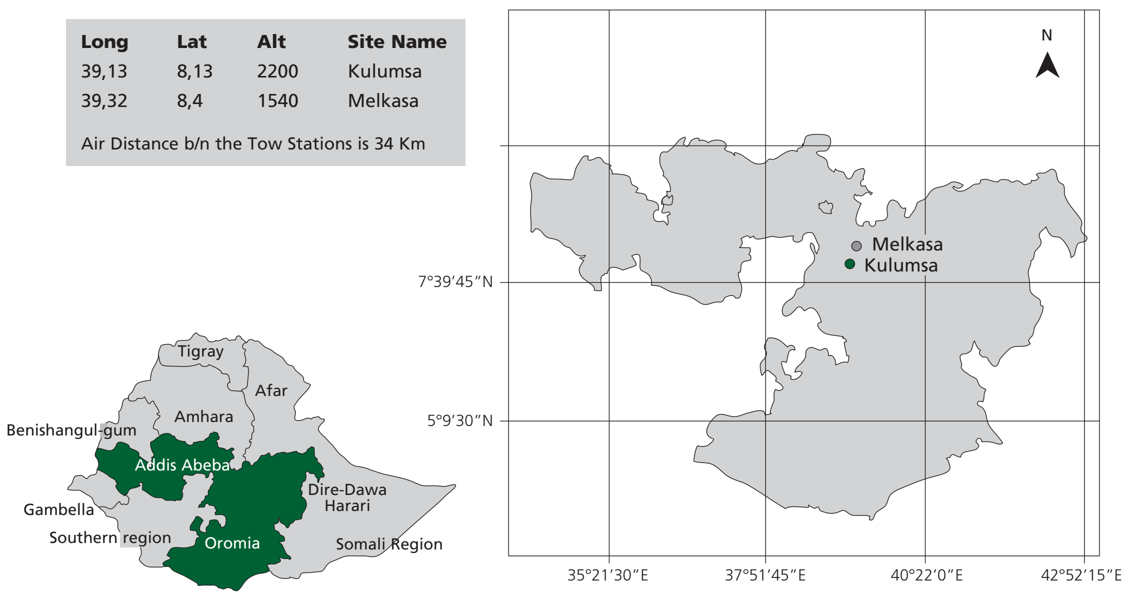
For this study, monthly data from two selected representative meteorological stations, Kulumsa and Melkasa for the highland and lowland areas of Central Oromiya were used (Figure 1). Using those data, this paper assesses the observed monthly, seasonal and annual rainfall / temperature variability and trends in extreme rainfall/temperature events. In addition, this paper identifies the anomalous wet and dry months, seasons and years based on the gauge data then the impact of climate variability on different economic sectors over the Kulumsa and Melkasa regions has been assessed. Furthermore, the future projection of the rainfall and temperature for the above-mentioned areas was made. Subsequently, future scenario runs using the Model for the Assessment of Greenhouse-gas Induced Climate Change (MAGICC/SCENGEN)/Regional and global Climate SCENario GENerator) model were analysed.

Generally, the paper aims at reviewing the observed seasonal and annual rainfall/ temperature variability and trends in extreme rainfall / temperature events, as well as their expected pattern in the future.

FIGURE 1
Location of study area

Long	Lat	Alt	Site Name
39,13	8,13	2200	Kulumsa
39,32	8,4	1540	Melkasa

Air Distance b/n the Tow Stations is 34 Km



CLIMATE, VARIABILITY AND TRENDS OVER THE STUDY AREA

Data and methodology

In this study, the rain gauge data obtained from the Data Management Department of the National Meteorological Agency (NMA) of Ethiopia was used. Two stations, Kulumsa and Melkasa, were selected to assess the trend of the rainfall and temperature over Central Oromiya as representative stations for the highland and the lowland areas of the rift valley, respectively. Hence, analysis was done using monthly and seasonal rainfall and temperature data.

Using the monthly, seasonal and annual data, rainfall and temperature trends for each station have been calculated. Besides, by subtracting the mean values (1977-2007), the anomalies are constructed. Each of the 10 percent extreme minimum and maximum anomalies was identified, the frequency of these extreme events analyzed and the impact of climate variability for different sectors over the study area assessed. Finally, the future trend of the rainfall and temperature, as well as the frequency of the extremes, was assessed by analysing scenario runs of MAGICC/SCENGEN model output for each station. The analysis was done in sections 2.2 and 2.3 below for the Melkasa and Kulumsa stations, respectively.

Climate of Melkasa (RepresEnting Low and dryland Areas)

Melkasa is located in the Oromiya region at 8°24' lat. and 39°21' long. with an altitude of 1 550 metres a.s.l. This area was selected as a case study for the lowland areas of Central Oromiya region. The main rainy season for this site is during the boreal summer from June to September (Kiremt) which contributes about 69 percent of its annual rainfall and the second short rainy season (Belg) is from March to May which covers nearly 24 percent. The third season, which is from October to January (Bega), is dry most of the time but contributes around 7 percent of the annual rainfall especially during October and January for the late cessation of Kiremt and early onset of Belg seasons, respectively (Figure 2)

For the period 1977-2006, the annual average rainfall of Melkasa is 702 mm and it ranges from 450 to 918 mm. The peak months are July and August with an average rainfall of 157.5 and 161.6 mm, respectively. The long-term mean rainfall for Bega, Belg and Kiremt seasons is 52, 166 and 482.5 mm, respectively.

For the period 1977-2006, the monthly mean annual maximum and minimum temperatures of Melkasa are 28.5 °C and 13.8 °C, respectively. The mean maximum temperature is between 30.9 °C during May and 26.2 °C during August (Figure 2).

Rainfall variability and trends at Melaksa

This area receives up to 93 percent of its annual rainfall during Kiremt and Belg. Hence, for this work, the trend of the extremes during these seasons was analysed. Drought was

FIGURE 2

Mean Monthly Rainfall Pattern for Kulumsa and Melkasa stations (1977-2006)

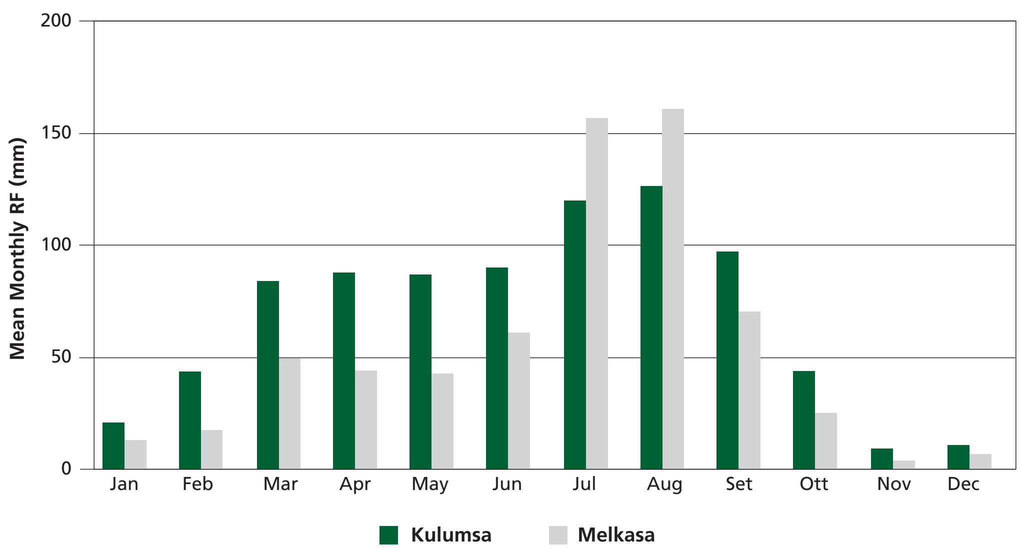
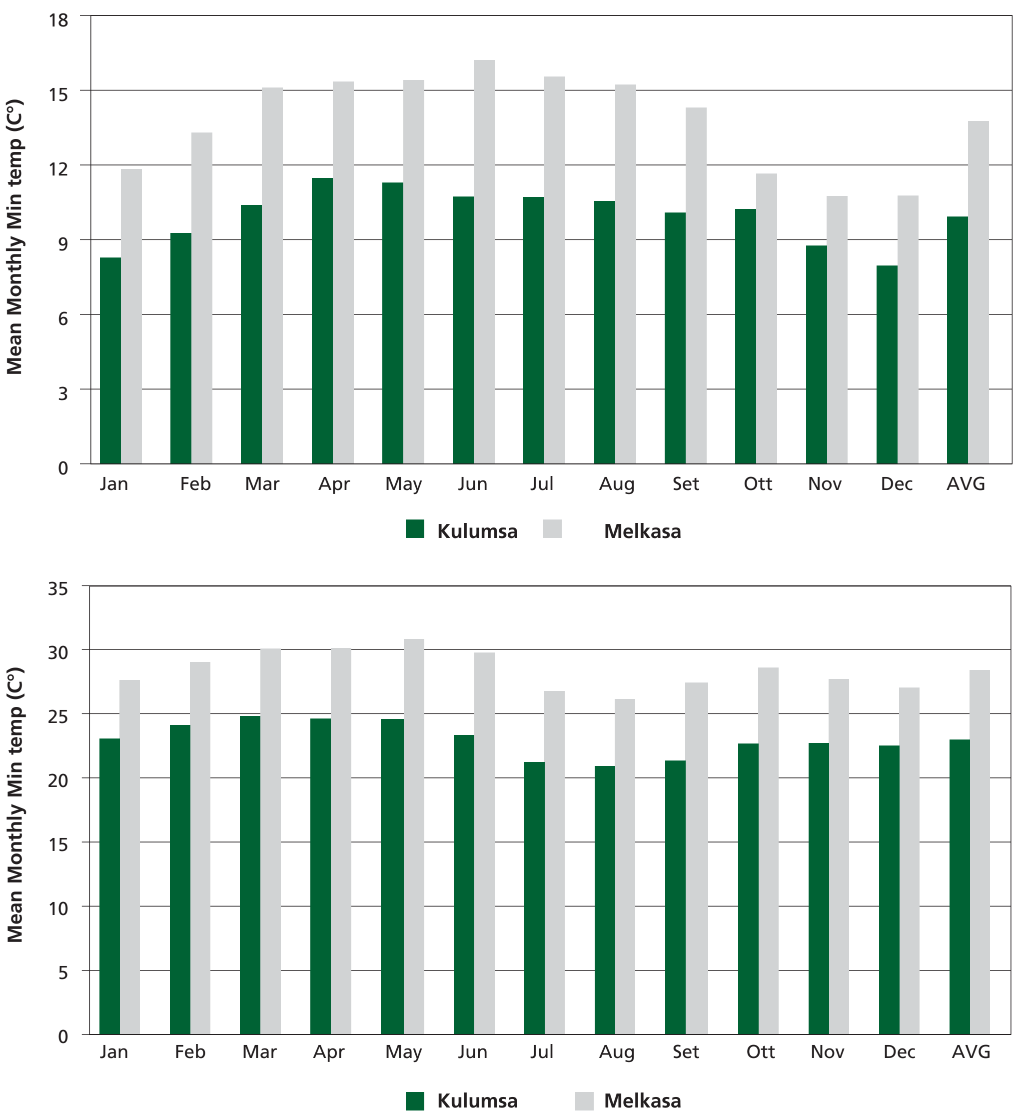


FIGURE 3

Patterns of mean monthly minimum (a) and maximum (b) temperature over Kulumsa and Melkasa



recurrent over many parts of the globe. But it is a very frequent catastrophic phenomenon over the sub-tropical regions which have had greatest impacts. In Ethiopia, these situations occurred in 1972, 1984, 1987, 1994 and 1999/2000. The trend of the extremes, the wettest and driest months, seasons as well as years was analysed.

The trend of the anomalies for the Melkasa station was analysed. The seasonal and annual rainfall shows an increasing trend (Figure 3). During Kiremt, Belg and Bega it shows an increase in 14.5, 18.6, 15.6 mm every decade and hence an increase of 47.3 mm per decade for the annual rainfall. We can clearly see that it is becoming highly variable from year to year.

Furthermore, the top 10 percent wet and dry anomalies were selected for each month, season and year over the season and the most frequent year over the area selected as the best anomalous wet or dry year.

Positive anomalies are more frequent than negative anomalies for the annual rainfall of Melkasa Analysis of 10 percent of the wettest and driest years of Melkasa indicates

FIGURE 4

Seasonal (Belg, Kiremt, Bega) and annual rainfall trends over Melkasa

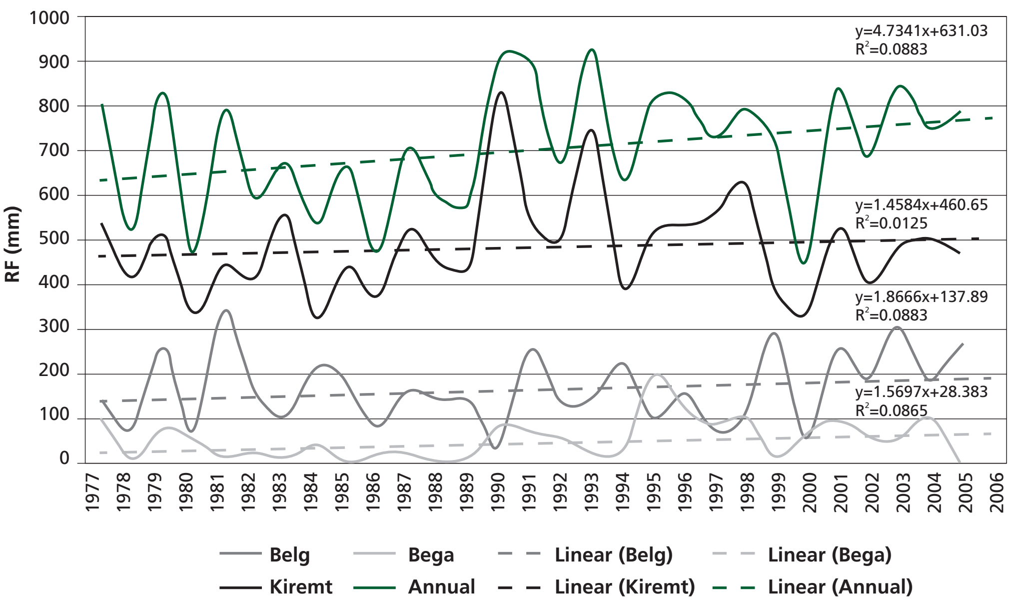
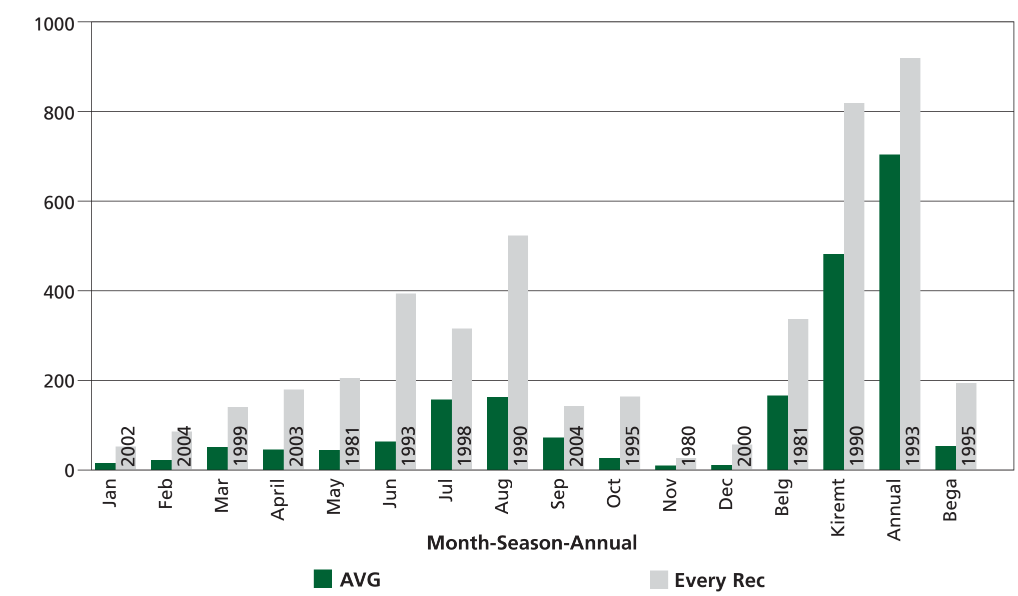


FIGURE 5

Ever Recorded Rainfall for Melkasa



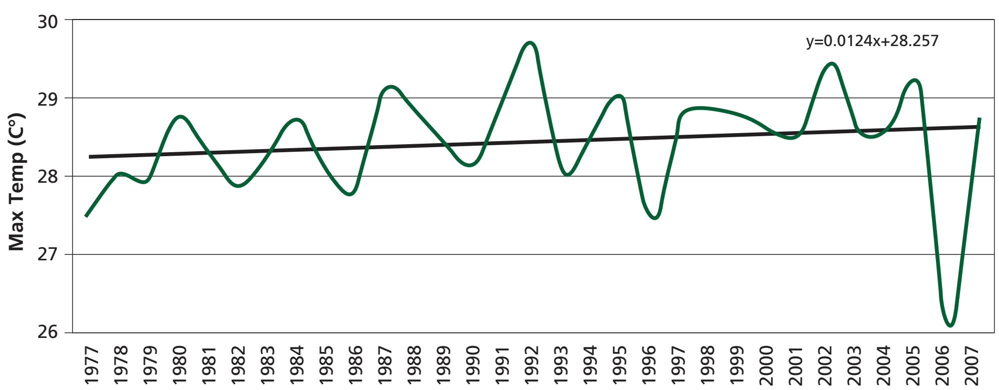
that most of the driest years are from 1981-1990 which agrees with the driest years that occurred over the country as in 1984 and also 2000.

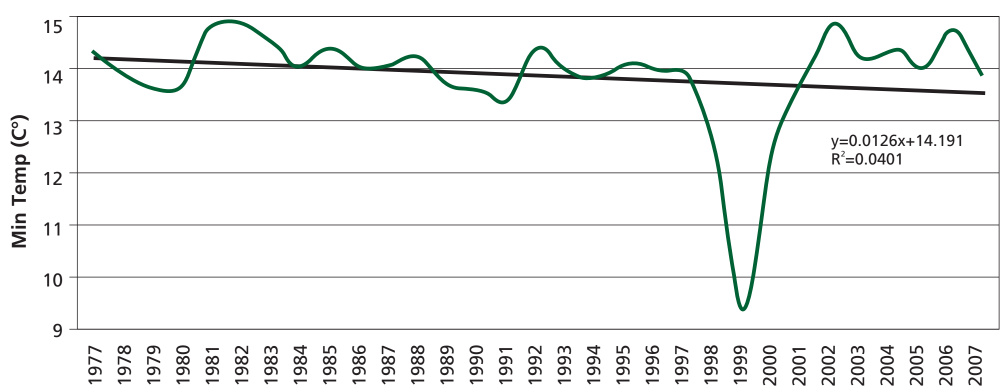
The trend of the annual and seasonal rainfall as well as the variability for a season and within a season can be seen in Figure 4 Until 1990, Bega had more negative anomaly, however, after 1990 it has more positive anomalies. Belg also has more negative anomalies compared to its long-term mean and is highly variable. This is in agreement with its general behaviour that it is high variability throughout the country. After 2000, however, it has more frequent positive anomalies. However, Kiremt is more stable and has positive anomalies most of the time.

The ever recorded monthly, seasonal as well as annual rainfall and time of occurrence has been analysed. As can be seen in Figure 5, 83 percent of the recorded values are from 1990 onwards. Compared to the long-term mean, an ever recorded value of up to 200 percent (314.8 mm and 142.7 mm for July and September, respectively) during July and September to 762 percent (54.6 mm) during December has been recorded. This indicates that extreme weather and climate events are becoming more frequent and intense under a changing climate.

FIGURE 6

Trend of mean monthly maximum (a) and minimum (b) temperature over Melkasa





Temperature variability and trend of extremes at Melkasa

The monthly mean annual maximum and minimum temperatures are 28.5 °C and 13.8 °C for Melkasa with a range of 29.7 °C -26.1 °C and 14.9 °C -9.5 °C, respectively. The mean maximum temperature is between 30.9 °C during May with a range of 33 °C-22.3 °C and 26.2 °C during August with a range of 28.2 °C -24.7 °C (Figure 6).

The trend of the anomalies of maximum and minimum temperature for Melkasa station has been analysed. The monthly average annual maximum temperature shows an increasing trend of 0.12 °C every decade (Figure 6). Even if there is trend, it is not statistically significant. However, the variability of the monthly maximum temperature is high with a deviation of 5.9 °C to -8.5 °C from the mean.

Average annual mean minimum temperature throughout the country indicates an increase of 0.37 °C every decade (NAPA of Ethiopia, 2007). However, a decreasing trend of monthly mean minimum temperature was observed over Melkasa with 0.22 °C every decade (Figure 6).

Climate of Kulumsa (representing highland area)

Kulumsa is located over Oromiya region at 8°08’ lat. and 39°08’ long. with an altitude of 2 200 m a.s.l. This area has been selected as a case study for the highland areas of Central Oromiya region. The main rainy season for this met. station is during boreal summer from June to September (Kiremt) which contributes about 53 percent of its annual rainfall and the second short rainy season (Belg) is from March to May which covers nearly 37 percent. The third season which is from October to January (Bega) is dry most of the time but contributes around 10 percent of the annual rainfall especially during October and January for the late cessation of Kiremt and early onset of Belg seasons, respectively (Figure 7). For the period 1977-2006, the annual average rainfall of Kulumsa is 833.8 mm and it ranges from 596.3 to 1 041 mm. The peak months are July and August with an average rainfall of 120.5 and 127.1 mm, respectively. The long-term mean rainfall for Bega, Belg, and Kiremt seasons is 83.5, 308.6 and 438.2 mm, respectively.

For the period 1977-2006, the monthly mean annual maximum and minimum temperatures for Kulumsa are 23.1 °C and 10 °C, respectively. The mean maximum temperature is 24.9 °C during March and 21.0 °C during August (Figure 8).

Rainfall variability and trends of extremes at Kulumsa

Kulumsa, like Melkasa, receives up to 90 percent of its annual rainfall during Kiremt and Belg. The trend of the extremes, the wettest and driest months, seasons as well as years has been analyzed.

The Kiremt and annual rainfall show a decreasing trend (Figure 8). A decrease of 15.2 and 13.2 mm per decade was observed for the Kiremt and annual rainfall, respectively. However, it shows an increasing trend for Belg and Bega seasons with an amount of 16.1 and 4.1 mm every ten year, respectively.

Even if there is an increasing trend, it is not statistically significant for all seasons. As the regression has low skill, it is less likely to regress both annual and seasonal rainfall on year. However, we can clearly see that it is becoming highly variable from year to year.

FIGURE 7

Seasonal (Belg, Kiremt) and annual rainfall trends over Kulumsa

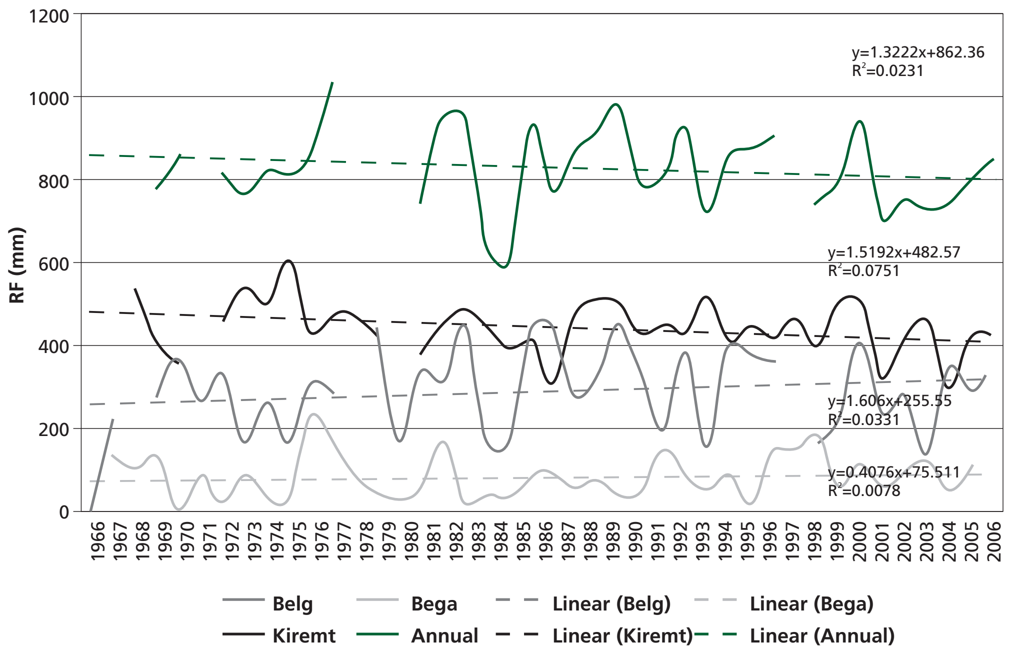
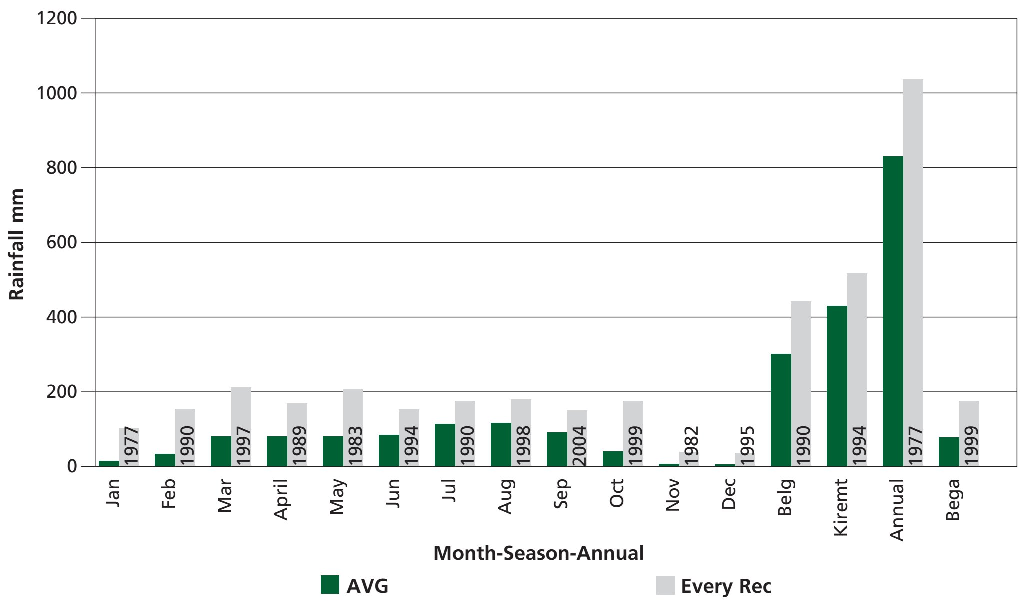


FIGURE 8

Ever Recorded Rainfall for Kulumsa



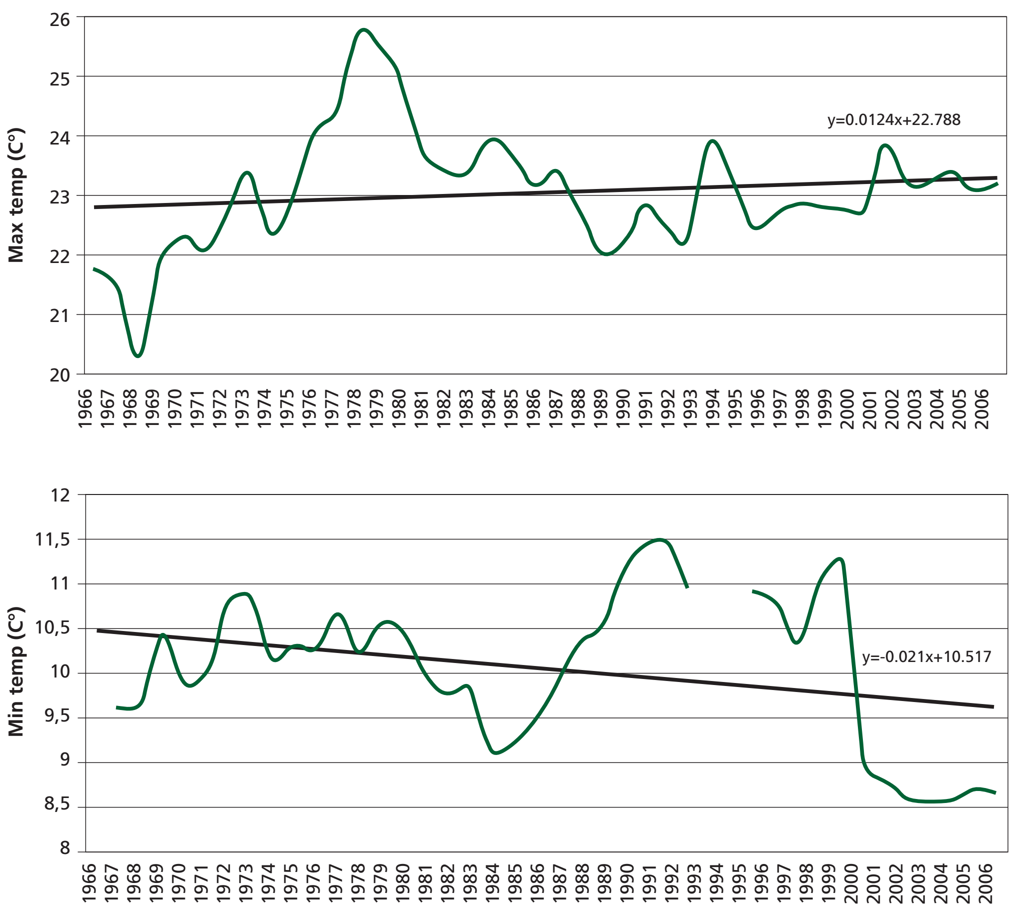
Besides, the top 10 percent wet and dry anomalous have been selected for each month, season and year over the season. Then the most frequent year over the area was selected as the best anomalous wet or dry year. The frequency of negative anomalies is slightly more than that of positive anomalies for the annual rainfall of Kulumsa. Analysis of 10 percent of the wettest and driest years of Kulumsa indicates that the highest numbers of driest years are from 1981-1990 which agrees with the driest years that occurred over the country like 1984 and also 2000.

The recorded monthly, seasonal as well as annual rainfall and time of occurrence was analysed. As can be seen in Figure 8 below, 63 percent of the recorded values are from 1990 onwards.

Compared to the long year mean, an ever recorded value of 147 percent (186.6 mm) during August to 532 percent (112.5 mm) during January was recorded. This indicates that extreme weather and climate events are becoming more frequent and intense under a changing climate.

FIGURE 9

Trend of mean monthly maximum (a) and minimum (b) temperature over Kulumsa



Temperature variability and trend at Kulumsa

The monthly mean annual maximum and minimum temperature is 23.1 °C and 10 °C for Kulumsa with a range of 25.7-20.3 and 11.5-8.5, respectively. The mean maximum temperature reaches 24.9 °C during March with a range of 28.4 °C -21.7 °C to 21.0 °C during August with a range of 26 °C -19.2 °C (Figure 6).

The trend of anomalies of maximum and minimum temperate for the Kulumsa station was analysed. Like Melkasa, the monthly average annual maximum temperature of Kulumsa shows an increasing trend of 0.12 °C every decade (Figure 9). Even if there is trend, it is not statistically significant as R^2 is less than 0.3. However, the variability of the monthly maximum temperature is high with a deviation of 4.8 °C to -5.3 °C from the mean.

Average annual mean minimum temperature throughout the country indicates an increase of 0.37 °C every decade (NAPA of Ethiopia, 2007). However, a decreasing trend of monthly mean minimum temperature was observed over Kulumsa with 0.21 °C every decade (Figure 9). Even if there is a decreasing trend, it is not statistically significant. As the regression has low skill, it is less likely to regress minimum temperature each year.

Comparison of the wettest and driest years of Melkasa and Kulumsa

The comparison of the wettest and driest years of the stations, Melkasa and Kulumsa is shown in Table 1 below. Common to Melkasa and Kulumsa are 1981, 1984 and 2000 for the driest years and 1977, 1988, 1990, 2001, and 2002 for the wettest years.

The trend of the annual and seasonal rainfall as well as the variability for a season and within a season can be seen in Figures 4 and 7. In general, Bega has more negative anomalies. However, after 1996, positive anomalies are more frequent. Belg has frequent positive and negative anomalies compared to its long year mean, which is in agreement with the general conclusion that it is highly variable throughout the country. Besides,

TABLE 1

Summary of the wettest and driest years of Melkasa and Kulumsa

DRIEST YEARS OF KULUMSA		DRIEST YEARS OF MELKASA		WETTEST YEARS OF KULUMSA		WETTEST YEARS OF MELKASA	
Year	Frequency	Year	Frequency	Year	Frequency	Year	Frequency
1984	4	1985	3	1989	3	1979	3
1980	4	2000	3	1990	3	1977	2
1981	4	1984	2	1998	3	1988	2
2000	3	1981	2	1977	2	1990	2
2002	3			1988	2	2001	2
				2001	2	2002	2
				2002	2		

negative anomalies become more frequent from 2000 onwards. During Kiremt, the positive anomalies were more frequent. However, the frequency of negative anomalies increases after 2000.

CLIMATE CHANGE SCENARIO FOR CENTRAL OROMIYA REGION (MELKASA AND KULUMSA)

Information about possible changes to the climate of central Oromiya in the short-term and long-term future is the basis for climate change impact and vulnerability assessments.

Future changes in climate depend on GHG emission levels in the atmosphere, which in turn depends on a number of factors including population growth, economic activity, type of technology used and policy measures adopted by governments. The future state of these factors cannot be predicated precisely but scenarios can be made. It is important to note that scenarios are not predictions. They are plausible future states. The IPCC has developed six emissions scenarios in its Special Report on Emission Scenarios-SRES (IPCC 2001). For this study three IPCC SRES namely the high case emission scenario (A1F1), medium case emission scenario (A1B) and a low case emission scenario (B1) were selected to generate climate scenarios for the region (Table 2).

The current approach for estimating the future climate is by using Global Climate Models (GCMs). Climate models use quantitative methods to simulate the interactions of the atmosphere, ocean, land surface, ice, etc. It is important to note that global climate model results are not weather forecasts, but are scenarios describing a possible future climate situation under a set of variables with given values. MAGICC/SCENGEN/ Version 5.3 software was used to generate climate scenarios for three periods centred on the years 2030, 2050 and 2080. The spatial resolution of MAGICC/SCENGEN outputs is 2.5 lat x 2.5 long (Hulme, M, 2000).

Compared to the 1961-1990 normal, the mean annual temperature over the region could increase by about 1 °C by 2030, by about 2 °C by 2050 and by about 3 °C by

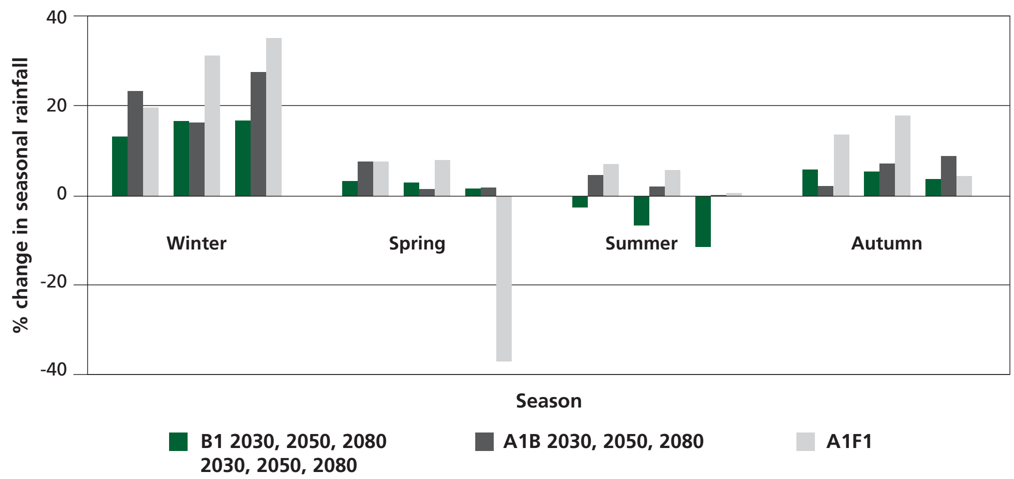
TABLE 2

Greenhouse gas (GHG) Concentration levels for selected emission scenarios

	GHG CONCENTRATION LEVELS IN THE ATMOSPHERE (PPM)		
YEAR/SCENARIO	2030	2050	2100
Low case emission scenario (B1)	420	485	533
Medium case emission scenario (A1B)	425	529	707
High case emission Scenario (A1FI)	430	564	976

FIGURE 10

Changes in mean Winter. Spring Summer and Autumn rainfall (%), compared to the baseline values over Melkasa and Kulumsa region in central Oromiya.



2080 for the IPCC medium (A1B) emission scenario (Table 3) when averaged over 20 GCMs included in the MAGICC/SCENGEN software. Seasonal temperature increases are more or less similar to the annual increases. Along with temperature changes, rainfall also is going to change. In general terms the region is expected to see an increase in its annual rainfall by about 10 percent, 4 percent and 5 percent by the years 2030, 2050 and 2080 respectively compared to current mean conditions. However, changes in rainfall are not uniform between the winter, spring, summer and autumn seasons. For example, a significant increase in rainfall is expected to occur in winter (DJF) (Figure 10). During this season, rainfall is projected to increase by up to 27 percent above current conditions by 2080 for A1B emission scenario.

Changes in temperature and rainfall over the region for the low and high emission scenarios are also provided in Table 3 as computed by the authors. It is important to note that changes in temperature that are expected to occur by 2030 are more or less the same among the three scenarios which implies that the region will face unavoidable warming, regardless of the type polices adopted on emission scenarios.

Differences in temperature projections among scenarios become significant as we look into the long-term time horizon. For example by the year 2080, mean annual temperature change is projected to be 2.1 °C, 2.9 °C and 4.2 °C for B1, AIB and A1F1 emission scenarios respectively. In order to appreciate the significance of these changes, it is important to refer to the baseline (current) climate of the two locations described above. For example, the high emission scenario temperature at Kulumsa by 2080 could be approaching that of Melkasa today.

Changes in climate at a place can manifest itself in three ways, namely shift in the mean values, change in variability or a combination of the two. Figure 3.2 illustrates how the

TABLE 3

Climate change projections averaged over 20 GCMs available in the Magic/ Scengen model for Melkasa and Kulumsa area (Central Oromiya) for different emission scenarios

EMISSION SCENARIO	SEASON	CLIMATE PROJECTIONS					
		CHANGE IN TEMPERATURE (°C)			CHANGE IN RAINFALL (PERCENT)		
		2030	2050	2080	2030	2050	2080
(Low case (B1) Emission Scenario	DJF	1.1	1.6	2.2	13.1	16.2	16.6
	MAM	0.9	1.4	1.9	3.3	2.7	1.2
	JJA	1.1	1.7	2.3	-2.7	-6.7	-11.4
	SON	1.0	1.5	2.1	5.6	5.2	3.6
	Annual	1	1.6	2.1	4.0	8.2	1.5
Medium case (A1B) Emission Scenario	DJF	1.1	2.0	3.1	22.7	16.0	27.3
	MAM	0.9	1.9	2.8	7.4	0.3	1.6
	JJA	0.9	1.9	3.0	4.4	1.7	-5.9
	SON	0.8	1.8	2.8	2.0	7.1	8.6
	Annual	0.9	1.9	2.9	9.7	4.3	5.1
High case (A1F1) Emission Scenario	DJF	1.2	2.3	4.5	19.3	30.9	34.6
	MAM	1.0	2.1	4.1	7.3	7.7	-36.7
	JJA	1.0	2.1	4.2	6.7	5.7	0.3
	SON	0.9	2.0	4.0	13.6	17.2	4.2
	Annual	1	2.1	4.2	10.4	12.5	9.6

(Source: Authors computation)

mean climate of Melkasa will look like in 2030, 2050 and 2080 for A1B emission scenario. Though future climate follows the current pattern a shift in the mean is obvious.

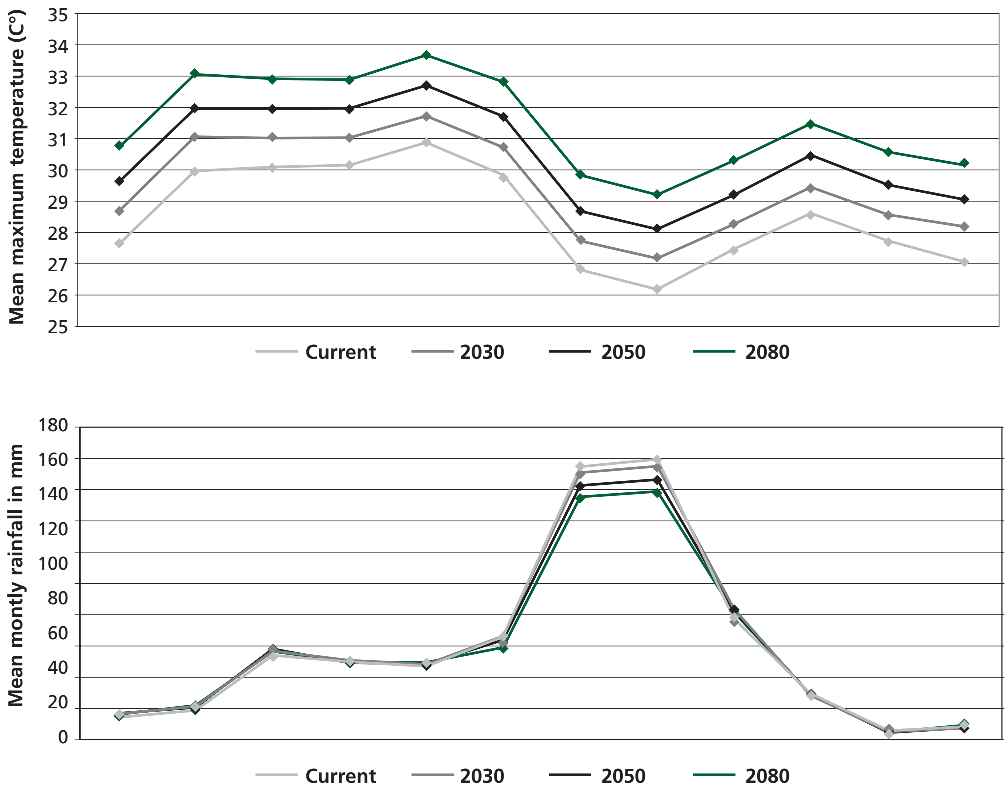
Changes in climate analysed and presented above are expected to have adverse impacts on many natural and socio-economic systems over the region. It will be critical to assess the impacts and identify adaptation measures that will enable to cope with adverse impacts.

Assessments made by the IPCC and other researchers indicate that, in general, crop yields will decrease in the tropics, water will become more scarce, ecosystems will shift, vector born diseases will spread, extreme climate events such as droughts and floods will increase in intensity and frequency.

According to the National Adaptation Plan of Action (NAPA) of Ethiopia, promotion of crop insurance, appropriate choice of crop verities, effective use of water resources through irrigation and water harvesting, promotion of agroforestry, diversification of livelihoods, strengthening of early warning systems and appropriate use of climate information are some of the adaptation options identified.

FIGURE 11

Changes in the mean climate of Melkasa for the current, 2030, 2050 and 2080 for A1B emission Scenario



SUMMARY AND CONCLUSION

The climate of Ethiopia varies from humid to semi-arid with both abundant and scarce moisture. Hence, flooding and drought are frequent phenomena which have a direct impact on the agriculture, health, water and other socio-economic sectors of the region. The aim of this study has been to analyse the expected changes in the frequency and intensity of extreme rainfall induced by climate change in Central Oromiya.

For this study two stations, Kulumsa and Melkasa, representing the highland and the lowland areas of Central Oromiya region were used. Anomalous wet and dry months, seasons and years were identified using rainfall data of Kulumsa and Melkasa. The climate and trends of these stations, as well as the extremes were analysed. Finally, the future trend for better preparedness of the coming change was projected using the MAGIC SENGEN simulations.

The long-term mean seasonal rainfall and its contribution to the annual rainfall for Bega, Belg, Kiremt seasons is 52 (7 percent), 166 (24 percent) and 482.5 (69 percent) mm, respectively for Melkasa and 83.5 (10 percent), 308.6 (37 percent) and 438.2 (53 percent) mm for Kulumsa. The monthly mean annual maximum and minimum temperatures are 28.5 °C and 13.8 °C, respectively for Melkasa and 23.1 °C and 10 °C for Kulumsa.

The climate of Melkasa and Kulumsa is characterized by strong seasonality. The main rainy season occurs during June to September. March to May is generally the short rainy season while November to February is the dry season. March to May is generally the hottest season of the year. Annual and seasonal rainfall is highly variable making socio-economic activities especially agriculture highly vulnerable to climate change.

Agroclimatically, Melkasa has a single growing season (S3), with adequate moisture to meet the full water requirements of short maturing crops in most years while Kulumsa has a double growing season (D7), with both of the two growing periods adequate for rainfed crop production in most years (NMSA, 1996).

The monthly average annual maximum temperature shows an increasing trend of 0.12 °C every decade both for Kulumsa and Melkasa. However, a decreasing trend of monthly mean minimum temperature of 0.21 °C and 0.22 C every decade for Kulumsa and Melkasa respectively was observed.

The seasonal and annual rainfall shows an increasing trend and is becoming highly variable from year to year for Melkasa. The Kiremt and annual rainfall shows a decreasing trend for Kulumsa. Even if there is an increasing/decreasing trend, it is not statistically significant as R2 is less than 0.3 for all months/seasons. As the regression has low skill, it is less likely to regress both annual and seasonal rainfall as well as temperature each year.

The mean annual temperature over the region could increase by about 1 °C by 2030, by about 2 °C by 2050 and by about 3 °C by 2080 for the IPCC mid-range (A1B) emission scenario (Table 3) when averaged over 20 GCMs compared to the 1961-1990 normal. Seasonal temperature increases are more or less similar to the annual increases. Along with temperature changes, rainfall also is going to change. In general terms the region is expected to see an increase in its annual rainfall by about 10 percent, 4 percent and 5 percent by the years 2030, 2050 and 2080 respectively compared to current mean conditions. However changes in seasonal rainfall are not uniform. For example, significant increase in rainfall is expected to occur in winter (DJF). During this season, rainfall is projected to increase by up to 27 percent above current conditions by 2080 for A1B emission scenario.

The region will experience more warming in the near and long-term future and models agree in the direction of change. The region also will experience change in rainfall. A significant increase is expected in the winter season while a decrease is expected in the summer. The models do not all agree in the direction of change in rainfall.

Even if models have certain uncertainties, especially over the tropical areas of Africa, in predicting the future pattern of weather parameters like rainfall and temperature, future impact and vulnerability assessments and adaptation options selected need to take into account all possible climate change scenarios generated for the region. Melkasa and Kulumsa, which are at different altitudes and separated by an air distance of 37 km, are in the same grid box. However, the actual climate of these stations is not the same. Hence, unless further downscaling is done at fine resolution, we will not have the right input to choose the most appropriate adaptation strategy for these localities.

ABBREVIATIONS AND ACRONYMS

a.s.l.	above sea level
b.s.l.	below sea level
DJF	December-January- February(Winter)
EALLJ	East African Low Level Jet
ECMWF	European Centre for Medium-Range Weather Forecast
ENSO	El Niño-Southern Oscillation
ERA-40	ECMWF 40 year re-analysis data
GCMs	Global Climate Models
GHG	Greenhouse gas
IOZM	Indian Ocean dipole or Zonal mode
ITCZ	Inter-Tropical Convergence Zone
JJA	June-July- August (Summer)
MAGICC/SCENGEN	(Model for the Assessment of Greenhouse-gas Induced Climate Change)/ (Regional and global Climate SCENario GENerator) model
MAM	March-April-May (Spring)
MARS	Monitoring of Agriculture with Remote Sensing
NAPA	National Adaptation Programme of Action
NMA	National Meteorological Agency
NMSA	National Meteorological Services Agency
NWP	Numerical Weather Prediction
RSCZ	Red Sea Convergence Zone
SON	September- October-November (Autumn)
SST	Sea Surface Temperature
TEJ	Tropical Easterly Jet

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PAPER 4

AGRICULTURAL WATER MANAGEMENT SYSTEMS IN THE CONTEXT OF CLIMATE CHANGE IN SUB-SAHARIAN AFRICA (SSA)

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CLIMATE VARIABILITY, RESOURCES DEGRADATION AND RURAL POVERTY IN SSA

Climate change, which is any change in climate over time, whether due to natural variability or as a result of human activity (http://www.gao.gov/new.items/d07285.pdf.), is threatening livelihoods due to increased greenhouse gas concentrations in the atmosphere and as a result the of warming of the Earth's surface. The impacts will likely include surface and ocean temperature increases, sea level rise, glacial melt, and more extreme weather events, such as droughts and floods and less precipitation in some areas (Freimuth *et al*., 2007) – resulting in decreasing agricultural productivity over time and space.

Climate variability in SSA has been happening for centuries, although the international recognition of climate change and variability as a global issue took place only in the last decade. Climate change is also likely to intensify the current challenges of water scarcity and water competition within and between communities and nations, linked by hydrological flows across watersheds and basins. Poor and vulnerable populations of SSA are likely to face the greatest risk. Moreover, there is recognition that climate change, mainly as a result of human action, is impacting SSA more than other continents because its economies are largely based on weather-sensitive crop-livestock and agropastoral production systems and also due to the low adaptation capacity of SSA countries to climate change and variability.

The major drivers of climate change in SSA are associated with increasing water scarcity and land degradation, catalysed by deforestation, demographic growth, poor governance, global energy and food trends and other externalities. The spiral of land degradation and water scarcity in SSA has commonly reduced crop and livestock productivity, reducing farm incomes, forcing land users to mine soil nutrients and reducing the once food secured communities to poverty and food insecurity (Amede *et al*. 2006). This has thereby reduced the capacity of communities to respond to climate variability.

Therefore, the adaptation capacity of land users to climate change is strongly linked to land, water and labour productivity at farm and landscape scales. In countries where agricultural resource efficiency is very high, the carbon sequestration capacity of the landscapes also tends to be relatively high. The great progress globally in increasing cereal yield per hectare, producing more meat and milk per animal and producing more farm outputs per unit of labour through agricultural intensification have reduced the encroachment into forests and grasslands, which are critical for mitigating climate change effects. However, there has been a decline in agricultural productivity in SSA, which has increased the number of food insecure people from 125 to 200 million between the 1980 and 2000 (IWMI, 2007).

SSA landscapes exhibit extraordinary biophysical, climate and socio-economic variability. As a consequence, only a small subset of the many established NRM practices prove effective in any particular setting (Wichelns, 2006). Even within a particular region, micro-variability in culture, hydrology, soils, climate, etc. can render techniques found effective on some farms ineffective on others nearby, which calls for adaption strategies reflecting socio-economic realities. Moreover, improved natural resource management practices for mitigating climate change are commonly adopted by farmers when farmers get short term benefits from investments in land and water management in terms of food security and financial returns (Wichelns, 2006).

The recent decline in agricultural productivity in SSA is partly the cause and consequence of deterioration in soil carbon upon which agriculture depends, which is aggravated by climate variability. Oldeman (1998) estimated that about 10 percent of the cumulative productivity losses in the last 60 years in Africa were as a result of human-induced soil degradation, associated loss of soil carbon and accelerated water depletion. About 65 percent of agricultural crop land and 31 percent of permanent grazing land in Africa were degraded during the same period of time (Scherer, 1999). Gross fertilizer use also fell by 9 percent in the late 1990s (Wichelns, 2006). These low-input agricultural practices in the region have led communities towards the downward spiral of poverty, deforestation, resources degradation and local conflicts, which all affect the adaptation capacity of communities to climate change. For example, cultivation with low-input methods (no fertilizer) in the humid savannah zones of SSA induced a 30 percent loss of soil organic matter after 12 years and 66 percent after 46 years, with rice yields declining from 1 ton/ha to 300 kg/ha (Barrett *et al.*, 2000), substantially decreasing the soil carbon stock. Return of crop residues to the soil alone is not sufficient to offset these losses. Soil carbon decline and recurrent spatial and temporal climate variations, aggravated by lack of water storage capacity, hinder effective use of water and nutrients by plants, leading to frequent crop failures, which in turn contribute to substantial poverty and resources degradation.

The unholy alliance between climate variability, recurrent drought and poverty in Ethiopia, aggravated by limited access for external inputs and weak institutional arrangements, is becoming a threat that has attracted the attention of multiple national, regional and global actors. Emerging challenges including the food and energy crises will also affect farmers' decisions in managing agricultural water resources. With increasing demand and competition among different users, water scarcity will probably dominate all other challenges for the next generation, which will be aggravated by low adaptation capacity to climate change.

AGRICULTURAL WATER MANAGEMENT AND CLIMATE CHANGE

Agricultural water management (AWM) embraces a whole range of wider practices including *in situ* moisture conservation (e.g. mulching) and *ex situ* water management (e.g. rainwater harvesting, supplementary irrigation, irrigation, various techniques of wetland development, IWMI (2006)).

Integrated natural resources management, which encompasses agricultural water management as a key intervention, is also critical to sequestering carbon through soil carbon accumulation and above ground biomass of trees, shrubs and grasslands. Integrated Natural Resources Management (INRM) is "an approach that integrates research on different types of natural resources, into stakeholder-driven processes of adaptive management and innovation, to improve livelihoods, agro-ecosystem resilience, agricultural productivity and environmental services, at community, ecoregional and global scales of intervention and impact" (CGIAR, 2001). Similarly AWM offers a way of doing development-oriented research that aims to simultaneously reduce poverty, increase food security and achieve environmental protection. These three key factors, which influence human well-being, are inextricably linked to the health of the ecosystems in which people live and work. Agricultural water management reflects these broad interactions. It focuses on ecosystems rather than commodities; on underlying processes (both biophysical and socio-economic) rather than simple relationships; and on managing the effects of interactions between various elements of the production systems. The water concept includes sustainable use and management of water, land, vegetation, biodiversity and environment through arrays of local institutions, technologies, approaches and consolidated partnerships.

KEY INVESTMENTS FOR ADAPTING CLIMATE CHANGE IN SSA

There exists a long-term development pathway through which farmers' livelihood priorities and associated market expansion drive changes in water use and management by inducing and enabling farmers to intensify land and water management through investments and innovations. Integrated investments focusing on soils, water, forest and germ plasm would probably give better economic and environmental return in the context of climate change. Descriptions of the key investments required to minimize climate change effects can be summarized as follows.

1) Improved water management across scales

Agriculture is the major user of water in SSA and about 95 percent of the agricultural sector depends on rainfed agriculture. The largest segment of the agrarian population who practise subsistence agriculture in crop-livestock, agropastoral and pastoral systems rely mainly on rainwater. They often occupy fragmented, marginal and rainfall-dependent lands that are commonly prone to erosion, droughts, floods and fluctuating market prices. Improving soil and water conservation is the first action to improve the water supply for agriculture, i.e., making a higher percentage of rainwater that falls onto a field available for plants (Rockström, 2000). Hence, strategies to reduce rural poverty will depend largely on improved rain water management across space and time. Interventions are required not only to minimize risk but also to improve water storage and productivity for increasing water access for food production and environmental services.

The threat of water scarcity in sub-Saharan Africa is real, due to the expanding agricultural needs, exacerbated by increasing climate variability and inappropriate land use (Amede *et al.* 2009). Competition for water between different uses and users is increasing at global, national and community scales although agriculture will remain the largest water user. Up to 70 percent of the water from rivers and groundwater goes into irrigation globally http://www.lenntech.com/water-food-agriculture.htm. Irrigation in SSA is the lowest despite the increasing needs to improve food security and respond to recurrent drought and climatic variability along with efficient rainwater management. Recurrent crop failure and livestock mortality due to drought has been a common phenomena, particularly in SSA, However, focusing solely on irrigation and agricultural production could result in freshwater shortages for wetlands and other aquatic ecosystems (Postel, 2000), but also in degraded water quality, with serious impacts on terrestrial and aquatic ecosystems. Major trade-offs are forecast between agriculture and ecosystem services, including trade-offs between increasing food security on the one hand and safeguarding ecosystems on the other hand (de Fraiture *et al.* 2007; Bossio *et al.* 2009). These demands will increasingly include water allocated to carbon sequestration.

Irrigated agriculture is becoming an increasingly important intervention towards managing climate variability, meeting the demands of food security, employment and poverty reduction. Irrigation and improved agricultural water management practice could provide opportunities to cope with the impacts of increasing climatic variability, enhance productivity per unit of land, increasing the annual production volume significantly (Awlachew and Merry, 2005). Irrigation farming is becoming a necessity in the drought-stricken regions of SSA in order to:

- reduce farmers' vulnerability to annual rainfall variability and associated variability in crop and livestock risks;
- increase agricultural production per unit of land, water and labour investments; thereby reducing the expansion of farming to less productive hillsides and valley bottom wetlands;

- enable communities to produce high value enterprises in homesteads and selected plots thereby enhance the capacity of communities to reinvest on their farms and demand for better services and production inputs;
- strengthen collective action for broader land and water management, and
- manage upper watershed of command areas, managing equitable water distribution and cleaning and maintenance of canals are key entry points for broader collective action.

There has been a strong association between small-scale irrigation (SSI) and protection of upper slopes from erosion, landslide and overtraining. It became an incentive to rehabilitate catchments through area enclosure, soil and water conservation and enrichment of the natural vegetation.

Although irrigated agriculture in Ethiopia started in the 1960s in response to major droughts, which caused widespread crop failures and consequent starvation, it has remained highly localized, contributing to only less than 5 percent of food production, much lower than even the African average. Only about 5.2 million hectares of land are irrigated in SSA, representing only 3.3 percent of cultivated land - much lower than the irrigated share of crop lands in any other continent. For instance, in Ethiopia irrigated agriculture has realized only 4.3 percent of its estimated potential area for irrigation and contributes to only about 3 percent of total food crop production. Moreover, the existing irrigation schemes are not giving the expected returns, due to excessive siltation, poor agronomic and water management practices, also failure of local institutions to sustainably manage them (IFAD, 2004). There still exists a substantial yield gap between achievable and actual yields both in terms of yield per unit of land but also yield per unit volume of water that should be exploited to ensure food security. Current yields from rainfed crops are only about 50 percent of those on irrigated land, when all other inputs remain the same. If the country is to achieve its stated aims of food self-sufficiency and food security, the current production shortfalls call for drastic measures to improve the water productivity in both irrigated and rainfed systems. In irrigation, non-productive water depletion could be reduced by improved irrigation water management, which comprises among others choice of water-efficient enterprises, minimizing conveyance, drainage losses and multiple use of water for household use, fishing and irrigation.

Rainwater harvesting (RWH) is the capturing and storage of rainwater from roofs and runoff, diverting it for household and agricultural uses, particularly during water shortages. It is an effective strategy to manage floods and droughts. It could be used to satisfy water demands during dry spells and create opportunities for multiple use (domestic uses or for human and animal drinking). It also encompasses *in situ* water management strategies through maximizing soil infiltration and soil water-holding capacity, which is a key component of agricultural water management. This is particularly critical for Eastern and Southern Africa, where about 70 percent of the land falls within arid, semi-arid and dry subhumid zones. Access to ground water is beyond the reach of most farmers, mainly because of financial constraints. However, RWH has the potential to provide enough water to supplement rainfall and thereby increase crop yield and reduce the risk of crop failure (Oweis *et al*. 2001) and also provide a supply for livestock. Enhancing and stabilizing crop yield and livestock production for farmers in these crop-livestock systems would encourage farmers to invest in rainwater harvesting and accompanied nutrient management at plot, farm and landscape scales. The choice of a certain agricultural enterprise or management would also influence water productivity, as it affects the quantity and quality of water used to grow crops, forages and pasture. Improved vegetative soil cover, strategic choice of cropping patterns (e.g. close row spacing), cropping systems (e.g. intercropping and agroforestry) and the crop (variety) (e.g. crops with early development of a closed canopy) could reduce unproductive water losses like evaporation and runoff and increase productive transpiration (Bouman, 2007).

2) Managing livestock-water integration in the context of climate change

Agricultural water demand goes beyond crops. One intervention that would improve agricultural water management is integrating livestock into the planning and management of irrigation schemes. Integration of livestock production systems in both small and large-scale irrigation schemes holds important opportunities to improve overall system productivity (Amede *et al*. 2009). Upper catchments, which formerly served as grazing areas, are also becoming protected through area enclosure to protect head works, diversion canals and command areas. This limits free movement of animals and could cause serious livestock feed shortage unless investments and preventive measures are in place. Recognizing the challenge PASIDP is recommending to increase access to livestock feed in the command area, partly through increasing the quantity and quality of crop residue from irrigated fields but also by growing forage crops on border strips, hilly patches, gullies and other underutilized niches - utilizing water from canal seepages, overflows and night storages. However, irrigation development is commonly becoming an incentive for farmers to convert grazing areas to crop fields, particularly vegetables and fruits.

The livestock number in SSA is projected to increase by 2.5- to 5-fold, from 200M head in 2005 to 500–970M head in 2050 (Cork *et al*. 2005), which will put a huge pressure on water and land resources unless productivity per unit of water investment increases significantly (Amede *et al*. 2009). Although the livestock revolution offers a chance for smallholders to benefit from the rapidly growing market and raise their incomes, it could also have negative environmental, social and health impacts if not managed well (Steinfeld *et al*. 2006). Four mechanisms of how livestock production triggers and aggravates water resource degradation are (Steinfeld *et al*. 2006):

- to satisfy increasing feed demands, pastures and arable land for growing feeds expand into protected and natural ecosystems;
- because of overstocking and inadequate watering points, rangelands are becoming degraded;

- in peri-urban environments soils and water resources are contaminated because of manure and wastewater mismanagement;
- growing feed crops will demand intensification, which may lead to resource mining and soil degradation.

Although water for livestock drinking and servicing might be the most obvious water use in livestock production systems, it constitutes only a minor part of the total water consumption (Peden *et al.* 2009). Recent reports indicate that the major water consumption by livestock is related to the transpiration of water in feed production, which is generally about 50 to 100 times the amount needed for drinking (Peden *et al*., 2009). Livestock systems depending on grain-based feeds, as is the case in the developed world, are more water intensive than systems relying on crop residues and pasture lands, as is the case in SSA and South Asia. Moreover, strategic allocation of livestock watering points could improve livestock water productivity and increase returns per animal by up to 100 percent. For instance in the drought-prone areas of Ethiopia, reducing the distance of livestock walking from 12 km to 3 km increased milk gains by 250 litres per lactation period per cow.

Extensive grasslands in pastoral and agropastoral systems have multiple uses in addition to being a very important source of livestock feed and of livelihoods for stock raisers and herders. Most grasslands are important catchment areas and the management of their vegetation is of prime importance for the water resources of downstream lands (FAO, 2009). For instance, in the Nile basin, about 70 percent of the water is depleted through the grass land pastoral and agropastoral systems. Grassland management, which encompasses erosion control, controlled grazing, availability of strategic watering points for livestock drinking and different forms of water harvesting structures could be effective adaptation strategies to minimize effects of climate change and variability. Minahi *et al.* (1993) stated that grasslands are almost as important as forests in the recycling of greenhouse gasses and that soil organic matter under grassland is of the same magnitude as in tree biomass; while the carbon storage capacity under grassland could be increased by avoiding overgrazing. Improved grazing management can lead to an increase in soil carbon stocks by an average of 0.35 t C ha-1 yr-1 but under good climate and soil conditions improved pasture and silvopastoral systems can sequester 1-3 t C ha-1yr -1 (FAO 2009). It is estimated that 5-10 percent of global grazing lands could be placed under C sequestration management by 2020 (FAO, 2009).

3) Climate-proof crop and fodder varieties

Agricultural drought denotes a prolonged period without considerable precipitation, which may cause a reduction in soil water content thereby cause plant water deficit. It is mainly caused by variable supply of rainfall across seasons, poor soil water holding capacity of soils and improper management of water resources (Amede 2006). It has been happening at least once in five years in Ethiopia for the last thirty years, causing human and environmental disaster. Despite the alarming demand for drought-resistant cultivars, breeders are slow in achieving this goal due to the challenge in identifying traits that reflect true drought resistance. Integrating improved forages into various crop-livestock and agropastoral systems is also a key strategy to improve water productivity of systems through using underutilized water that could be depleted through non-productive evaporation and run-off. Adoption of crop varieties and forages with increased resistance to heat stress, shock and drought are critical to minimize climate change effects. For example, a private-public partnership under the leadership of the African Agricultural Technology Foundation called Water Efficient Maize for Africa (WEMA) intends to develop drought-tolerant African maize. This initiative, though, is not uncontested as it uses biotechnology besides conventional breeding and marker-assisted breeding techniques (www.aatf-africa.org).

TABLE 1

Varietal traits that would minimize the effect of climatic variability on crop yield (Amede 2006).

INTERMITTENT STRESS	TERMINAL STRESS
Synchrony of fast growth stages to water supply	Synchrony of flowering/early pod filling to water supply
Early vigour	Mobilization of assimilates from sink to source
Stomatal regulation	Root depth
Developmental plasticity	(Osmotic adjustment of roots and shoots)
Root depth and density	
Leaf area maintenance	
other survival strategies	

4) Enhanced soil carbon sequestration

The long history of subsistence agriculture in SSA caused serious nutrient depletion in most of the cropping systems, aggravated by soil erosion and improper management of cropping sequences (rotations). These soils rarely satisfy nutrient and water demands for crop production, which necessitate for addition of external inputs. With the current pace of land degradation, associated soil fertility decline and population increase, SSA cannot produce enough food to satisfy its food and environmental needs (Lal, 2001). The prospect of agricultural intensification in Africa has also been hampered by the deterioration of land quality, soil health and nutrient mining, manifested as the decline in soil carbon and associated decline in crop and livestock production and productivity. While crops in SSA remove about 4.4, 0.5 and 3.0 million t ha-1, year-1of nitrogen, phosphorus and potassium, land users return only 0.8, 0.3 and 0.2 of these major nutrients, respectively (Bationo *et al.* 2006). Hence, there has been an ongoing five-fold nutrient mining, in comparison to yearly nutrient application.

Soil health, which is the continued capacity of soil to function as a vital living system, is a key factor which sustains biological and economic productivity of soils, it is vital to maintain the quality of surrounding air and water environments, as well as to promote plant, animal, and human health (Karlen *et al.* 2001). Moreover, soil health in African smallholder farms can vary dramatically from one end of a field to the other and from homesteads to outfields (Amede and Taboge, 2007), partly due to the preferential treatments of farmers, but also due to the land user's choice of enterprises, reflecting present challenges and future uncertainties.

While soil fertility decline is well recognized as major production bottleneck in SSA, the critical investment required is very much limited for one or a combination of the following reasons:

- The cost of chemical fertilizers is higher than the benefits farmers may get from increased agricultural production.
- Nutrient availability and associated nutrient storage in the soil is commonly undermined by soil erosion. Weak land use policies and institutional arrangements not only aggravated soil erosion but also became disincentives for investment in chemical fertilizers.
- Farmers manage multiple enterprises of crops, livestock and/or woodlots, which are interdependent. However, decisions are commonly biased towards those which have a direct impact on household food security and income, than those interventions with indirect long-term benefits.
- Farmers currently manage multiple enterprises which are interacting both positively and negatively in terms of nutrient use and management depending on household decisions and externalities.

In many cases, trade-offs among components dominate benefits from long-term environmental services (e.g. effect on water, nutrients and so on). In this case, farmers single-out enterprises with huge economic benefits regardless of the negative impact on other system components and future production scenarios. Moreover, the high variability of soil health brings about its own complexity. It dictates the crop choice, agronomic practices and market opportunities, which would require the application of niche-based integrated soil fertility management principles. Farmers' decisions to adopt soil fertility improving interventions and labour intensive practices also depend on the short-term incentives of those practices in terms of generating income and household food security. Therefore, farmers demand incentives to invest in sequestering soil carbon both for long-term sustainable agricultural growth and mitigating climate change, despite the fact that they bring short-term economic benefits from their crop and livestock enterprises.

5) Integrated landscape management strategies

Integrated landscape management, which integrates both decreasing the unproductive water losses (runoff, evaporation, conveyance losses, deep percolation) from a system and increases the water use efficiency of the respective enterprises will increase returns per unit of water investments. Managing water at landscape scales brings an accompanied benefit of managing run-off, controlling soil erosion and improved vegetative cover. Within the group of soil and water conservation measures, a distinction can be made between physical structures on the one hand and vegetation management on the other hand (WOCAT, 2007). Vegetation has a direct impact (through its effect on surface roughness and soil protection) and an indirect impact (through its effect on soil organic matter and soil structure) on rainwater infiltration and runoff (Descheemaeker *et al.* 2006). In general, increasing the vegetation cover will result in higher biomass production, higher rates of converting locally unproductive water to economical and productive water use and increased carbon sequestration at all levels, from farm to landscape scales. Better water and nutrient management using integrated approaches could capture more CO_2 from the atmosphere and contribute to mitigating many of the negative effects of climate change and increasing weather variability.

One of the major factors affecting agricultural productivity in SSA has been the destruction and siltation of agricultural fields due to soil erosion emerging from upper catchments. In some regions in Ethiopia (e.g. Tigray), there has been considerable success in managing upper catchments, mainly through the 'Safety Net' programmes. This is a programme designed to improve the food security of the poor while facilitating the engagement of the local communities in improving natural resources management through food / money for work arrangements. The institutional structures of the programme heavily rely on the existing local arrangements including community representatives / leaders, disaster prevention committees and local governments. It also considers assets, income and livelihood criteria for household selection and their ability to physically work. The work includes soil and water conservation structures, planting trees in degraded slopes, protecting landscapes from excessive use by livestock through 'area enclosure'. Although the success rates of adoption vary, the benefits of upper catchments protected in the late 1990s in selected sites of the Ethiopian highlands could be clearly seen. In schemes where extensive soil conservation was done, erosion and siltation has been considerably reduced - head works and canals continue to serve without the need for frequent maintenance. The greatest benefits are found in situations where physical measures were accompanied by innovations that bring short-term benefits in terms of fodder, fuelwood, water and other resources. Introducing and promoting multipurpose legume trees, with feed, fodder and wood values, in farm niches including farm borders, soil bunds and farm strips is important for sustainable NRM. They increase the vegetation cover, minimize erosion and improve watershed functions. Farmers' groups were found to be effective approaches to identify farm and landscape niches where trees could be integrated without competing with other enterprises.

INSTITUTIONAL LINKAGES AND PLATFORMS

Research and development focuses on the linkages, flows and dynamics of the various production and organizational systems in agricultural water management, providing a method for understanding, measuring and if necessary, intervening in the social and production relations of climate change and adaptation. An interdisciplinary and multi-institutional approach, which recognizes the complexity of climate variability, resources governance and use, would provide food, employment and income while assuring the adaptive capacity of communities to climate change. These impacts could be realized if research in water management aligns investments with improving productivity and incomes with managing marginal environments - and are linked with enterprise development.

Moreover, in the onset of climate change, the need is increasingly recognized for integrated, holistic research that may include technological, social, policy and institutional interventions for sequestering carbon while increasing productivity of water, nutrients and labour for food security and environmental sustainability. A new approach to research is needed, which places poor men and women farmers at the centre of the climate change research. This also demands wider collaboration among key stakeholders at local and higher levels through action research. Action research, which envisions engagements ranging from definition of research and development objectives and methods to the reformulation of roles of actors, using evidence emerged from case studies in the region.

Various global and regional research and development institutions are engaged in action research identifying and developing interventions and options that would improve water productivity for adaptation to climate change in the region. One such large initiative is the CGIAR Challenge Programme on Water for Food (CPWF), which is working in six major river basins in the world. CPWF is one of the global multi-institutional research consortiums, which brings together research scientists, development specialists and river basin communities in Africa, Asia and Latin America, aiming to improve the productivity of water, livelihoods and ecosystem services at landscape, basin and wider scales. CPWF represents the largest, most comprehensive investment in the world on water, food and environment research. Through the paradigm of water productivity, developing ways to produce more food within limited water availability offers a new approach to agricultural water management in the context of climate change. CPWF works together with National Research Institutions, Ministries, NGOs and community groups in partnerships which seek meaningful impact for the people who use the new innovations developed by scientific research (see http://www.waterandfood.org/about-cpwf.html). The Nile basin is one of the six basins where CPWF-led research on improving agricultural water management has been undertaken, together with the national and regional research and development partners. Currently CPWF, IWMI and ILRI have launched a long-term research agenda, Nile Basin Development Challenge (NBDC) with major emphasis on Rainwater Management Systems. Aligning the climate change related research agenda with similar initiatives, through formation of platforms and alliance at various scales, could help to create local capacity in implementation and adaption of intervention for addressing climate change and variability.

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PAPER 5

RAINWATER HARVESTING AS A MAJOR CLIMATE CHANGE ADAPTATION OPTION IN ETHIOPIA

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INTRODUCTION

Worldwide, including in Ethiopia, climate change (CC) is increasing the variability in temperature and rainfall (NAPA, 2007; LNV, Wageningen UR, ASARECA and IUCN, 2008). It is broadly accepted that drought and flooding are two of the major inevitable consequences arising from increasing variability and CC. Water availability, being the primary determinant of land productivity is consequently affected by CC. Rainwater harvesting is a key strategy to adapt to CC (NAPA 2007; Water Policy Briefing, Issue 13, 2005). Rainwater harvesting can serve to avoid the two of the major consequences of CC, namely drought and flooding. Individual households or communities with the harvested water stored in structures, soils and groundwater are better resilient to the evils of CC (Prinz *et al*. 1998; Pandey *et.al*. 2003; Water Policy Briefing, Issue 14, 2005; Issue 32, 2010). Rainwater harvesting during wet seasons and allowing the water to stay in soil root zone or underground, apart from controlling flood in wet seasons, increases the base flow over dry seasons. In Ethiopia, in response to the recurrent drought, many types of rainwater harvesting technologies have been promoted by various actors.

Water availability is the primary determinant to land productivity. Rainwater harvesting is an umbrella term describing methods of collecting and concentrating numerous forms of runoff from various sources and for different uses. Runoff harvesting is the deliberate collection of rainwater from a surface (catchment) and its storage to provide a supply of water (UNEP, 1983 cited in Hai, 1998; Critchley, 1992; FAO, 1994; Carucci, 2000; Owes *et al*., 2001). Generally it is widely accepted that water leaving an area without satisfying the need of that area is considered as water lost. Rainwater can be harvested from roof tops, ground catchments and stored in aboveground and underground tanks or directly into the soil. However, as far as storage media is considered, soil is the best storage media.

As a means of adaptation to CCs NAPA (2007), Water Policy Briefings, Issue 31, (2009) and (2010) focus on rainwater harvesting measures as a top priority. Rainwater harvesting is one of the three pillars of land, water and labour in the national food security strategy of Ethiopia (MoI, 2001; MoA, 2002). To alleviate the problem of recurrent drought rainwater harvesting is the main entry point in the country's food security programme (MoA, 2002; Eva Ludi, 2009). Rainwater harvesting through construction of household ponds, cisterns (of various shapes, sizes and construction materials) and hand dug wells are proposed as divisible, practical and more effective alternative to reach individual households and small communities. Household level rainwater harvesting and income generation through the above schemes are considered effective to improve the lives of rural poor with minimum cost and external assistance. The increased realization that "every drop matters" is a key to resolving the recurrent episodes of drought and moisture stress (Water Policy Briefing, Issue 8, 2003). In rainwater harvesting, the aspect of supplementary irrigation is more important than total irrigation.

TYPOLOGIES OF WATER HARVESTING SYSTEMS

Aboveground tanks: these are primarily from rooftops using ferro-cement, masonry, brick, and Roto plastic tanks. These were introduced in the region e.g. 46 m^3 in Kenya and 40 m^3 by ERHA - Ethiopia. The smallest size can be jars which can vary from the size of a barrel to 2 or 3 m^3. The shape of all the tanks is cylindrical. The cost of aboveground masonry tanks is extremely high, as they require a wall thickness of ca. 30 to 40 cm and are not easily replicable. On the other hand, low cost ferro-cement tanks, introduced in East Africa using BRC-mesh-gauge 65, are less expensive, probably half the cost of masonry tanks. The promotion of brick tanks have been dwindling because of environmental reason, as natural wood is required as fuel for making the bricks. Furthermore, bricks also need to be reinforced using barbed wire. For all forms of aboveground tanks, installation of gutters, splash guards and downpipes is required. Water from roof tops is primarily for domestic use. Water abstraction from above ground tanks is direct by gravity and only preparations of tap points are required.

Underground tanks: these can harvest rainwater/runoff from rooftops or ground surfaces. Where the catchment is ground surface, the water is meant for livestock or backyard irrigation. Underground tanks can also be masonry, brick or ferro-cement. If the source of the water is from ground catchments inclusion of a silt trap is required. The shape of these tanks can be hemispherical, dome, bottle, cylindrical, sausage, or spherical. In some areas, rectangular shapes have also been introduced. Clearly, where water is stored in underground tanks, it requires to be lifted for use.

Surface ponds: are structures primarily meant to store water from rainfall/runoff and in some cases can also be constructed to store spring or stream discharge water as night storage. Inclusion of one or two silt traps in a cascaded arrangement is required. Surface ponds can be constructed for/by a household or a community to provide water for irrigation and LS. Household ponds were intensively promoted in the country over the last few years by Federal Government and Regional States. The shape of surface ponds can be either circular or trapezoidal reaching a storage capacity up to 180 m^3. They can also be constructed in a cascade arrangement along cricks (embankment type) or off the crick/stream. The main challenge in the planning and use of surface ponds is the lining material. Ponds can be lined by compaction, clay blanket, flexible geo-membranes, bentionite and chemical additives. If the proper lining material is available for a surface pond, then ponds are the least-cost of all storage structures storages. When better options are not available, microponds can supplement water for a short period. However, promotion of microponds alone as a first choice is inadequate and the potential of using shallow wells need to be explored (Carruci, 2006, OCHA, 2003).

Birka/haffir is another form of surface pond. This compares to the HH surface pond but with much larger capacity. For example, the Somali's Birka is constructed on the rocky or gravel areas where the tank floor and wall is plastered with cement mortar. Since the source of the water is surface runoff series of silt traps are necessary. The size of Birka can go beyond 1000 m^3 per HH or in group. The water is used for LS and domestic purposes. Similar to underground tanks and surface ponds lifting is required for water from Birkas.

Shallow wells or hand dug wells: if the ground water is within the reach of the manually dug holes, these are low cost structures (Water Policy Briefing, Issue 8, 2003; Issue 31, 2009). The mouth of the well can be capped using masonry, brick or metal cut from barrel. The water source/catchment is from ground water recharge. In this case, the watershed has to be treated well and geologically the aquifer should also be a suitable one. Once these conditions are met, then hand dug wells are least cost methods for domestic, livestock and backyard irrigation. One household can have one or more dug wells depending on the rate of recharge and its use. Related to the recharge, the density of the hand dug wells need to be optimized by neighbouring users. In the Amhara region, where TanaBeles Integrated Water Resources Development Project is operating, South Gonder Zone, Farta Wereda, Maynet Kebele Administration in a community watershed known as Zefie (343 ha) more than 26 handdug wells are being used for backyard vegetable production and raising tree seedlings. Depending on the intensity of catchment treatment, there are more dugwells in planning. Apart from catchment/watershed level treatment, point recharging can also be used using recharging ponds, pits and wells. These are well-known practices in other parts of the world and need to be promoted in Ethiopia.

Sand dams or subsurface dams: sandy river water courses in arid and semi-arid areas carry short lived but heavy flash floods. The sand deposits originate from the catchments. They are important traditional water sources in arid regions where communities dig holes and access the water during dry seasons for use by human and livestock. Sand dams are similar to subsurface dams except that the top of the dam wall exceeds the level of the sand river bed. This helps in trapping or retaining more sand, thus providing storage capacity. Sand dams require a high bank on both sides of the river because they raise both the sand and the water levels. This, therefore, calls for appropriate site selection. Subsurface dams can be built of clay while sand dams are built of masonry or concrete to withstand floods above the sand bed. Water from sand dams can be abstracted by sinking hand dug wells in the deepest part of the sand on the upstream side of the dam while for sand dams can be extracted in the lower side by gravity. The wells are fitted with hand pumps capable of withstanding the torrential flood. Water stored behind sub-surface/sand dams has the advantage that it is socially acceptable, because it has already been under use traditionally. Evaporation is low and less liable to contamination. The construction of hand dug wells further improves the quality of the water. Mosquito breeding is minimal; reptiles, insects and other small animals cannot pollute the water. A number of these have been promoted in Borana area by ERHA.

Rainwater harvesting typologies can be summarized as follows:

- Structural storage: cylindrical, jars, rectangular, hemispherical, spherical, sausage, gourd, dome cap, brick cap, bottle shape, plastic lined, clay lined; cisterns, haffirs, small farm reservoirs.
- Soil storage: negarims, semi-circular bunds, trapezoidal bunds, contour bunds, contour ridges, contour stone bunds, runoff strips, zay pits, meskat, inter-row rainwater harvesting, water spreading bunds, large bunds (could be trapezoidal or semicircular shape), runoff harvesting from the road or small waterways, hillside conduits, jassour or sediment storage dams (big as well as small); permeable rock dams (streambed cultivation).
- Underground: hand-dug/shallow wells, subsurface dams, infiltration galleries.
- Sand dams.
- Various pumps.
- Drip systems.

OVERVIEW OF IMPLEMENTATION OF RAINWATER HARVESTING SCHEMES AND THEIR ACHIEVEMENTS

According to the PASDEP midterm evaluation report, the aggregated national level target was to construct 470 water reservoirs for rainwater harvesting and 95 percent of the targets have been constructed. The Agricultural Sector Support Project (ASSP-MOARD/BOARD) 2008 reported that rainwater harvesting and Small Scale Irrigation (SSI) activities in ten regions over the five-year programme are being implemented by utilizing small amounts of cash for work, also technical and physical resources to help support food insecure communities and households. Primarily, the assistance is in the planning and implementation of self-help-based programmes in the natural resources sector of which rainwater harvesting is the main one. The rainwater harvesting structures are: Community Drinking Water Supply - from public rooftops such as schools and health centres, spring development of different types and hand dug wells; Backyard Agricultural Production - such as hemispherical, dome cap, cylindrical/trapezoidal/ rectangular tanks; LS Pond - 5 000 m^3.

Based on site specific studies conducted (e.g. Chencha, Abrha Weatsbha - WFP_ MERET 2002, 2005 (a), 2005 (b), Minjar, Bati, Lome, MoARD/BoARD 2006), linked to income generating activities, considerable improvement has been achieved both in quantity as well as quality of water made available for irrigation and slight improvements for domestic use. Rainwater harvesting and Income Generating Activities (IGAs) are also to some extent integrated with complementary measures such as catchment treatment and groundwater recharge (Water Policy Briefing, Issue 32, 2010). IGAs are high value horticultural crops, animal fattening, dairy, beekeeping and sale of eucalyptus trees. Fruits including apple, plum and pear (e.g. Chencha) and improved dairy breed

(SG2000) animals were provided on credit by different projects/programmess of the MOARD/BOARD and NGOs.

Through treatment of the upper parts of watersheds and the treatment of large gullies, the replenishment of water tables is possible (Water Policy Briefing, Issue 33, 2010). The induced effect is often spectacular in terms of raising water tables. Groundwater development through construction of shallow wells has brought major benefits in food security, safe drinking water supply for households, horticultural crops and flood buffering. Ethiopia's groundwater potential (shallow and deep) is estimated at 2.6 billion m^3 (MoWR, 2005). It is reported that farmers in a number of places in the regions have discovered groundwater at only 2-3 m depth during excavating surface ponds (OCHA, 2003, TBIWRDP, 2010, Zefie - Model Watershed site).

Ethiopian Rainwater Harvesting Association (ERHA), in partnership with AFD, RAIN, SASOL and Acacia Institute, is currently implementing sand dams in the Borena areas. Sand dams and subsurface dams have also been introduced in Eastern Ethiopia (Dire Dawa, East Hararge, and Somali areas) since 1974. Where the site permits, it can store water up to 1 500 m^3. In Kenya, Kitui District alone about 750 sand dams have been constructed with the assistance of SASOL in the last 15 years.

There are more donors, bilateral and multilateral organizations including rainwater harvesting activities in their programme/projects now than ever before. There are a growing number of research topics on rainwater harvesting being undertaken by graduate students. Along with research on the various technologies/structures, various training and technical manuals have been prepared or are being prepared on specific technologies. To start with, adequate numbers of infotechs[1] on rainwater harvesting have been included in the Participatory Watershed Development Guideline (MOARD, 2005). Working principles have also been developed for some of the measures. This however, is not to undermine the extra effort needed to bring many traditional and modern rainwater harvesting technologies and approaches to areas which are still in need.

Under the homestead approach, composting and rainwater harvesting have been made to go hand in hand (e.g. Zefie community watershed in Farta Wereda, South Gonder Zone, and TBIWRDP). It is to be noted that compost cannot be prepared without water. The presence of organic matter in the soil increases the water holding capacity of the soil. Organic matter carries 4 to 7 times its own weight in water.

Promotion of rainwater harvesting at household level, in addition to supplementing crops harvested water has also helped farmers to run their own horticultural and tree nurseries. Harvested rainwater is used to raise vegetable, fruit and tree seedlings on individually prepared raised beds. Seedlings are prepared over the dry season and made ready for planting when the rain sets in. In the past, the vast majorities of tree nurseries were run at government level through the assistance of food for work (FFW) and cash for work (CFW). The current trend is that households should have their own rainwater

[1] Infotech is a technology compilation in one or two pages (recto-verso) so that a development worker in the field can use it easily.

harvesting structure and is its own nursery. Most of the rainwater harvesting technologies promoted has been attached to income generating activities.

There is a noticeable increase in land size under supplementary irrigation and off-season horticulture production, diversity of crops watered, animal fattening, keeping of dairy cows, more fodder from vegetable residue, more beekeeping, less drudgery, increased composting, higher household incomes (if not at national level), higher replication of the low cost technologies and more integration of agricultural practices with rainwater harvesting, at least around homesteads.

EFFECTS OF RAINWATER HARVESTING ON INCOMES AND LIVELIHOODS

Farmers' cash income sources have shifted from being limited to the sale of potatoes and pulses to high value horticultural crops, thus rainwater harvesting has catalysed a change of cropping pattern from e.g. "Enset" and conventional cereals/pulses to horticulture. Additional income generating activities such as sheep fattening, dairy, improved beekeeping, use of the residues of horticultural crops for fodder and poultry are under expansion.

In some places such as Chencha, farmers who had migrated have returned to their place of origin to farm apples and other high value horticultural crops. The rate of out migration in search of jobs has been reduced.

There is much better knowledge and experience on how to farm and market horticultural crops.

In the past, children used to be sent away from homes for labour employment. Following the introduction of rainwater harvesting, many households have been able to send their children to school and universities – there is significant increase in students' enrolment in elementary, secondary schools and colleges. Households now have more cash at hand compared to the pre-project scenario.

Many farmers who were not direct beneficiaries from the shallow wells project have built their own shallow wells, in some cases two or three wells, thus a sign of replication. Consequently, there is improved access to food and balanced diet.

Through the capacity building provided (training, follow-up and input provision) to the participants, their skills and experience in undertaking the various activities have developed.

In the Rift Valley system of Ethiopia and in the neighbouring countries as well, some households were seen using the harvested water in ponds and tanks for the construction of soil blocks/bricks - to be used in the construction of houses with corrugated iron sheet.

LIMITATIONS AND SHORTFALLS ENCOUNTERED

- Low cost techniques in terms of lining, construction materials and water lifting have not been adequately researched/tested.
- Skyrocketing prices of construction materials.

- The role of the private sector in the provision of replaceable parts (continuously) and in the promotion of RWH practices has been limited.
- In drier areas (over the dry seasons), water required for constructing rainwater harvesting structures is a limitation.
- Still, the larger focus of rainwater harvesting is to crops, compared with livestock, forestry and other income generating activities.
- Despite the presence of a many indigenous rainwater harvesting practices in the lowland and pastoral areas, the soil storage aspect of rainwater harvesting and runoff farming has not been adequately promoted in the same areas.
- Aspects of artificial groundwater recharging and its use are not yet being promoted.
- When initiating rainwater harvesting projects, there is lack of collecting and capturing baseline information - this is a limitation for impact studies; farmer's recall or zero scenario of nearby areas are considered, but this is not adequate.
- It is only the project/programme supported schemes which are so far performing well.
- Poor cross-regional and federal linkages.
- Shift of focus/emphasis from time to time – that the directions of programmes are altered from time to time.

LESSONS LEARNED

If rainwater harvesting can be made an entry point activity to rural households through feasible and locally adapted technologies (e.g. hand dug wells, plastic lined ponds, etc.) many income generating activities can be linked to attain household food security and can significantly improve livelihoods. Among rainwater harvesting practices, high value horticulture - apple seedling/fruit and off-season garden vegetables production, composting, forage production, fattening and beekeeping can be integrated without problems.

Number of households practising rainwater harvesting and income generating activities has increased spectacularly and this trend will continue to do so into the future. Concomitantly the land area under high value horticultural crops is growing at an increasing rate. The practice of fattening small/large ruminants is also rising. Crop residues from high value horticultural crops are being used as a feed source for the animals being fattened.

Prior to the promotion of rainwater harvesting practices, farmers did not have adequate cash at hand; they have now considerable amounts of cash. Farmers' cash income sources have shifted from the sale of potatoes and pulses to high value horticultural crops, thus rainwater harvesting has catalysed a change of cropping pattern. Income generating activities including sheep/oxen fattening, dairy, improved beekeeping and poultry have also been developed – this diversification is considered to be a clear sign of increased resilience to effects of climate variability. The value of land and water has increased. The profit margin when rainwater harvesting is used for livestock fattening and dairy is much higher than from crops. If a household has water, sequentially, they first use it for drinking, cooking, cleaning, watering small ruminants, watering large ruminants and if there is still more water left then they will put it into the soil first to garden vegetables followed by tree crops and annuals.

Farmers who had migrated have returned to their place of origin to farm apples and other high value horticultural crops and the rate of out migration have declined. Children used to be sent away from homes for labour employment. Households are now able to afford to send their children to school and universities – there is significant increase in students' enrolment in elementary, secondary schools and colleges. Many farmers who were did not directly benefits from projects introducing shallow wells have built their own shallow wells, exemplifying scaling-up.

Planning rainwater harvesting requires correct reading of the land potentials and promoting interventions which follow participatory watershed development principles. Where groundwater is available at shallower depths and within the reach of individual efforts in terms of cost, easy construction and manageability, hand dug wells are the best choice. Rainwater harvesting measures need to be developed beyond microponds, cisterns and shallow wells. For instance, through the cumulative effects (synergies) of numerous interventions such as trenches on hillsides and "smart" compost applications along the edge of terraces will store large quantities of water.

CONCLUSIONS

Overall in the country rainwater harvesting and income generating activities have contributed to reducing drudgery, environmental benefits and increasing incomes to significant numbers of households and this will continue to grow. In conclusion, for much enhanced performance and scaling up of the projects/programmes in their adaptive capacity to CC in the future the following points should be noted.

Consolidation of partnerships, discussion and presentation of scalable initiatives with partners, regions and districts, developing programme proposals and resources mobilization strategy, developing guidelines/dissemination mechanisms - the example of community watershed - development of advocacy strategy.

Identification of quick-wins for scaling-up and support implementation, strengthen and/or establish broad stakeholders working groups, examples: rainwater harvesting users access to packages (income generating activities), capacity building, sustainable land management interventions, ensure women-led initiatives mainstreamed in all priority areas, rural-urban linkages (micro-enterprise development, markets, etc.).

To enhance income opportunities so that households are more resilient to impacts of CC, marketing outlets, availability of credit facilities and complete financial appraisals should be conducted for the high value horticultural commodities (apple and garden vegetables) and livestock production. Community members should be provided with skills in the preparation of business plans. Provision of improved seeds and reinforced support in areas of livestock and tree crops is required. Strong extension support needs to be provided to rainwater harvesting practising communities and households for quality/quantity production of horticulture, seedlings and animal products. This includes strengthened effort in the provision of grafted seedlings, pest and disease and weed control measures.

As lifted water is either showered with uncontrolled gulps out of buckets or flooding the fields through treadle pumps and hoses, there is wastage and uneconomical use of lifted water from shallow wells and other rainwater harvesting structures. Due to high evaporation rate, especially during the dry season, water is lost before it reaches the roots of plants. Micro-irrigation is the most efficient way to provide water to plants and is particularly desirable in water scarce areas where water is valuable and its efficient use is essential. It has a potential to save up to 70 percent of the water used in flood irrigation and increase yields by up to 50-60 percent. The local production and distribution capacity of treadle pumps and family drip kits through a value-chain approach by including sustainable supply of its replaceable parts need to be promoted.

For more sustainable use of groundwater proper utilization and recharging techniques need to be applied. There are many measures to balance demand and supply and often these are not adequately utilized. When groundwater is abstracted faster than the recharge, the water level drops, it means overdraft. There is a large variety of traditional rainwater harvesting and retention structures in many areas which are adapted to local geology/terrain and rainfall patterns and for which local people are skilled. These are practices that address the problem of CC from the supply management side. Measures that augment local groundwater supply by point or artificial recharging (such as recharging pits, ponds and wells) should be introduced, researched and promoted along with the water retention and protection/activation of the natural recharge. Approaches in demand management measures are those that reduce the demand for groundwater and include levelling and bundling of fields to be watered, use of drip irrigation and use of better soil moisture conservation techniques by application of compost and mulching. However, for any groundwater recharging, nearby gullies must be treated first.

As there is no widely agreed empirical evidence on the positive or negative impacts/effects of CC in the drought or flooding episodes in Ethiopia, enhanced meteorology-hydrological monitoring can be used for accurately forecasting these extreme variables.

To improve the adaptive capacity to CC, more capacity building activities that include farmers and technical staff in the form of exchange visits to best performing sites, skill training, on job training, refreshing training are necessary in a planned and coordinated manner. Rainwater harvesting practitioners including farmers need to be taken to best practice sites. A substantial capacity gap is also reported in NAPA.

Technology generation should be dynamic – what is appropriate technology today is not necessarily appropriate technology tomorrow and this requires continuous research and development.

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PAPER 6

EXPERIENCES IN WATERSHED MANAGEMENT: REDUCING CLIMATE CHANGE VULNERABILITIES IN ETHIOPIA

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INTRODUCTION

Ethiopia needs to tackle climate variability and climate change, which now pose a frightening risk to growth, development, and poverty reduction. Even the hard-won progress of recent years could be reversed with extreme weather, crop failures, and outbreaks of hunger and disease. Thus the need to adapt to this situation requires urgent action in planning of all development activities.

The Integrated Watershed Management Component under FAO-Crop Diversification and Marketing Development Project (an Italian Trust Fund 2006-2010) has thus considered this important issue (climate change) in improving the livelihood of the selected watershed sites for total recovery in highly degraded land in Mire Sire (lowland) and as a pilot scheme to sustain the looming threat in Mankula watershed site (highland).

Two pilot sites were selected:

- Arid lowland/Mire Sire watershed Awash Melkasa Area (Food insecure and highly vulnerable area to climate shocks): highly degraded and recurrent drought is a common phenomenon. Natural resources are in an extremely desperate condition. Forests have been continuously utilized without thorough thought for the need for replacement to keep the ecological balance of the area. There are many gullies in the area. Currently, efforts in protecting and developing the natural resources are in initial stages.

- Highland/Mankula watershed Assela area (relatively high potential but rapidly degrading NR base): at present, this area is relatively better-endowed in natural resources. However, there is accelerating degradation of land, water and forest resources due to overpopulation and inadequate agricultural practices. There are expanding gullies, run-offs, floods, and sediment accumulation threatening farmlands and spring water and small streams. Fuelwood crisis and resulting deforestation is a serious problem, and the remaining indigenous trees (Junipereous) spread across the farm land and mountain areas will be depleted soon if the current condition continues. It is imperative to arrest this onslaught of natural resources degradation before it is more difficult and costly to address, given this is a high potential agricultural area.

Watershed development implementation by the project includes two basic components: namely, the planning process which includes a socio-economic survey and a biophysical survey; and the work plan prepared with the participation of the Wereda Administration, Wereda ARD office and experts, zonal and regional experts and local community.

The socio-economic survey of the targeted area was conducted using PRA methods and conventional questionnaires. In this survey, natural resources trends in the area, village mapping, vision of change exercise in which communities' dreams and realization of proposals was done; problem identification and ranking with different gender groups and transect work was conducted.

Through the biophysical survey the project area was visited and observed including major land use types, and assessments were made of soil depth soil texture, slopes, degree of erosion, deforestation level and the traditional irrigation practices in the area. A base map was also produced representing the area.

NATURAL RESOURCES BASE IN SELECTED SITES

Dry land/Mire Sire site is highly degraded and denuded with recurrent drought and ecosystem imbalance. The total area of land under the watershed is 1 500 ha with 755 inhabitants. Mean Annual Rainfall is 700-800 mm; Temperature: 20-25 ^{o}C (moderately warm): Altitude range (m.a.s.l): 1 360-1 800.

Highland/Mankula is relatively better-endowed in land, water and forest cover, but rapid degradation due to expanding population, inadequate agricultural and natural resources management practices is a common occurrence. The total area of land under the watershed is 6200 ha with a farming population of 5 000. Mean Annual Rainfall is 1 100-1 200 mm; Temperature: 10–15 ^{o}C (cool): Altitude range (m.a.s.l): 2 620-3 720.

MAIN OBJECTIVES

Mire Sire watershed

The main objective in this watershed is:

- To reverse and rehabilitate natural resource degradation. This includes: soil conservation and fertility management, moisture conservation, reforestation, area closure, small scale irrigation.

- Build ecosystem resilience and enhance sustainable food production and diversification.
- Training and mobilizing communities for action.

Mankula watershed

The main objective in this watershed is:

- To arrest natural resources degradation in selected sites before it is too costly. This includes: soil conservation and fertility management, reforestation, area closure, small scale irrigation.
- Diversification crop and livestock activities.
- Training and mobilizing communities for action.

Main Intervention – Mire Sire

The main intervention area of watershed development includes the following integrated activities to be carried out within the watershed area:

- Soil conservation and fertility management, reforestation and area closure.
- Arable land: soil bund, fanajuu, fuel saving stoves.
- Non arable land: soil bund, micro basins, seedling plantation/reforestation
- Hillside: hillside terracing.
- Crop husbandry: horticulture development (improved vegetable seeds, grafted fruit seedlings) with small scale irrigation in 15 ha.
- Animal husbandry; forage development (susbania, lucinia, cowpeas, elephant grass), goat fattening.

Main Intervention – Mankula

The main intervention area of watershed development includes the following integrated activities to be carried out within the watershed area:

- Soil conservation and fertility management, reforestation and area closure.
- Arable land: spring development, fuel saving stoves.
- Non arable land and hillside: area closure. Check dam, tail escape, hillside terrace with trenches, reforestation.
- Crop husbandry: horticulture development with small scale irrigation in 120 ha.
- Animal husbandry: forage development (treelucer, elephant grass), heifers, sheep fattening, apiculture).

Results - Mire Sire

Works accomplished so far:

- Increased community participation in decision-making and management of natural resources base was established.
- Improved grass and natural vegetation cover (good establishment of exotic trees, revival of indigenous tree and introduction of fodder plant) on hillsides was observed.
- Reduction in topsoil erosion and improvement in water holding capacity of the soil on hillside and crop land was observed.

- Improved survival rates of tree planted was gained which reaches up to 62 percent.
- Yield increase and income though smallscale irrigation using river diversion and horticulture development was obtained.
- Diversification of crops (vegetables and fruit seedlings) and year round cultivation has started.
- A demand for fuelwood reduced, assisting women who spend considerable time in looking for fuelwood.

Results - Mankula

Accomplished works so far have resulted as follows:

- Increased community participation in decision-making and management of natural resource base was established.
- Gullies were plugged, and regeneration of natural grass and vegetation covering the gullies was observed.
- Reduction in topsoil erosion and runoff that are blocking springs recharging capacity and water availability was observed and flow throughout the site with developed springs is common.
- Good nursery establishment including indigenous trees and fodder crops (such as acacia saligna, sesbania, tree lucer alfalfa and hyginia abysinica or Koso) was done
- Traditional free grazing system no longer practiced: farmers have already benefited from the grass and vegetation from the closed area.
- Demand for fuelwood reduced assisting women who spend considerable time in looking for fuelwood.
- Yield increase and income though small scale irrigation using river diversion and horticulture development was obtained and diversification of farm activities (vegetables and livestock) in an integrated way was practised.

Win-Win Options for improving livelihood and climate change adaptation

The pilot-integrated watershed management experience in both the highland Mankula and the lowland Mire Sire demonstrated the link between natural resources degradation, food insecurity and poverty. Meeting short-term food security needs should be balanced with long-term sustainability issues. Although the overwhelming emphasis of the GTFS project called for immediate increase in crop and livestock production for markets and for small-scale irrigation scheme to support such production, it was clear that natural resources and soil fertility management practices are closely linked to the sustainability of the production system. As indicated above, horticulture development using surface irrigation was a cash earner in drought-prone Mire Sire that suffers frequent crop failure. Such income-earning opportunity has also reduced the pressure on both cultivable and non-cultivable land. The natural resources management and conservation activities in the upper catchment which are demanding and do not bring immediate reward, play an important part in reducing silt and soil debris accumulating in the irrigated area and even block the irrigation channel. Farmers in Mire Sire pointed out that they would not have been able to expand the irrigation command area without conservation and natural resources management activities under the integrated watershed management approach. Similarly, the expansion of the potato as a cash crop in Mankula was closely linked to groundwater recharge capacity and availability of adequate water to both upstream and downstream which was greatly facilitated through spring development and conservation measures aimed to arrest soil erosion and deforestation. Hence, this pilot community-based integrated watershed management has demonstrated win-win benefits where farmers' income and food security have been improved while protecting the natural resources base and building ecosystem resilience at watershed level.

Synergy between small-scale irrigation and watershed management is a crucial component for development of cash and food crops, development of exotic fodder species, and introduction of beekeeping, production of seedlings and management of nurseries in both the drylands and highland areas. These experiences have further established the critical role of small–scale irrigation and water harvesting as a crucial element in promoting adaptation and reducing vulnerabilities of smallholders to climate change and related risks.

Improved management practices (in crops, livestock and agroforestry) and diversification schemes such as introduction of horticulture, small ruminants and beekeeping have shown a remarkable achievements in terms of productivity, income and adoption of good farming and natural resources practices. These could be key elements in up-scaling adaptation practices among smallholders in similar agro-ecological zones.

Crop-livestock integration was not an intended objective of the project. But in the pilot integrated watershed management sites it proved to be a vital outcome in improving both crop and livestock productivity and resilience of smallholder to vulnerability of climate-related risks in moisture-stressed drylands areas. In dryland Mire Sire, the introduction of Sesbania (very good fodder crop for livestock) along the embankment of soil bunds addressed the most serious shortage of livestock feed in the area in short time. Thus farmers had an added incentive to maintain the soil bunds rather than abandoning them or turning them to crop land as seen in some safety net covered areas. In the highland Mankula where there is a shortage of cultivable land, the development of forage crops in the farmer's back yard, or live fences around homestead has enhanced the feed availability, particularly to ruminants. As a result, some farmers are involved in fattening their sheep through a revolving fund and are reported to get good prices. Feed availability close to homestead has also reduced free grazing and the resulting land degradation that impacts on crop productivity. Hence, crop-livestock integration in the pilot integrated watershed management sites proved to be a vital outcome in improving both crop and livestock productivity and resilience of smallholder to vulnerability of climate related risks.

Experience in tree planting from both the lowland and highland sites also suggests that it is important to meet farmers immediate needs for fuelwood and livestock feed if it is to be successful. Hence, nursery establishment should strive to have both short-cycle exotic trees and forage species (such as acacia saligna, sesbania, tree lucer and alfalfa) and long-cycle indigenous trees (such as juniperous procera, hyginia abysinica and doviyalis abysinica) as much as possible. A balance of short and long-term trees was practiced in Mankula with good results and having impact on both farmers well-being and the environment. Secondly, tree planting experience also suggests that there are species that are more likely to have higher survival rate depending on the agro-ecosytem. In the dryland Mire Sire area acacia salinga has done remarkably well both in terms of aboveground carbon storage capacity and building of soil formation and humus around the root zone area. In the Mankula the rare indigenous species heginia abysinica (Koso) has spread widely among farmers field which has good water retention capacity. From exotic tree species lucier has shown fast growth and highly nutritious and desirable fodder crop particularly for dairy.

The pilot watershed experiences have underscored that initial investment in adaptation is vital to bring synergy with mitigation. Location-specific tree species that have a higher survival rate have helped farmers to meet their immediate basic needs. It has also helped to establish noticeable build-up of humus and dark soil around the root zone dryland Mire Sire. If this continues it could result in aboveground carbon storage capacity in due time resulting in carbon sequestration and climate change mitigation.

The most remarkable achievements in terms of production, income and adoption of good farming and natural resources practices have been at individual farm plot level. This is in contrast to decades of experiments in communal farming in the past in Ethiopia. Aware of activities implemented in similar environment and initial seed investment and support though FAO, farmers in highland Mankula were quick to expand their potato fields with improved potato varieties, plant multipurpose trees in their backyard which provided forage to their livestock (and reduced free grazing) and diversified production by introducing beekeeping. Such diversification of the farming system will be a major win-win approach in coping with climate change among smallholders in Ethiopia and possibly with similar environments in East Africa.

Training and guidance of farmers enabled them to initiate and establish a well-functioning community mechanism in managing and protecting the natural resources and sharing of benefits – a crucial element for the success in adaptation and for a community-based carbon sequestration project.

PAPER 7

CLIMATE CHANGE - FOOD SECURITY NEXUS: TACTICAL RESPONSE THROUGH SLM PRACTICES IN EASTERN AFRICA

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INTRODUCTION

The relationship and concern over climate, food and food security is not a new issue. For instance, in 1974 the United Nations convened a World Food Congress under the guidance of FAO and reminded governments of the urgent need to focus on existing and yet-to-emerge food security and related issues. Related, serious issues emerged, including both the energy crisis and climate change. Concerning climate change, publication of the Fourth Assessment has clearly played an important key role, catalysing a marked sharp increase in concern. The awarding of the Nobel Peace Prize to the IPCC has served to enhance the influence of the assessment and sparked an unprecedented "rush to action", in many ways providing a tipping point for policy-makers who have truly begun to take the climate situation more seriously.

However, within this "rush to action", there has been relative neglect of the agriculture sector and, by extension, of food security. The Climate Change Conference in Copenhagen ended with an Accord, which was noted by Parties. Although this indicates progress in the negotiations, in the area of agriculture and climate change, no specific reference on agriculture was made in the Accord. The next UNFCCC COP takes place towards the end of 2010 in Cancun, Mexico – it is hoped that this will provide an opportunity to advance the agricultural agenda.

This illustrates that what may be regarded by an emerging, mostly African, group as the common nexus of the climate change and food security it is lagging behind in its wider appreciation. This is an importance pre-requisite before it can be well articulated in the next conference then possibly graduate to the financing arrangement sphere. The challenge is to not only well articulate but maintain a firm stand on the recognition that Africa can benefit from a major agricultural transformation, in the wake of climate change and its vulnerability.

CLIMATE CHANGE AND FOOD SECURITY IN EASTERN AFRICA: FORECASTING AN ENVIRONMENT WITH FOOD SECURITY SHORTFALL

The IPCC Fourth Assessment addresses food security by discussing the foreseeable impacts of climate change on agriculture productivity and production in different regions around the world (IPCC, 2007). The report collectively suggests some regions will benefit from global warming though most areas will be adversely affected. However, the people of Africa will be the most affected and most in need of resources if they are to effectively respond to climate change as agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change.

Climate change will exacerbate the existing food security issues across Africa - specifically eastern Africa. The predicted forecast is that in these areas the poverty, hunger and nutrition situation will continue to generally deteriorate. By 2009, about 212 million people were undernourished in Africa, an increase of about 44 million from 1990 (FAO, 2009). Poverty has also increased, with 388 million living on less than US$1.25/day in 2005 as compared to 295 million in 1990 (World Bank, 2009). When these statistics are considered in the context of continuing population growth rates of between 2.5-3.0 percent (i.e. totals will double after approximately the next 25-30 years), the absolute number of people who are hungry remains a major concern.

But, the seemingly “visible boundaries” between food, energy and climate seem to have been historically missed. It is no wonder, as the year 2015 approaches rapidly, that prospects for attaining the Millennium Development Goal-1 (cutting by half poverty and hunger rates) are mixed as the nexus remains invisible or rather neglected. The nexus was articulated in the FAO high level conference on “World Food Security: Challenges of Climate Change and Bioenergy” in 2008.

Food, energy and climate. For the first time in history, those three are closely linked. Without an understanding of this new reality, countries and the international community lack the most fundamental policy decisions (FAO, 2008).

The most important factor that explains food crises at the local, country, regional and/or international level are changes in food supply. Underlying this are the changes in supply (even small changes) which have a considerable effect on prices. It should be remembered that the main characteristic of the market for food crops is the inelasticity of demand (i.e. people cannot consume less than minimum subsistence levels).

Changes in the supply of food originate from two main causes: (i) changes in production due to a combination of weather (droughts, floods) and productivity, and (ii) trade policies in neighbouring countries that reduce food exports to thin international markets, causing huge increases in international food prices, which can be easily transferred to domestic food prices. In recognition of the former reason, climate change poses an additional challenge for future food security in eastern Africa as it is already a hungry and poor region due to low productivity. Sub-Saharan Africa is likely to surpass Asia as the most food insecure region in terms of the absolute numbers of affected.

Africa, a case of low productivity

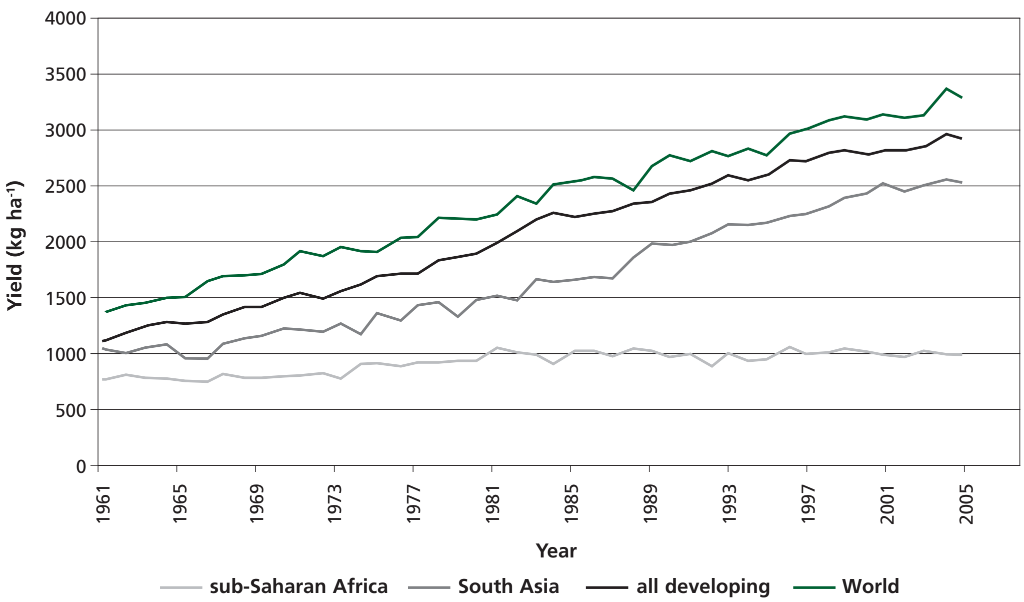
At the global level, agricultural production has grown much faster than the population in recent decades, leading to a steady increase in per capita agricultural output (including food) and a steady decline in world prices for most agricultural commodities, particularly since the late 1970s. In a dramatic break with historical patterns, expansion of the total cropped area in most parts of the world has played a remarkably small role in increasing agricultural production in recent decades, to the point that growth in the global extent of cropland has virtually stagnated. The switch from area expansion to intensification of input use as the primary production growth strategy has reduced the demand for land conversion by over 1 billion hectares globally since the early 1960s (Cassman & Wood 2005).

Unfortunately, not all countries have shared in the global success of agriculture; hunger and malnutrition persist in many parts of the world. Africa as a continent has not been able to increase its agricultural production to keep pace with population growth, leading to periods of decline or stagnation in its food and total agricultural outputs per capita.

Consequently, urgent and comprehensive actions are required to reverse those trends and put Africa back on the development ladder. This cannot possibly be undertaken without increases in productivity. The challenge is therefore to develop and promote food and livelihood systems that have greater environmental, economic and social resilience in the face of changing climatic conditions.

FIGURE 1

Global trends in cereal yield by region (1961–2005)



Adapted from FAOSTAT (2006)

Among the factors widely understood to be reducing crop productivity, other than the low use of inputs, is land degradation. This is particularly the case in Africa, where land is the key asset of the rural poor. Sustainable land management is viewed in this paper as an important pillar to contribute to making farming systems, especially those of the rural poor in Africa, more resilient to the adverse impacts of climate change.

SUSTAINABLE LAND MANAGEMENT OPTION

Sustainable land management as defined by the TerrAfrica Partnership is the adoption of land use systems that, through appropriate management and practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources (FAO, 2009b). The African Heads of State within the NEPAD's Comprehensive Africa Agriculture Development Programme (CAADP) outlined and endorsed "sustainable land and water management (SLWM)" as one of their four priority investment areas for the revitalization of African agriculture.

Potential sustainable land management practices for climate change adaptation that contribute to productivity increases and thus ensure food security can be arbitrarily divided into those for:

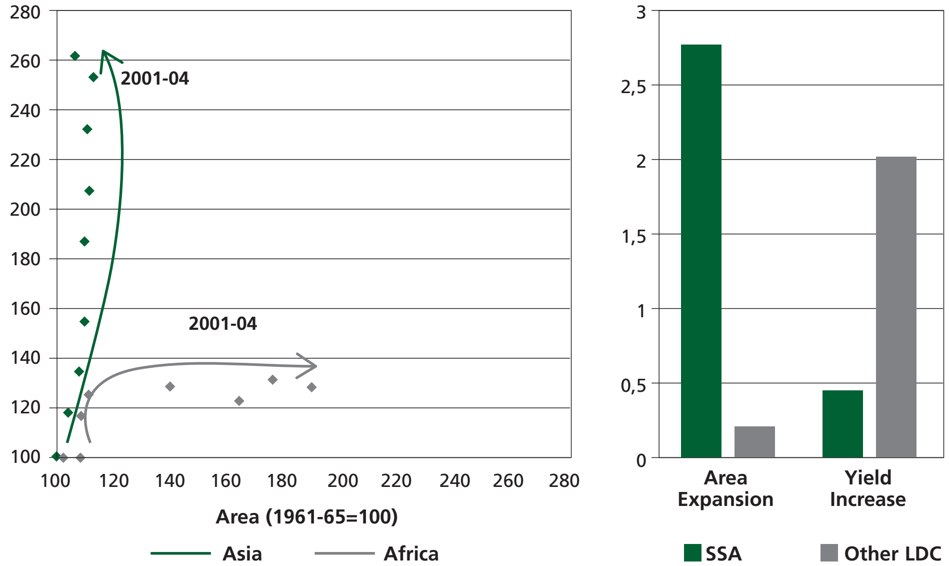
- **Crop management:** plant residues provide a renewable resource for incorporation into soil organic carbon (SOC). In agriculture systems however, as plants are harvested, only about 20 percent of production will be accumulated into the soil organic matter. Failure to return sufficient aboveground plant residues will inevitably lead to a reduction of SOC. Some of the crop management practices which enhance SOC include mulching with crop residues, crop rotations, fallows, crop diversification and intercropping, conservation tillage and conservation agriculture, organic agriculture, integrated plant nutrient management and integrated plant and pest management.

  For example, use of a mulch of crop residues contributes to adaptation in situations where precipitation is erratic and of higher intensity. Increasing rotation complexity also reduces the risk of the harvest being insufficient in subsistence farming systems, as failure of one crop-type, for example due to pest, is less likely to ruin the entire harvest contributing to adaptation.
- **Pasture and range management:** it is predicted that climate change will double the frequency of droughts in the drylands of sub-Saharan Africa, with drought periods lasting longer. Without adaptation, this will have a deleterious effect on the sustainability, viability and resilience of livestock and cropping systems and thus livelihoods in the drylands.

  Some of the sustainable pasture and range management practices include sustainable grazing management, silvopastoral systems, integrated crop-livestock systems and limiting use of fire. Integrated crop-livestock systems in Senegal for instance have led to a 75-195 percent improvement in millet yields and made them less variable year to year (FAO, 2007). Consequent improvements in household food security clearly contribute to climate change adaptation.

FIGURE 2

Lagging agrcultyural productivity



Source 1: Shantan Deverajan, World Bank Chief Economist for Africa

- **Forest management:** Forests need to be kept healthy so that they can maintain their biodiversity and the environmental services they provide. SLM practices will boost forests' resilience and resistance to climate change.

  Adaptation practices that guarantee increase in productivity rather than area growth would control expansion of agriculture (for cultivation or grazing). This would make an important contribution to mitigation of climate change.
- **Rainwater harvesting:** Possibly the most vital concern for SLM in the face of predicted changes in precipitation patterns and increased temperatures is to ensure that rainwater is used to maximum beneficial effect for rainfed and irrigated agricultural production.

  SLM practices that lead to improved land drainage systems in areas predicted to receive increased total precipitation is key to adaptation. Where rainfall totals are expected to decrease, techniques which improve infiltration will, for instance, help cereals to become better established and reach maturity before the end of the rains thus contributing to adaptation in drylands.

Thus, SLM is a key entry point for improving land resource resilience and productivity within the context of the potentially devastating effects of climate change specifically in sub-Saharan Africa, bridging the needs of agriculture and environment, with the twin objectives of:

- Maintaining long term productivity and ecosystem functions (land, water, biodiversity), and increasing productivity (quality, quantity and diversity) of goods and services (including safe and healthy food).

Sustainable land management activities are such that if neglected, especially in the environment of climate change, they lead to degrading processes of soil erosion, deforestation and reduced productivity of land - leading to a cycle of poverty. Proven technologies (a majority well documented), contribute to food security and sustainable development.

As the majority of SLM practices exist, there is a need for up-scaling. The existing best practices should be viewed as providing a source of tactical response (short term) to a changing environment, as opposed to an acceptance of untested strategic responses (longer term). If applied, countries, sectors or groups would probably have capacity to respond (adapt) to climate change, turning this to their future advantage.

Up-scaled, sustainable land management practices will enable farmers and communities to become more resilient to climate change, contributing to increasing the much needed food production.

CONCLUSIONS

Agriculture contributes to development as an economic activity, as a livelihood and as a provider of environmental services, making the sector a unique instrument for development (World Bank, 2007). It will only fulfil such a potential if it can adapt to predicated climate change and the increasing frequency of extreme weather events.

Therefore, for the agriculture sector policy-makers will need to focus on both short term and long-term options and sustainable land management practices could provide a pathway to the near future. Sustainable land management practices can be used individually or, better still, in combination to gain the benefits of synergies both in cropping systems and wider landscapes.

Successful adoption of SLM will include:

- improving access to information and knowledge about available proven technologies in order to enhance their adoption;
- helping people to understand the short, medium and long-term implications of climate change and how they can alter or change their agricultural practices;
- appreciating traditional knowledge, while encouraging land users to also embrace new SLM technologies, where the traditional cannot encompass the required changes.

RECOMMENDATIONS

Maintain a degree of flexibility in the application of best practices: Adaptation is an ongoing process, as identifying a single set of best practices to the potential impact of climate change on food security in any area is inappropriate, as weather and climate are likely to continue to vary into the future. Decision-makers must maintain a degree of flexibility in the application of SLM best practices. The reality of this unknown suggests that considerable precaution must be taken in policy-making for food security.

Policy-makers should adapt policies to halt/reverse environmental degradation, as land degradation hotspots adversely affect food security.

There is a need and possibility to review current and potential financing mechanisms (such as the Clean Development Mechanism and voluntary carbon markets) to finance the use of adaptive SLM practices. For example, carbon sequestration in rangeland soils is not currently eligible for payments under the CDM, due especially to issues of permanence and verification.

As Africa grapples on the international scene in the search for practical proposals and actions on climate mitigation and adaptation, it should at the same time protect the right of Africa to achieve greater agricultural productivity for assured food security.

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PAPER 8

SUSTAINABLE LAND MANAGEMENT: SUCCESS STORIES WHICH CAN BE SCALED-UP TO INCREASE RESILIENCE OF FARMERS TO CLIMATE CHANGE

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INTRODUCTION

Land degradation is a cause for the country's low agricultural productivity, persistent food insecurity, and rural poverty. Moreover, reliance of Ethiopia's rapidly growing population on unsustainable subsistence agricultural practices is a major cause of land degradation. The estimated annual costs of land degradation in Ethiopia range from 2 to 3 percent of agricultural GDP (EHRS 1986). Inherently fragile soils, undulating terrain, erosive rainfall and environmentally destructive farming methods that many land users practise, make the land highly vulnerable to soil erosion. In addition to physical land degradation, the soils of Ethiopia also suffer from chemical degradation. Nearly one-third of the agricultural land is moderately to strongly acidic because of damaging farming practices. The causes of land degradation are complex and diverse.

The farming systems, particularly in the highlands, are dominated by cereal cultivation and do not produce sufficient protective ground cover when the most erosive rains fall. Cereal growing requires frequent working or pulverization of the soil, making it more susceptible to erosion. Dependence on wood and other biomass for household energy, together with rapid expansion of agriculture into forested areas has resulted in high rates of deforestation. Nearly 95 percent of the nation's energy consumption comes from biomass fuels, triggering the cutting of trees but also including widespread use of animal dung. Excessive rates of deforestation have ultimately stripped the land of its vegetative biomass and exposed it to high levels of soil erosion. In the highlands, the expansion of grazing beyond the land's carrying capacity occurs at the expense of the remaining natural vegetation, further accelerating land degradation.

In recognition of these problems and the resulting consequences, land management activities started in the northern regions of Ethiopia in 1973 following the severe drought events. Then the Extension Programme Implementation Department (EPID) of the Ministry of Agriculture introduced modern ways of managing land in the other parts of the country through the extension program. Following this, the Soil and Water Conservation Department was established in the year 1980, with the responsibility of coordinating the implementation of the National Soil and Water Conservation Program. Systematic and planned activities in land management through the watershed approach were launched with the creation of the department. About 117 watersheds, ranging from 20 000 – 40 000 ha in size, were planned and implemented pursuing the incentive-based watershed management approach. In the meantime, land management activities have been implemented by the extension programme in areas considered less affected by land degradation but with very negligible focus.

Uncoordinated efforts, coupled with the lack of essential policies have, however, resulted in unsustainable land management interventions in the past, although a great deal of effort and investments were made through the watershed and extension approaches. Overall, the major bottleneck to sustainable land management has been the lack of commitment to implement the policies and proclamations in place. Free grazing animals have been the cause for the low survival rate of vegetative measures practised in several land management projects and programmes. Physical measures including terraces, check dams and bunds have been removed or trampled to collapse, as livestock had free access into areas with these measures.

Several actors have over the past decades been involved in the implementation of projects and programmes of land management in support of the government national land management programme. Many good practices have evolved in the course of these endeavours, but these were not systematically documented as successful practices that could be scaled-up. The Ministry of Agriculture, in collaboration with the World Overview of Conservation Approaches and Technologies (WOCAT) and other stakeholders in the country, initiated the establishment of the EthiOCAT network that was given the responsibility of documenting successful technologies and approaches. EthiOCAT has been documenting land management technologies and approaches of both indigenous and exotic origin since 2000 and has recently produced an overview book (unpublished) to be used by practitioners, researchers and decision-makers in the country.

TECHNOLOGIES AND PRACTICES SCREENED FOR SCALING-UP

The Ethiopian Overview of Technologies and Approaches (EthiOCAT) Network of the Ministry of Agriculture and Rural Development (MOARD) has documented over 50 traditional and introduced land management practices from 30 woredas representing various agro-ecological zones in Ethiopia. A number of review workshops have been conducted to review the work and enrich the information at different times in various regions. Some of these technologies and practices have been evaluated on the basis of agro-ecological applicability, scope for scaling-up and the high level of adoption and adaptation.

About 33 technologies and 8 approaches have been screened to be scaled-up.
These include:

i) Introduced SLM Technologies: stone check dams and terraces (DewaChefa), contour stone bunds (Tigray), graded soil bunds and relay cut-off drains (Hossana), Desho-bund, Integrated land management measurers with area closures (Alaba), stone bunds (North Shewa).
ii) Vegetative and Agronomic Indigenous SLM Practices: ridges and furrows of sweet potato (Harerghie), broad basin and ridge (Harerghie), trashlines (Wozeka/ Derashe), multiple cropping (Konso), crop residue and stone mulch management (Konso), ridge Basin (Konso), chat strips and rectangular bunds (Harerghie).
iii) Combined Physical and Vegetative SLM Technologies: stabilized soil bunds Boreda), vegetated fanya juu (Omo-Sheleko), hillside terrace, Konso bench terrace, stone-faced trench bund (Tigray), gully rehabilitation (Gonder), stone-faced bunds (Abay Gorge), stone faced soil bund (Harerghie), soil bund and fanya juu vegetated (Adama), graded bunds with disposal structures (East Gojjam), paved and grassed waterways (Farta), stone bund terrace (Gonder) stone-faced soil bund (Tigray), vegetated stone – soil –stone bunds (North Wello), sorghum terrace (Harerghie), area closure combined with hillside terraces (Tigray), earth-checkdams for gully reclamation (Damot Galle), microbasins, trenches and area enclosures, Lemo (Hadiya), runoff and floodwater farming (DireDawa).
iv) Agronomic and vegetative measures for improving grasslands: grassland improvement (Chencha).

APPROACHES DOCUMENTED FOR SCALING-UP OF SUCCESSFUL PRACTICES

Various projects and programmes including the extension programme of the Ministry of Agriculture and Rural Development have embarked on scaling-up best practices and technologies pursuing better approaches. Among the approaches used for implementing land management activities in Tigray is the mass mobilization approach which has been in use for about 20 years. Other approaches used include the participatory local planning approach and the incentive-based watershed management approach. The objectives of the approaches in general are to: enhance the participation of all land users in the planning and implementation of land management activities collectively, in groups or individually by mobilizing work force and material needed for the work; provide effective technical and material support to implement planned activities; monitor results and outcomes more systematically.

Successful interventions to prevent or control land degradation require integrated and cross-sectoral approaches to sustainable land management. Development partners have developed interest to catalyse the adoption of the advantage of using the resources they make available to leverage additional funds from bilateral and multilateral development agencies.

Homestead development was, in the meantime, introduced as an entry point to watershed management with the emergence of the CBPWMG, which focuses on mini-watersheds (200-500 ha size) as the unit of planning and as well as implementation. Currently, most projects and programmes are required to use the CBPWM guidelines for planning and implementing SLM activities. The SLM programme, the MERET project and the Productive Safety Net Programme are examples of projects that are using the guidelines to carryout land management activities in food insecure woredas. The extension programme of the MOARD follows the watershed management principles for all development programmes in the country.

MECHANISMS FOR SCALING-UP GOOD PRACTICES

Scaling-up good practices in land management is necessary in order to counter increasing land degradation, improve declining productivity and halt biodiversity loss, thereby deal with a major obstacle to economic growth and sustainability. Opportunities for scaling-up sustainable land management practices exist among which include: the availability of a number of proven and demonstrated traditional and introduced technologies that are documented and compiled in an SLM overview book; institutions which have experience and manpower to execute SLM programmes; international donor institutions and UN agencies to support the implementation of SLM and conventions; readiness of the government to mobilize the public and resources to scale-up SLM activities; the availability of willingness of land users to mobilize their own resources.

Establishment of a coordination mechanism for SLM is necessary as a number of interventions, including pilot activities on SLM, are being financed by the government and its development partners across Ethiopia. To avoid duplication and promote synergies, in 2006 the Government established a mechanism to coordinate all SLM investments in Ethiopia. This mechanism comprises a national steering committee, chaired by the State Minister for the Federal Ministry of Agriculture and Rural Development (MOARD), a national technical committee that comprises representatives from government, civil society, and development agencies and a SLM Support Unit. Furthermore, MOARD has developed a Country SLM Investment Framework, which outlines key priorities for SLM investments and a strategy for scaling-up.

SLM has evolved from the various experiences gained in land management during the past years in implementing various projects and programmes and lessons learned. SLM is developed to comply with and on the basis of the Paris Declaration on Aid Effectiveness and GEF's TerrAfrica framework and its Strategic Investment Project (SIP) for Sustainable Land Management in sub-Saharan Africa. The Government has embarked on promoting synergy and coordination among institutions that are dealing with and are in support of sustainable land management by establishing a multisectoral institutional mechanism which comprises a national SLM Steering Committee, a National Technical Committee, the SLM Support Unit in the Federal Ministry of Agriculture and Rural Development and the strategic Investment Framework for Sustainable Land Management.

Experience shows that viable strategies, effective policies and also approaches are needed to enhance the scaling-up of best practices in the different agrological zones with varying socio-cultural, farming systems, biophysical and policy settings. Studies conducted have indicated that several problems constrain the scaling-up of land management practices in Ethiopia. Some of these include, socio-economic, policy, cultural practices, approaches, appropriateness of the technologies and sticking to poor land management practices. The problems vary in magnitude and scale in different localities and agro-ecological zones. Sustainable land management practices have shown low adoption, adaptation and replicability in the high rainfall areas but are well-adopted and expanded in low rainfall areas (EthiOCAT, 2008).

Sustainability can be achieved only through the collective efforts of those immediately responsible for managing resources. This requires a policy environment that empowers farmers and other local decision-makers to reap benefits for good land use decisions, but also to be held responsible for inappropriate land uses. The Land Administration and Use Proclamation of the Federal Democratic Republic of Ethiopia stipulate that land users have user rights on the land they hold and have responsibilities to manage it and, in particular, maintain its productivity.

Mechanisms for enhancing SLM adoption and scaling-up include: enhancing partnership; creation of an enabling environment; increasing implementation of best practices; practising policies and strategies; improving extension systems; enhancing awareness promotion among land users and the public in general; increasing investments, applying community based and integrated approaches; developing proper institutional mechanisms and mainstreaming SLM; applying improved monitoring and evaluation methods (result based M&E) and implement land tenure policies favouring investments on land.

Scaling-up is dependent on putting in place measures, practices and associated investments that can work synergistically to expand the adaptation and uptake of SLM in a rapid and cost-effective manner at higher scales, as appropriate. Successful scaling-up and mainstreaming of sustainable land management requires that we learn from our past and make advances in thinking – including what has worked and abandoning redundant technologies.

Experience shows that viable strategies, effective policies and approaches are all needed to enhance the scaling-up of best practices in the different agrological zones with varying socio-cultural, farming systems, biophysical and policy settings. Studies conducted have indicated that several problems constrain the scaling-up of land management practices in Ethiopia. Some of these include, socio-economic, policy, cultural practices, approaches, appropriateness of the technologies and sticking to poor land management practices. The problems vary in magnitude and scale in different localities and agro-ecological zones.

STRATEGIES FOR SCALING-UP SUCCESSFUL PRACTICES

Unlike the past land management programmes and projects which focused more on soil and water conservation activities, SLM involves bringing together wider areas of interventions that could result in improved livelihoods and ecosystem functions. In order to address these goals, proper strategies and polices need to be developed and implemented carefully. The following are some of the strategies to be implemented in order to bring about sustainable development.

Sensitizing land users and communities is a key entry point, to make land users understand that environment-conscious development is key to poverty reduction and contributes to household food security through environment management and protection measures. Communities and land users need to know SLM interventions help to increase real income of households through environment friendly interventions and improve quality of life through the provision of community operated and managed land management practices.

Strategic support for the production and distribution of organic fertilizers; provision of material inputs for apiculture development, construction of communal water points and toilet facilities scaling-up SLM and improve livelihoods of land users.

Water harvesting: sound land management plans consider the practising of water harvesting structures in their appropriate locations. Farm ponds, water tanks and small earth dams are among the major water harvesting structures considered in this case. Improving pastures and grazing lands should be considered as a priority livestock management policy in land management endeavours. Fuelwood plantation at villages and seeking other alternate energy sources should be considered.

Integrating physical measures with biological measures: constructing physical structures alone is not SLM but it is just the first measure to control soil erosion and runoff moving from one strip to the other and alone it does not control erosion taking place within the terraces. Combining trenches with soil bunds ensures increased runoff retention and hence increases soil moisture. Improving soil fertility is to be viewed from two perspectives in land management. One aspect is from the point of view of improving productivity and the other is the building of soil resistance to erosion. When soil fertility is improved its structure is improved and it develops resistance to erosion because of soil particles aggregation. Biological land management measures, agronomic measures and cultural practices, which improve soil fertility, are to be considered in this case.

Purposeful and effective gully treatment: the plan for treating gullies should take into account the purpose for which the gully is to be rehabilitated. The choice of treatment measures is to be made on the basis of future intended use of the gully. If the gully to be treated is to be used for growing crops after rehabilitation, then the type of structural and vegetative measures to be applied should be different from the ones to be applied for the gully treated for tree plantation or grassland development. Gullies can further be developed as waterways in which case the treatments are different accordingly.

Various actors in land management have used different approaches for implementing land management measures. The most commonly used approaches include: food for work, cash for work, mass mobilization, infrastructural support, extension, self help, land users groups or Debo (EthiOCAT documentation, 2008). The MERET Project assisted by the

World Food Programme uses food for work as an approach for land management activities. The European Commission assisted land management project of the 1980s used cash for work for implementing activities in land management. A number of NGOs involved in land management use food and cash payments to land users in land management activities. Food is given as a wage payment and some used food as an incentive for participation. Wrongly perceived and introduced incentives caused dependency and in the absence of them it was difficult to get land users to participate in land management activities. Only few projects which used food as an incentive for motivating land users participation were able to some degree reduce dependency on it.

POLICIES

Sustainable land management combines technologies, policies and approaches followed to implement activities. SLM further aims at integrating socio-economic principles with environmental factors, in order to simultaneously: maintain and enhance production, reduce risk, improve soil characteristics and prevent degradation of soil and water quality, be economically viable, socially acceptable, maintain the potential of natural resources and assure access to the benefits from improved land management. Developing and effectively implementing policies in land use and management are of crucial importance for SLM to be scaled-up. Backward cultivation practices, improperly designed and constructed rural roads, deforestation by bushfires and for cultivation on steep slopes are among factors that have contributed to unsustainable use of natural resources.

Ownership of enclosed areas: enclosure areas were in the past protected largely by site guards and in some cases by the community members themselves. Site guards are expected to guard many hectares, in which case the guarding task was often cumbersome unless the community members supported them in discharging this responsibility. Studies show that community members should benefit from the grass and the other benefits coming from the enclosures if sustainable area closure management is to be realized. Enhancing productivity of enclosure areas is of extreme importance in view of improving the carrying capacity of the land under rehabilitation. In this regard, rehabilitation plans should consider the future intended land use and apply appropriate measures according to the needs of the intended land use.

Maintenance: maintenance is essential to all sustainable land management measures. For maintenance work on cultivated lands, land users should assume the responsibility for measures placed on their land if the damage is minor and caused by carelessness, but if the damage is of a larger magnitude, a group of land users organized in land management teams or the community should assume the responsibility for the maintenance. In areas where communities and land users have been maintaining the SLM measures, many have attained a high level of sustainable development and have become food secure.

Technology generation and dissemination: this could be achieved by increasing the capacity of service providers in SLM, promoting integrated service provision to maximize SLM in villages and strengthening land user-extension-research linkages to generate appropriate SLM technologies.

Supporting Policies: land users may require better access to credit for SLM investments and to be encouraged regarding the implementation of the national population policy. Ethiopia had issued population policy but this policy is currently not properly implemented. SLM projects and programmes can contribute by creating awareness among communities of the population policy and its potentially beneficial impacts on land degradation and overall livelihoods.

PAPER 9

VETIVER SYSTEM APPLICATIONS FOR ENHANCING ECOLOGICAL AND SOCIAL SYSTEMS RESILIENCE: EXPERIENCE OF SIDA/ SLUF ENVIRONMENTAL PROTECTION PROGRAMME IN ETHIOPIA

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INTRODUCTION

The Swedish International Development Authority (Sida) and the Sustainable Land Use Forum (SLUF) environmental protection programme is supported by the Swedish NGO/CSO cooperation programme which aims at providing resources to enable partner umbrella and sub-grantee CSOs that are working in environment in Ethiopia to actively play their part in addressing cross-cutting environmental conservation challenges. The program was started in 2004 with nine umbrella and 155 NGOs. SLUF is one of the nine specialized umbrella organizations, which have been involved in the programme.

SLUF has worked with more than 13 NGOs in implementing the first phase of the programme, which ran between 2004 and 2007. SLUF has managed to identify best SLM land management practices implemented in the first phase of the programme which include Vetiver System (VS) applications for soil and water conservation. In 1971, for the first time ever, vetiver grass was introduced into Ethiopia for its oil content from Yamungi, Tanzania by the Jimma Agricultural Research Centre, (Tesfu and Tesfaye, 2009).

In the second phase, SLUF decided to scale-up the vetiver system applications, which proved to be effective in all its programme areas and government programmes implemented by different sectors such as rural development, road construction and electric power generating dams, which have very close relation with the destruction and conservation of the Ethiopian environment.

WHAT IS VETIVER GRASS?

Vetiver grass is a tropical plant which grows naturally in a wide range of areas from lowlands to highlands, from the altitude close to mean sea level to as high as 3 000 m. above mean sea level and in various soil conditions. It is a member of the family Poaceae (formerly Gramineae). The ecotypes which are commonly found are Vetiveria zizanioides and Vetiveria nemoralis. Vetiveria zizanioides reclassified as Chrysopogon Zizanioides is the one introduced to Ethiopia from Tanzania by Jimma ARC some 4 decades ago. This species appears in a dense clump and grows fast through tilling. The clump diameter is about 30 cm. and the height is 50-150 cm. The leaves are erect and rather stiff with 75 cm of length and 8 mm of width (Chaipattana network).

According to the source, at one year of age, Vetiveria zizanioides can produce roots penetrating more than 3.6 metres deep in 12 months. The roots densely bind together like an underground curtain or wall enabling it to store water and moisture. Vetiver hedgerows maintain soil moisture and soil surface and at the same time, are suitable for cultivating along with economic crops.

BENEFITS AND APPLICATIONS OF VETIVER

Vetiver is used for its multiple benefits including soil and water conservation and restoration of degraded ecosystems like wet lands, river bank and road sides and polluted water treatment. It is also currently recognized that vetiver is one of the best strategies for mitigation and adaptation to impacts of climate change as it sequesters carbon in the soil (Lavania and Seshu) and generates income for local communities and thereby enhancing ecosystems and social resilience.

Prevention of soil erosion, preserving soil moisture and rehabilitating deteriorated land and infrastructure

a) **Watershed management benefit on sloping areas**

On steep slopes where farming activities are being carried out, such as on highland, vetiver is planted along contour lines across the slopes or in a semi-circle around each tree facing uphill in order to reduce soil erosion. Vetiver will effectively perform its duty if the cultivation is carried out following a well-designed cultivation plan; i.e. they should be planted in a number of rows suitable to the steepness of the slopes and farming areas. Moreover, in a single row they should be planted closely together. Proper treatment of sloping areas through biological methods of conservation like the use of vetiver benefits not only uphill farmers but also communities at the bottom. According to Afework (2009) the cumulative effect of the introduction of vetiver in the Wichi area of Illubabor is the restoration of wetland-watershed together with its water, biodiversity and livelihood.

b) **Use of vetiver on flat lands for production of planting materials and mulch**

The purpose of vetiver cultivation on flat land is to use the leaves for mulching so as to preserve soil moisture and conserve rainwater in the soil. Another benefit from mulching is to restore deteriorated land by enriching the organic contents and allowing the translocation of minerals in the lower layers to the upper layers of the soil. An abandoned State Farm is transformed into a productive improved maize seed farm producing up to 12 tonnes per hectare (Tesfaye & Gadissa, 2009) in Anno Agro Industry PLC farm at Gobusyo Wereda, East Wellega. Vetiver is also cultivated on flat land for propagation purposes. For this topographical condition, vetiver grass can be cultivated in any single or integrated patterns such as in rows, semi-circle, circle, etc.

c) **Use of vetiver on other land use types and for infrastructures**

Edges of ponds, dams and reservoirs, road shoulders, gullies, hills, roadsides etc. are areas, where cultivation of vetiver should be carried out for conserving the environment and the infrastructures themselves. Vetiver is termed a "soil nail" or "living nail" for its effective conservation role of road and water infrastructures.

Soil should be fertilized to enhance growth performance and clumps should be trimmed to allow side growth and tilling. The thicker the clump, the more effective it will be in trapping silts from runoff and in preventing erosion. Another pattern is to plant vetiver horizontally across the gully to trap silts which eventually fill up the gully. On critically deteriorated land, it is vital to shape vetiver clumps and strengthen them by planting more rows and accelerating growth performance using fertilizer, which thus effectively retards heavy runoff.

Around road shoulders: vetiver cultivation helps to prevent the damage of road shoulders and erosion caused by runoff. The rows should be lined parallel to the road shoulders at a distance of 3 050 cm to prevent car accidents due to poor visibility.

Vetiver also prevents siltation of water sources and checks chemical substances from flowing into the water sources, thus controlling water quality to be acceptable for daily consumption and for raising aquatic animals. Recommended methods of planting of vetiver for the various applications are given below.

Around reservoirs: three rows of vetiver should be planted around reservoirs. One row should be grown around the edges at the water detention level and another row planted 20 cm vertically above the first and the third row 20 cm vertically below the first one (normally the water will not reach the detention level).

Around ponds: two rows of vetiver should be planted 50 cm away from the pond edges and from the water entrance passage.

Along irrigation and drainage canals: vetiver is planted in rows along the irrigation or drainage canals with a 50 cm space away from the canals.

Around road shoulders: vetiver cultivation helps to prevent the damage of road shoulders and erosion caused by rain. The rows should be lined parallel to the road shoulders at a distance of 30-50 cm to prevent car accidents due to poor visibility.

Use of vetiver for mitigation and adaptation to climate change

a) **Mitigation**

The principal, human-generated greenhouse gases that causes global warming are Carbon Dioxide (CO_2), Methane (CH_4) , Nitrous Oxide (N_2O), Fluorinated Gases

Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulfur Hexafluoride (SF_6) (IPCC, 2007) . Carbon dioxide however plays the major role in changing the earth's climate. According to IPCC, the concentration of CO_2 in the atmosphere has increased from a preindustrial value of about 280 parts per million (ppm) to 379 ppm in 2005. The 'best case' computer climate models estimate that the average global temperature will rise by 1.8 °C to 4.0 °C by the year 2100, which will not be tolerable by human kind and plant species.

Taking a concerted effort is, therefore mandatory for the global community to reduce the concentration of this gas from the atmosphere. Sequestration of atmospheric carbon into subsoil horizons is one of the strategic measures to be taken along this line. Fast growing grasses with a penetrating deep root system would facilitate long-term locking of atmospheric carbon below plough layer with reduced chances of being recycled to atmosphere and recuperate soil carbon sink. Vetiver is an ideal global candidate with a holding potential of 1 kg atmospheric carbon, sequestered annually deep into the soil pool from one square metre surface area (Lavania and Seshu).

Ethiopia is one of the least developed countries which have little or no contribution to the concentration of greenhouse gases (such as carbon dioxide) in the atmosphere. It does, however, have to take appropriate mitigation actions and follow the green development pathway expected from developing countries as agreed in the international climate change negotiations at the United Nations Framework Convention on Climate Change (UNFCCC).

It is also known that the country has embarked on implementing a substantial sustainable land management programme over the next decades to redress the problem of environmental degradation at watershed levels. In view of this it will be evident that the contributions of biological conservation measures like the use of vetiver, towards the success of the programme would be inevitable while contributing to meeting the climate change mitigation responsibilities of the country along with its clean energy development strategy.

b) Adaptation

Adaptation is fundamentally about sound, resilient development. It encompasses actions to reduce vulnerability and build the resilience of ecological and social systems and economic sectors to present and future adverse effects of climate change in order to minimize the threats to life, human health, livelihoods, food security, assets, amenities, ecosystems and sustainable development.

Income and livelihood diversification is one of the several strategies available to enhance social resilience in the face of climate change. On top of its ecological services, vetiver is used as fodder and fibre and generates income for local communities. Its leaves and roots can be used for other purposes (especially its leaves), which usually have to be cut to keep the vetiver rows in order and can be used for roofing as well as making handicraft products to earn extra income.

Use of vetiver leaves for handicraft weaving products

The vetiver species, Vetiveria zizanioides has long and waxy leaves which soften when they are wet making them suitable for making handicraft products.

Handicraft items which can be made from vetiver leaves including weaving products which are popular and serve various purposes such as:

- basketry and kitchen utensils
- home decoration items
- accessories
- office supplies.

Preparing the vetiver leaf material can be done using the traditional simple and convenient sun-dry method. For faster drying, vetiver leaves should be placed on a raised screen, thus allowing both sides of the leaves to dry within 3-6 days after which the dried leaves need to be soaked in water to soften them for weaving.

The aromatic vetiver roots are used for making perfumes, medicine (aromatherapy), fans and cloth hangers or are mixed with other dried flowers and leaves to make different materials.

Use of vetiver for pest control and ornamental purpose

Vetiver can also be used for pest control such as stalk borer in maize and sorghum, nematodes, etc. In this regard vetiver can applied as complement in conservation agriculture. Vetiver is also a good ornamental grass.

Use of vetiver culms and leaves for mushroom culture

Vetiver culms and leaves contain chemical compounds (cellulose, hemicellulose, lignin and crude protein) as well as various minerals with certain bacteria that can be grown by the fermentation processes. They can be beneficially used as planting material suited for mushroom culture. This is performed by cutting culms and leaves of the grass into small pieces (1-1.5 inches) soaking them in water and fermenting them for 3-4 days. The material is then packed in a sterilized bag after which it is inoculated with mushroom spawn under the mushroom spawn preparation procedure. Oyster mushrooms, Bhutan mushrooms, angel mushrooms, abalone mushrooms, and Chinese mushrooms can all be grown successfully using this economical method.

Use of vetiver culms and leaves for roof material

The vetiver grass best suited for efficient roof material should be selected from healthy culms more than one year old. The colour of leaves should be turning from green to yellow and can be found by cutting about one-hand palm or less in length above the ground. In roof operating, it is important that the culm (shorter side) with each set of the thatch is to be placed against the roof structure, while the leaf (longer side) is the upper side. The connecting points need to be laid accordingly from lower levels up to the top end of roof structure.

It appears that vetiver grass produces a higher-quality roof material. This is because the vetiver culms and leaves are coated with uniquely-scented wax and are not susceptible to insect pests. Life expectancy of the vetiver material depends on the actual method of thatch making and the type of roof on which it is placed; a thatch set with more culms and leaves or denser grass will be more durable.

SCALING-UP STRATEGIES

A national workshop on the vetiver system applications for soil and water conservation, environmental protection and land rehabilitation in Ethiopia was organized by SLUF, which ran from 16 to 18 March 2009 in Addis Ababa. The workshop deliberated on various issues and during which it was agreed that the use of vetiver and its applications should be augmented country-wide through the following strategies.

a. Training and experience exchange: will be required for users and those who provide services for communities. Short sector focused workshops work best (e.g. ERA, EEPCO, SLM). Special workshops for community leaders introducing course work in schools and universities would be useful.
b. Publications and information: good and relevant publications and other information needs to be developed and made available on a large scale (SLUF procured five types of books prepared for various applications of vetiver and posters and a double-sided brochure).
c. Planting material: private sector needs to expand multiplication of good quality vetiver slips. As demand grows this should not be difficult, if properly orchestrated. Vetiver "banks" should be established. Private farms like Anno Agro-Industry plc, Coffee Plantation Development Enterprise (CPDE), Jimma Agricultural Research Center, GTZ SUN project, and SLUF sub-grantee project areas are currently serving as planting material sources. SLUF has also started vetiver banks managed by individual farmers in its project area as part of its scaling-up strategies. According to Baye and Terefe (2009), the enterprise (in its plan of disseminating the vetiver technology), provides planting materials to organizations and institutions which are needy to adopt the technology basically through sales and as well the enterprise acts as demonstration field for the vicinities and distant areas.
d. Technical Specifications: these need reviewing and establishing.
e. Institutional and Service Organization role: much of this is already in place. Vetiver is currently used by SLUF sub-grantee organization, some members, other NGOs and the SLM national programme. It will need review and modification.
f. Government should be firmly committed to the up-scaling of the Vetiver System (VS) and should incorporate VS use in all relevant sectors. The role of government departments, NGOs, private sectors and end-users should be encouraged.
g. Current policy relating to FFW funds for structures should be reviewed. It is possible to expand by at least five times or more land improvement area using VS.

Net benefits from structures are minimal compared to VS. According to Habtamu (2009), for the past thirty years the Government of Ethiopia and NGOs have made great efforts in tackling the problem of soil loss with the use of physical structures, such as stone bunds, soil bunds, and fanya juu on farmlands, and hillside terraces on degraded lands. Despite the fact that this form of conservation has not proved popular with farmers, experts have persisted in the deployment of physical structures. Farmers often agree in the building of these structures so as to get the benefit of FFW (Food for Work) or CFW (Cash for Work).

Habtamu (ibid) claims the reasons for the resistance by farmers to the erection of physical soil conservation structures include:

- Competition for land resulting in a yield reduction of 10–20 percent.
- Rodents harbour resulting in yield losses estimated at 25 percent of the standing crop.
- High labour and maintenance requirements.
- Physical structures hinder ploughing operations.

Taking these reasons into consideration, he said, different Organizations decided to employ vetiver hedge technology as an alternative to physical structures on farmlands for the purpose of soil and water conservation.

h. The Government should fund relevant training and research.
i. Bilateral and multilateral funding agencies should be informed that VS is part of government policy for land and water development. Special stand-alone VS funded projects should be considered.
j. Monitoring systems need to be developed to identify VS applications and impact. High-resolution satellite imagery can do much of this.

CONCLUSION

At this time of increasing hazards from climate change and population demand, The Vetiver System would appear to be the best stand-alone technology that, if widely applied, would result in significant and sustainable improvement of water and land resources at low cost and without high demands on professional and financial resources. Based on the past 20 years of experience in Ethiopia and more than 100 other countries, worldwide up-scaling of VS in Ethiopia could be done relatively quickly (10-20 year programme) and would have a great impact on poverty reduction and the betterment of a sustainable environment including climate change mitigation and adaptation.

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PAPER 10

THE ETHIOPIAN NATIONAL ADAPTATION PROGRAMME OF ACTION (NAPA) WITH RESPECT TO PROMOTION OF ON FARM FORESTRY AND AGROFORESTRY: CASE OF HIGHLAND AND LOWLAND AREAS IN THE OROMIYA REGION, ETHIOPIA

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INTRODUCTION

The Government of Ethiopia has recognized the challenge changing climate poses to the country for which attempts are being made to mainstream potential response measures for reducing the resulting impacts. At the higher level, the government has signed and ratified all the Rio Conventions, namely the United Nations Framework Convention on Climate Change and its Protocol, the Biodiversity Convention and the Conventions to Combat Desertification.

In efforts to address the impact of climate change, the Government of Ethiopia has prepared the National Adaptation Programme of Action (NAPA) with the primary objective of identifying and promoting activities that address the urgent needs for adapting to the adverse impacts of climate change. Of the 11 priority projects outlined in the NAPA document, practising tree planting in its diverse forms, including agroforestry, takes the centre stage in the adaptation-mitigation efforts.

This paper is based on the review of relevant literature on agroforestry and natural resource management related to climate change adaptation practices in Ethiopia and selected African countries (notably Eastern and Southern Africa); consultation with the various governmental, NGO and bilateral agencies at federal and regional level in Ethiopia and field investigation in the highland (Kulumsa) and lowland (Melkasa) communities in the Oromya region of Ethiopia (with the support of FAO). The study reviewed experience gained in climate change adaptation practices relevant to community based carbon sequestration on farm and homestead forestry and agroforestry in Ethiopia; prepared inventory of improved practices and techniques on agroforestry and carbon sequestration in arid, semi-arid and sub-humid areas that are most promising in improving both farm productivity and environmental benefits such as ecosystem resilience, increased biomass cover, reduced carbon release as well as improved soil water recharge; identify and analyse the institutional and policy frameworks and roles of key organizations in the operationalization of the two NAPA projects with emphasis on promotion of on-farm and homestead forestry and agroforestry practices in Ethiopia.

The highland and lowland sites selected that are both in Oromiya are extremely vulnerable to climate change. Both of them fall within the Central Rift Valley but differing in their degree of farming system complexity and extent of land degradation. Kulumsa used to be known for its high rainfall, dense vegetation cover and excellent experience in soil and water conservation practices during the earliest ARDU/CADU project, but where heavy deforestation is currently underway due to the declining changes in economic status of the community. Awash Melkasa of the Adama District on the other hand forms the best example for inadequate rainfall denuded vegetation, poor soil and water conservation practices and dry land belt crops production.

The semi arid conditions around Melkasa make agriculture challenging and force many farmers using marginal land for agriculture out of production. Land degradation has significantly reduced the economic productivity of the land to the extent of producing desert-like conditions. The change in climate is an additional stress to an already degraded Melkasa area. Conditions that aggravated the vulnerability are:

- The over-utilization of land leading to a decline in soil fertility.
- Shortage of land exacerbated by large families.
- Predominantly little or no cash crops.
- Dependency on fuelwood and kerosene for energy which perpetuates deforestation and the loss of vegetative cover. Climate change has also a direct effect and put increased stress on water availability for irrigation and tree planting.

CLIMATE CHANGE IMPACTS IN THE STUDY AREA

The effect of climate change is different depending on the livelihoods of farmers and where they live. It seems that the Melkasa area is more vulnerable compared to Kulumsa. In many cases it is the most vulnerable groups in society wich are reliant on natural resources for subsistence that will be the most affected and for whom effective coping strategies are needed.

Based on interview of selected farmers and the focus group discussion with farmers in the selected highland and lowland communities in the Oromiya region the study revealed some insights on farmers' perceptions on climate related impact. Significant number of farmers believed temperatures have already increased and that precipitation has declined. Evidence is building that impacts are being felt in the form of drought, increase in temperature and decrease in rainfall. Experts in the study area have already perceived that the climate has become hotter and the rains less predictable and shorter. There is an increasing trend for climate change and rains do not come on the usual time and if they come, they are of short duration.

The delay in the rainy season and the seasonal distribution of rainfall has substantial impacts on agricultural production, which is directly related to the issue of food security. This has been observed since the last ten to 12 years. The change in rainfall has caused a decline in the production of food and fodder supply to the livestock dependent communities especially for those in Melkasa.

Many also witnessed a change in the timing of the rains. Farmers also perceive that the rainfall intensity has changed. It is intense and of short duration. Rainfall stops earlier and there is a decrease in the grazing land and species diversity too.

The major impacts of climate change have been the drying of up-streams, rivers. This is related to rain fall intensity and patterns. The drying of streams and rivers caused negative impacts on those who want to practise irrigation. Such impacts are further aggravated by the stresses already associated with subsistence production, such as small farm size, low level of technology and narrow employment options.

The ways in which climate change has affected smallholder farmers and as identified through the perception of farmers and as confirmed through the focus group discussion in the two sites selected are summarized in table below. Also the impact at a national level is shown in graph.

OPPORTUNITIES IN FORESTRY AND AGROFORESTRY IN RELATION TO THE ETHIOPIAN NAPA

Agroforestry is a sustainable land management practice that incorporates trees and shrubs in croplands and pastures. The trees help to moderate air temperature, serve as windbreaks and improve water infiltration by reducing evapo-transpiration by the extent proportional to tree height. In addition, vegetation produces wood, fruits, fodder and medicine which diversify livelihood sources for the rural poor. The products of agroforestry provide multiple assets that are valuable to people particularly to the rural poor. These assets include food security, browse and fodder, fuel wood and non-timber forest products, all of which provide the basis for livelihoods. This study report therefore provides knowledge bases on the existing agroforestry practices in Ethiopia with the aim to enhance its contribution to carbon storage, ecosystem resilience, food security and livelihood.

The different agroforestry practices currently promoted in Ethiopia are home garden, alley cropping, boundary planting, wind breaks, live fences, improved fallow and woodlot establishment. Planting of trees in and around compounds is the most commonly practised techniques because it offers the greatest security of both the land and tree resources. The wood supply from these practices is mainly fuelwood for the rural population and wood for fencing and construction. Much has been learned about how to promote agroforestry and increase benefits to farmers. However, the widespread adoption of agroforestry technologies by smallholder farmers is constrained by issues related to policy and institutional.

From past experience, there is little or no institutional structure to make agroforestry tree seedling/seeds available unlike the seeds of annual crops where organized institutions exist to promote. The capacity and institutional support for the promotion of agroforestry are not well developed. Such structures need to be developed and institutionalization of agroforestry is required for success in the promotion of the practice.

Lack of data and information, and training on the exiting agroforestry technologies limited its further promotion. Providing agroforestry technology training opportunities to government extension staff to help them provide information, and scale up the technologies to the farm communities.

Farmers with insecure land rights are not willing to plant trees as agroforestry and are inclined to plant trees on own land rather than on a communal land.

The selection of appropriate tree species for the practice has been limiting and focus is given to few selected tree species. The performance of the different agroforestry species has not been properly documented and a blanket recommendation is made. In addition, the invasive nature of some tree species that invade grazing and crop lands require the proper screening of tree species before introduction. The identification of high value tree products which significantly contribute to the farm economy is crucial. There is a need to identify and promote the dissemination of agroforestry technologies which are efficient in soil fertility improvement and water conservation to fulfil the objectives of NAPA. In addition, marketing opportunities for agroforestry products should be assessed.

In the northern part of Ethiopia, especially in Tigray, a study showed that nine out of ten villages have community woodlots and on average, there are nine woodlots per tabia with average size of 8 hectares (Gebremedihin *et al*. 2002). These are established primarily for ecological regeneration rather than economic and managed by the community at village level. The local community is involved in delineating the boundaries of the enclosure area. In the same region, there is a new approach through hillside distribution systems in which communal hillside plantation in degraded elevations are planted with eucalyptus and set aside as pasture lands. Individual planting of trees was adopted as the mode of replanting the hillsides. This system has been in operation for over a decade now, and has

FARM FORESTRY AND TREES OUTSIDE FOREST IN ETHIOPIA

There are a number of tree species deliberately left on crop and grazing fields for use as fodder, fuel and construction wood. The different agroforestry practices currently promoted in Ethiopia are homestead tree planting, planting of trees on farm as shelterbelt, roadside tree planting, windbreaks and fodder strips. Trees along farm boundaries also bring more trees into the farming system. Planting of trees in and around compounds is the most commonly practised techniques because it offers the greatest security of both the land and tree resources.

The wood supply from these practices is mainly fuelwood for the rural population and wood for fencing and construction. After the declaration of the mixed economic policy as of March 1990, increasing numbers of farmers are seen planting trees on farm and woodlots (WBISPP, 2000). Prior to 1991, there was very little on farm tree planting as reported by WBISPP (2000). The reasons cited were that between 1975 and 1991, cutting of on-farm trees was prohibited and reallocation of land was frequent. The same survey reported that there has been a massive increase in the planting of on-farm trees mainly eucalyptus in the period 1993-2000. However, there appears to have been an increase in the annual consumption rates of fuelwood and in the use of crop residues as fuel and the consumption rate of dung on the other hand has reduced.

In recent years, the role of forests and trees outside forests in food security has received attention because of the increased realization of the rural people's dependence on trees and forest to meet their needs.

Among the lessons learned are that tree planting efforts are most successful when undertaken by private individuals.

Policy both in land use and forestry are required to be in place in order to promote forestry as one of the long-term investment options.

In most of rural Ethiopia, there is a growing interest in individual planting of trees on household as opposed to community tree planting. The future intervention therefore, should focus on private planting of trees.

In addition, the Woody Biomass Inventory and Strategic Planning Project of the Ministry of Agriculture have identified a number of issues related to on-farm tree production that is relevant to NAPA implementation. The survey revealed that farmers do not plant trees for one purpose and eucalyptus species dominate on-farm tree planting and the main purpose is for pole production and fuelwood is seen as a by-product. There has been a very significant increase in on-farm planting of trees since 1990. This is related to the change of state policy on individual tree tenure. There is also a gender division in decision-making with regard to farmland development activities. For example, the choice of crops, planting of trees, and disposal of tree products for own consumption or sale is decided by men.

Source: Woody Biomass Inventory and Strategic Planning Project (WBISPP, 2002) been adopted by the Tigray regional government through the Bureau of agriculture and natural resources as a means of allocating land in degraded hillsides to landless members of communities apart from providing critically needed fodder for livestock. The enclosure areas are also important in conservation of dry lands biodiversity.

LESSONS LEARNED: OVERCOMING MAJOR CONSTRAINTS IN THE IMPLEMENTATION OF NAPA RELATED TO AGROFORESTRY AND LESSONS LEARNED FOR FUTURE ACTIVITIES

Community level adaptation strategies

Over time, households and communities have developed a number of coping strategies in response to extreme climate events. The identified adaptation options are either traditional that are locally managed response, state supported responses and innovative responses. The coping measures can only help farmers in the short term and cannot assist them to overcome severe and long-term shocks. However, they are supportive to better prepare and plan long-term adaptation plans. Local level coping strategies differ among households and communities depending on the resources available and social capacity. It varies from collecting wild fruits, switching to non-farming activities and selling assets. Collection of forest products/fuelwood and charcoal for sale has also provided households with the badly needed cash for use during difficult times. The sale of household goods is another coping strategy. Other strategies for coping with seasonal food shortage include petty business, change in diet, fewer meals and loans from traders. With regard to agroforestry as a coping mechanism, scattered trees in croplands, home gardens, hedgerow intercropping, riparian zone vegetation, enclosure and natural regeneration are practised.

The farmers around Kulumsa use home gardens and sheep fattening that have contributed greatly to improving the adaptive capacity of the small rural farmers. These activities provide an important source of cash to allow households to purchase food and cater for other necessities at such times. Household assets and goods such as land and livestock are also contracted and even sold to pay off debts incurred during extreme events. This erodes the asset base and, ultimately household's chances of long-term survival.

Farmers use mixed cropping and diversification of crops as a form of insurance against rainfall variability and pests attack. The risk of complete harvest failure is reduced by having different crops in the same field. Replacing farm activities with non-farm activities, changing planting and harvesting date, and increasing the use of water and soil conservation techniques are also the other coping measures. In addition, using inputs with increased resistance to heat shocks and drought; altering the timing of or location of cropping activities, and diversifying income by integrating additional activities such as livestock raising/fattening and using seasonal climate forecasting to reduce production risks are already in place. Migration to urban areas in search of paid employment is high.

The different agroforestry practices currently promoted in the study areas are homestead tree planting, planting of trees on farm as shelterbelt, roadside tree planting and windbreaks. Trees along farm boundaries also bring more trees into the farming system. Planting of trees in and around compounds is the most commonly practised techniques especially in the Kulumsa area. Such short-term coping strategies need to be managed to ensure that households do not descend into a state of helplessness.

Some of these coping measures can only assist families in the short term and cannot deal with the increased and more severe shocks. However, many traditional coping strategies do provide important lessons for how Ethiopia can better prepare and adapt to climate change in the long-term. There is a need to strengthen these coping strategies to enable households to live with current climate variability as well as help them adapt to long-term climate change. In order to share experience from other East African countries, few selected practices are shown in boxes below for the study areas.

Summary of the adaptation practices at the study sites

Adaptation practices at Kulumsa area (Highland)	Adaptation practices at Melkasa area (Lowland/Dryland)
Planting trees such as apple, eucalyptus and Sesbania sesban. The shift from subsistence to cash-crop farming through introduction of apple fruits	Irrigation using awash river but becoming limited due to access problem and shortage of water
Introduction of livestock and dairy production including fattening of sheep	Better economical use of motor for getting irrigation water and grow fruit trees
Shift to production of fodder crops	Migration to town for employment
Contract land to those who can afford to cultivate land	Fuelwood gathering
Selling fuelwood and charcoal as an alternative sources of income	Fodder production for livestock
Migration to town and look for other sources of income	Short term crops grown
Change in planting dates and row spacing. Crops are planted apart so that more moisture is available for each row.	
Use of compost	
Dairy production beekeeping	
Planting drought resistant crops	
Change of crops, transfer of wheat from lowlands to the highlands	

CARBON SEQUESTRATION

Ethiopia has proposed a number of strategies and measures geared at adapting its agricultural sectors to the adverse effects of climate change. Among the strategic measures proposed by NAPA to adapt to climate change and variability for Ethiopia are community-based Carbon Sequestration projects in the Rift Valley System of Ethiopia and the promotion of on farm and homestead forestry and agroforestry practices in arid, semi-arid and dry subhumid zones. However they are not specifically implemented as a focused strategy except at Humbo which is located in southwestern Ethiopia. The project is established with the objective to restore natural forests in the vicinity of the town of Humbo, in southwestern Ethiopia. The implementation is jointly by World Vision Ethiopia and Australia, the Ethiopian agriculture and rural development and the Humbo Forest Management Group. Previously the land has been overgrazed and cleared for fuelwood collection. This was almost barren and subject to severe erosion and flooding. The effect of these processes was intensified by the high altitude and rainfall. A management agreement involving all local stakeholders and benefiting members of the community from the project was made. They established the legal ownership of the community land and manage it for carbon, biodiversity and income producing activities to the account of the local population.

The project practises the Farmer Managed Natural Regeneration (FMNR) technique, in which existing tree and shrub root material in the soil is identified, selected, pruned, and managed to enable re-growth. Only native species are regenerated since the technique is based on genetic material already present on the sites. The existing vegetation is enriched using endemic species, including Acacia spp., Aningeria adolfifericii, Podocarpus falcatus, Olea africana, Cordia Africana, and other locally indigenous species. The regeneration of the native forest provides habitat for many local species and enriches local biodiversity. Major environmental benefits stem from the reduction of soil erosion and local flooding. The project is expected to sequester around 0.05 Mt CO_2e by 2012 and around 0.16 Mt CO_2e by 2017. Many households are self-employed for pruning and harvesting, and the forest will increase the safety of local livelihoods, particularly through the provision of new sustainable income and food sources, and the protection of springs and streams originating in the project area. The additional income from carbon sequestration is planned to be partly invested in local infrastructure and food security activities. This technique is also applicable on small private farms and it is expected that the knowledge will spread throughout neighbouring regions.

Specific arrangements are implemented to avoid any potential leakage that could occur due to reduced access to the area during the first years of tree growth. The strong involvement of the communities in the project and the numerous benefits created will likely increase the permanence of the regenerated forest. Benefits include biomass benefits that will be shared with local communities, carbon payments to improve local infrastructure and food security. The activity include restoration of 15 000 hectares of biodiversity natural forest in the rift valley and about 3 000 local households will benefit from the project.

COMMUNITY PARTICIPATION

Tree planting efforts including agroforestry interventions are most successful when undertaken by private individuals. In most of rural Ethiopia, there is a growing interest in individual planting of trees on household as opposed to community tree planting. Farmers plant more trees on their own farms or on land under their control to provide tree products for household needs and market demand. Smallholder farmers see tree farming income and security as a means to diversify their production, reduce risks and build assets to enhance family.

Indigenous coping mechanisms are not enough on their own to respond to climate change, but can serve as a useful entry point for interventions by governments. They are inadequate since they operate without any formal government support. Most adaptation options are based on informal economic activities. Therefore, external help is necessary to rebuild or enhance the social and ecological resilience among rural communities. Research is needed to better understand the usefulness of traditional practices and see how they can be used as an entry point to operationalize NAPA.

FARM FORESTRY/AGROFORESTRY AS A VULNERABILITY AND ADAPTATION OPTION: EXAMPLES FROM OTHER REGIONS OF AFRICA

The following section discusses some of the main results obtained from the review of undergoing climate change initiatives in East, West, Southern Africa and Ethiopia.

In Tanzania, the experiences cover woodlots, improved fallow and fodder banks that are widely practised. In Uganda and Ethiopia, the forest policies, the national forest programmes all are supportive of the promotion and adoption of agroforestry as a strategy for poverty alleviation. The indigenous agroforestry systems are also in operational and are a mix of silvopastoral and agro-silvopastoral systems (Bashir *et al*. 2006).

In the Maradi and Zinder Regions of Niger, there are now about 4.8 million hectares of Faideherbia-dominated agro-ecosystems that are estimated to harbour quite dense populations of Fadeherbia of up to 150 trees per hectare. The farmers in Niger claim that the trees improve their crop yields, and protect their crops from dry winds and their land from wind and water erosion. They also relate that the foliage and pods provide much needed fodder for their cattle and goats during the long Sahelian seasons. Encouraged by the experience in Niger, several new programmes to promote farmer-managed natural regeneration of Faidherbia and other species have been established in other countries across the Sahel. (World Agroforestry Centre, 2009). These practices can be promoted in Eastern African countries including Ethiopia.

Another technology that has been tested along with fallow to enhance land productivity in smallholder's farm in Southern Africa is biomass transfer (Bashir *et al.* 2006). This is the cutting and carrying of leaves from trees grown outside the cropping area such as the field boundaries to be applied in relatively small areas for crop production.

Domestication of indigenous trees for fruit production also provide farmers with alternative or additional sources of income thus strengthening their capacity to cope with the adverse impacts of climate change (Bashir *et al.* 2006).

In many parts of East Africa, farmers traditionally practise agroforestry; trees are planted in agricultural or silvopastoral systems or planted to meet household energy needs; improved varieties of fruits are used to supplement household income and medicinal trees are planted or left on farm. The International Small Group of Tree Planting Programme (TIST) of Tanzania are a few of the good experiences to share.

THE INTERNATIONAL SMALL GROUP OF TREE PLANTING PROGRAMME (TIST)

Farmers form TIST small groups: The small groups plant trees and the trees created carbon credits. The carbon credits are then sold. TIST farmers own the trees and benefit from the fruit, timber and other forest products. TIST empowers a rapidly expanding group of subsistence farmers in Africa and India to counteract the devastating effects of climate change; deforestation, poverty and drought through an innovative yet simple solution. TIST members make money from the carbon their trees sequester and from the fruits harvested from their trees.

The agropastoral people living in the Shinyanga and Mwanza regions of central Tanzania have restored formerly cleared and degraded forests. The implementation use an indigenous natural resources management system based on individual and community owned pieces of land. The system involves conserving fallow lands and rangelands to restore vegetation. About 70 000 hectares of important woodlands have been restored. The outputs are increased availability of fodder and wood products and facilitated environmental conservation at the local level. Farmers are able to collect and fodder, fuel wood and poles. Species diversity has increased. The practice has also contributed to soil conservation and reduced soil erosion.

Source: TIST (www.tist.org)

MAJOR CONSTRAINTS IN THE IMPLEMENTATION OF THE ETHIOPIAN NAPA RELATED TO ON-FARM FORESTRY AND AGROFORESTRY

Institutional capacity building

These study and field level investigations have shown a number of barriers to the implementation of adaptation to climate change. A lack of awareness on the extent of the problem as well as possible actions that could be taken is the foremost among these barriers. This lack of awareness exists at all levels from regional level and local level officials and the most vulnerable communities themselves. The other barrier is the lack of tools, knowledge and methodology to provide guidance to the community affected by climate change on how to adapt to the impacts of climate change through agroforestry and carbon sequestration measures.

The institutional barrier ranges from inadequate staffing and insufficient training of personnel to limited technical capability and weak institutional linkages among institutions and organizations that operate in natural resources management and conservation. There is no institutional structure to make agroforestry tree seeds available and multiplication and distribution of agroforestry trees is not common. The human capacity and institutional support are not well developed as for annual crop technologies. Farmer's lack of access to quality tree seeds is another limitation for scaling-up the practice. Low priority and inadequate resources given to forestry management activities is also additional burden to the practice.

MAIZE AGROFORESTRY IN MALAWI

Since the early 1990s, the World Agroforestry Centre and its partners in Eastern and Southern Africa have developed agroforestry systems that improve soil quality and significantly boost yields, providing high returns on both land and labour. The most popular system in areas like southern Malawi, where land holdings are very small, is intercropping with nitrogen-fixing trees such as Gliricidia sepium, Calliandra calthyrsus and Leucaena species. Using this system, farmers can double their yield of maize, or even triple it if they also use a small quantity of mineral fertilizer-about a quarter of the recommended dose. Under this system, farmers plant nitrogen-fixing trees in rows between their crops. These are pruned back several times a year, and the leaves and biomass are incorporated into the soil. A long-term experiment spanning more than a decade, involving continuous cultivation of maize with Gliricidia at the Makoka Research Station, Malawi, yielded more than 5 tonnes per hectare in good years, and an average of 3.7 tonnes per hectare. Many farmers in Malawi have begun intercropping their maize with fertilizer trees. Besides increasing soil fertility, these agroforestry systems help to suppress weeds, improve water filtration, and increase the amount of carbon in the soil. By mid-2009, over 120 000 farmers had benefited from Malawi's Agroforestry Food Security Programme. The program provides seeds, nursery materials and training for a range of agroforestry practices, including the planting of fertilizer trees.

Crop production systems such as these, which incorporate Gliricidia, Faidherbia and other leguminous cover crops, can help rural populations to adapt their agriculture to the adverse effects of climate change. There is clear evidence from research, as well as from the experience of farmers, that these systems enable farmers to harvest grain during serious droughts, which are becoming more frequent in the subhumid and semi-arid areas of Africa. With these systems, farmers say they can obtain at least a modest yield during seasons when farmers who have not yet adopted these systems may experience total crop failure.

Maize agroforestry in Malawi has increased soil fertility and enabled farmers to double or triple their yields. The use of tree legumes also helps to suppress weeds. This practice also improves drought resilience and increase above and below ground carbon sequestration as well.

Source: World Agro forestry Centre, 2009.

However, access to agriculture extension has a positive and significant impact on implementation of adaptation measures. This was confirmed by farmers around Kulumsa who are better in planting trees as homestead tree planting, planting trees around the farm lands and practise mixed cropping. Planting trees as wind break is also another intervention observed in the field.

Knowledge and technical limitations

Although Ethiopia has gained considerable experiences with implementing a range of different agroforestry activities, this has not been sufficiently documented with information on the best agroforestry technologies and approaches for promoting within specific areas lacking.

There is need to elicit innovative knowledge and technical systems that ensure local gains to battling the global environmental problems of climate change. Innovations are sought in the following areas as it relates to agroforestry: (i) methods to scale up payments to farm forestry and agroforestry; (ii) increased local incentives and benefits to the poor in payment for services schemes; (iii) enhancement of community-level adaptation to climate change in rural areas; (iv) sustainable use and promotion of biodiversity within farm forestry and agroforestry, and (v) addressing the definition and measurement of degradation

Socio-economic constraints

Climate change in Africa is not only a conservation problem but is a socio-economic issue that must be dealt with at a global scale. In Ethiopia, climate impacts affect agriculture that communities are largely dependent upon, threatening development and economic stability. The impacts of climate change are being felt particularly hard because of the lack of economic development, and institutional capacity.

Unfortunately, it is more of a double-edged sword as climate change impacts have the potential to undermine and even, undo progress made so far in improving the socio-economic well-being of Ethiopia and Eastern Africa as a whole. Occurrence of a single climate disaster such as drought or flood is capable of stagnating or even reversing the economic growth achieved over a decade or so.

Recommendation and proposed action

Capacity building:

There is serious limitation in the capacity to address the multidisciplinary climate change challenges. Capacity building is the highest priority including the need to train and retain the built capacity together with strengthening scientific and technical capacity.

Capacity building is critical in all areas including ability to identify climate change risks and vulnerability as key determinants of well-being of the vulnerable communities; monitor impacts on regional climate; verification of models; downscaling global climate models to regional/local conditions; developing impact scenarios; reduce vulnerability to climate change; effectively access and utilize resources and technology required to minimize the costs of climate change; education, public awareness and outreach, together with addressing regional technological needs and challenges, including issues related to the integration of `indigenous technology.

Community awareness and sensitization on the reality of climate change is required for effective implementation of adaptation. Local people need to understand the possible impacts of climate change and how they may be affected so that they can prepare themselves for any future shocks.

Technical and other resource options necessary to adapt to climate change need to be available and accessible. Watershed communities should be supported to implement agroforestry activities through sensitization and training, pilot farmers and extension agents should be trained in the different agroforestry techniques. Establishment of tree nurseries for climate resilient species and reforestation activities should be in place. Improved agricultural extension capacity about climate change and its potential implications is crucial, too.

Appropriate tree seed varieties should be identified and training on tree management and seedling production should be provided to increase the availability of drought tolerant seedlings and improve the distribution system.

Policy and institutional issues:

Facilitate the integration of adaptation to climate change into sustainable development plans at regional and local levels. Develop regional and local level climate change institutional frameworks to strengthen the coordination, networking and information flow with different levels of governments and local civil societies to have better response to poverty eradication and climate change.

Networking among public institutions, non-governmental organizations and the community for integrated planning and coordination and decentralized responsibility for implementation of actions proposed. Develop and promote rural credit mechanisms.

Rainwater harvesting system well established for the promotion of agroforestry and homestead tree planting in areas where water is a limiting factor for the promotion of agroforestry. Development of efficient and effective reward structure for environmental services need to be in place for effective agroforestry.

Adaptation to climate change should not focus simply on new activities, but strengthen existing livelihood coping strategies and incorporate development initiatives that may create and diversify income opportunities.

Meteorological stations need to be strengthened to collect and disseminate timely information as part of an early warning and disaster preparedness scheme. Information for public use should be translated into a simple and easily understood format or translated into local languages wherever possible.

Climate change information:

Climate information is a crucial component of climate change adaptation strategies and therefore, the capacity of the information users should be enhanced. Information access for farmers should be improved and farmers have to be assisted in identifying alternative technology viable options for livelihoods adaptation.

Climate information is a crucial component of climate change adaptation strategies in different socio-economic sectors. Seasonal climate change prediction skills should be built. The capacity of the users to effectively utilize the information must be equally enhanced. Institutional capacity building and organizational networking with clear definitions of roles and responsibilities are essential. This is a basic precondition to making adaptation work.

The experience from the radio Internet Project of Kenya that helped for the dissemination of information to rural communities so that they are able to receive weather and climate information in formats and languages they understand, is a good experience to share. Community Based Organizations access weather and climate prediction and then pass this information to the rural communities for application to agriculture, livestock and health management. The use of community based FM radios to pass information to communities and forming a network of journalists and meteorologists with the main goal of advancement of accuracy and timeliness to climate reporting is another component of the programme.

This will enable to pass timely information on climate and other development information for the people in the envisioned project areas. The information will enable local population to improve the state of drought preparedness and food security.

CONCLUSION

Improvements in on-farm forestry and agroforestry practices can thus have beneficial impacts at multiple levels: large environmental footprint can be reduced, farming systems made less vulnerable to climate change and agriculture harnessed to promote national and local level benefits as well as global environmental benefits in adapting to climate change and mitigating its impact.

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PAPER 11

THE BALE MOUNTAINS REDD PROJECT DEVELOPMENT: SOME EARLY LESSONS

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INTRODUCTION

The Bale Eco-Region Sustainable Management Programme (BERSMP) is a partnership initiative between Oromya Forest and Wildlife Enterprise and FARM-Africa/SOS Sahel, implementing a programme intervention in the Bale Mountains area. It focuses on expanded conservation and development actions, bringing local communities into a central role in sustainable natural resource management and developing natural resource based livelihoods. One of the six component themes of the programme is to ensure continuity of the community-based conservation approaches, aiming at identifying sustainable financing opportunities, mainly focusing on carbon trading, for the Bale Mountain Eco-Region. Based on a preliminary study, the development of a Reduced Emissions from Deforestation and Degradation (REDD) project to be offered on the voluntary carbon market has been started.

This paper highlights the progress being made so far in the development of the Bale REDD project and emphasizes the role of communities through Participatory Forest Management (PFM) for effective natural resource management. As reducing emissions from deforestation and forest degradation and carbon stock enhancement (REDD+) is getting more and more recognition as a critical component of national and international strategies for mitigating global climate change, a key message is also that REDD presents new opportunities to address long-standing threats to forests,

FORESTS AND CLIMATE CHANGE

Human activity systems are thought to be mainly responsible for the changes observed today and those predicted in the future regarding the earth's rapidly changing climate. Some of these activities that have led to increased concentrations of carbon dioxide (CO_2) in the atmosphere include those that involve burning of fossil fuels and loss of forested areas (Margaret Skutch, *et al*. 2007). Even though much of the GHG emissions come from industrial processes, production of electricity and transport in industrialized countries which use large amounts of fossil fuels, there are large emissions of CO_2 from deforestation in many developing countries. Tropical forest clearing accounts for some 20 percent of the anthropogenic carbon emissions and destroys significant carbon sinks globally (IPCC, 2007) and hence deforestation and forest degradation are the second leading causes of global warming.

Afforestation/reforestation or improving degraded forests into forests leads to sequestration of CO_2 from the atmosphere to the terrestrial ecosystems, where CO_2 is stored in biomass and soil. When forested lands are cleared or converted into other land uses such as agriculture, or urban landscapes, the carbon earlier stored in aboveground and below ground biomass, including in the soil, is released back into the atmosphere.

Therefore, it is evident that the role of forests in climate change mitigation is significant and that the carbon dynamics of forests need to be taken into account in mitigation efforts. Forests play an important role in the global carbon cycle (Margareth Skutsh *et al.* 2007). Forest biomass acts as a source of carbon when burned or when it decays. Also when soil is disturbed it releases CO_2 and other GHGs into the atmosphere. On the other hand, forests also act as carbon sinks when their area or productivity increases, resulting in an increased uptake of CO_2 from the atmosphere. This is known as carbon sequestration. They absorb CO_2 and release oxygen into the atmosphere through the natural process of photosynthesis in which CO_2 is converted to carbon and stored in the woody tissue (biomass) of the plant. It is because of this that some forms of forestry activities are used as valid means for atmospheric CO_2 reduction as they contribute significantly to climate change mitigation.

CARBON MARKETS

The global response to climate change is coordinated through the United Nations Framework Convention on Climate Change (UNFCCC) and since early 2005, under the Kyoto Protocol. Efforts to reduce atmospheric GHG concentrations (and thereby mitigate increases in global temperatures) are being made through schemes that aim to reduce the use of fossil fuels, increase energy efficiency and sequester carbon dioxide in biological matter. In developing countries these schemes are managed in two ways: first, regulated or certified projects which come under the Clean Development Mechanism (CDM) of the Kyoto Protocol and which are regulated according to international standards; and second, ‘voluntary’ projects which operate outside of the Kyoto Protocol and have no overall governing body, although voluntary standards may be complied to. These certified and voluntary projects involve the trading of Certified Emission Reduction (CER) or Voluntary Emission Reduction (VER) credits respectively. One CER or VER credit is equivalent with the capture of one ton of carbon dioxide. More simply, carbon markets are climate change mitigation tools whereby units of GHG emission reductions – known as Certified Emission Reductions (CERs), Verified Emission Reductions (VERs), Credits, or tonnes of Carbon Dioxide equivalents (tCO_2e) – are sold. The demand for this trading arises either as a result of limits to emissions imposed on nations and businesses, or from ‘green’ businesses and consumers that want to offset their own private emissions.

The carbon market, conservatively worth 126 billion in 2008, represents one of the most promising means of reducing greenhouse gas emissions quickly and effectively. The

Clean Development Mechanism (CDM) of the Kyoto Protocol and the non-compliance ("voluntary") carbon offset markets offer an opportunity for Ethiopia to tap into the global carbon market and to harness associated investment and technology flows.

CDM AND REDD

Almost all CDM projects involve energy efficiency or energy reduction, with very few projects relating to carbon sequestration through forestry, falling under the 'Land-Use, Land-Use Change and Forestry' (LULUCF) category. The lack of forestry projects is considered to be due to the high transaction costs of the CDM process and restrictions placed on forestry projects by the CDM. In contrast, the more flexible voluntary market is dominated by forestry related projects located throughout the developing countries.

Under the CDM's LULUCF programme, only Afforestation and Reforestation (AR) projects are currently recognized and many projects in the voluntary market involve the planting of trees, meaning that there is a little scope for projects that work through 'avoided deforestation'. Reasons given for the exclusion of the avoided deforestation include the difficulties in ensuring 'additionality' (i.e. the project provides emissions reductions which are additional to what would have occurred in its absence), problems in establishing 'baselines' (levels from which to estimate emission reductions due to the project), problems in preventing 'leakage' (changes in emissions due to project activities but which occur outside of the project area, e.g. shifting deforestation to another area), the problem of ensuring that reductions are permanent, the fact that the large potential scale of avoided deforestation emission reductions could flood the market, and finally, that it may reduce incentives for developed countries to 'de-carbonize' and reduce emissions through energy efficiency or energy reduction (Eliakimu Zahabu, 2008).

However, interest in the potential of avoided deforestation has been growing and solutions to the problems listed above are currently being worked-out through the development of a proposed mechanism, REDD. At the 13th Conference of Parties (COP 13) of the UNFCCC, held in Bali in 2007, it was agreed in principle to consider REDD in developing countries upon completion of the first commitment period of Kyoto Protocol. Under the proposed REDD Policy there is a strong move to reduce CO_2 emissions from terrestrial ecosystems by reducing deforestation rates in the tropics. Moreover, at the UNFCCC meeting in 2008, REDD gained a broader support for an agreement to reward actions that enhance forest cover and is additional to avoided deforestation and forest degradation (popularly called REDD+). Once it comes into operation, this will add value to the existing forest capital and the stream of income that flows from it through reduced deforestation, reduced degradation and forest enhancement, and, hence, should benefit all primary stakeholders.

At COP 15 in Copenhagen, even though a legally binding agreement was not achieved, the Copenhagen Accord recognized the crucial role of REDD and need for a REDD+ mechanism. REDD discussions provide a clear signal that REDD activities will be embedded in the future international climate change policy design. Critical points that still need to be resolved are financing mechanisms; national vs. subnational approaches to

REDD; and the extent of social safeguards required. A wider climate change agreement between countries is expected at COP 16 in Cancun, Mexico, (December 2010) before REDD can reach full potential.

However, to make claims to this income, it will be essential to demonstrate that there has indeed been a net sequestration of carbon. Other social, economic and technical issues will also have to be complied with.

THE BALE MOUNTAINS REDD

A study conducted by the Bale Eco-Region Sustainable Management Programme to identify sustainable financing opportunities for the Bale Mountains has come up with an assessment on the general environmental services that could be included into Payment for Environmental Services (PES). Based on this assessment, a business case for a carbon finance project is elaborated and a Project Idea Note (PIN) developed to approach carbon funds.

According to the study, a huge potential exists for both Clean Development Mechanism (CDM) eligible Afforestation/Reforestation (AR) and for Reduced Emissions from Deforestation and Degradation (REDD) components, to be offered on the voluntary market.

Around 700 000 ha in the Bale Mountain Eco-Region (including the Bale Mountains National Park managed by the Ethiopian Wildlife Conservation Authority [EWCA]) have been identified as a suitable project area for a REDD project (Figure 1). In addition, some 3 000 ha will be setup as a CDM eligible reforestation project, 2 000 ha of which will be managed by the Oromiya Forest and Wildlife Enterprise (OFWE) while the other 1 000 ha are to be used for a community based woodlot planting project. This will also serve as a leakage mitigation measure.

The REDD project will be managed through using three types of Sustainable Forest Management (SFM) schemes. These are: forest areas managed by Community Based Organizations (CBOs) with exclusive user rights; Joint Forest Management (JFM) schemes managed jointly by CBOs and OFWE/EWCA; and forest areas under full management of OFWE/EWCA.

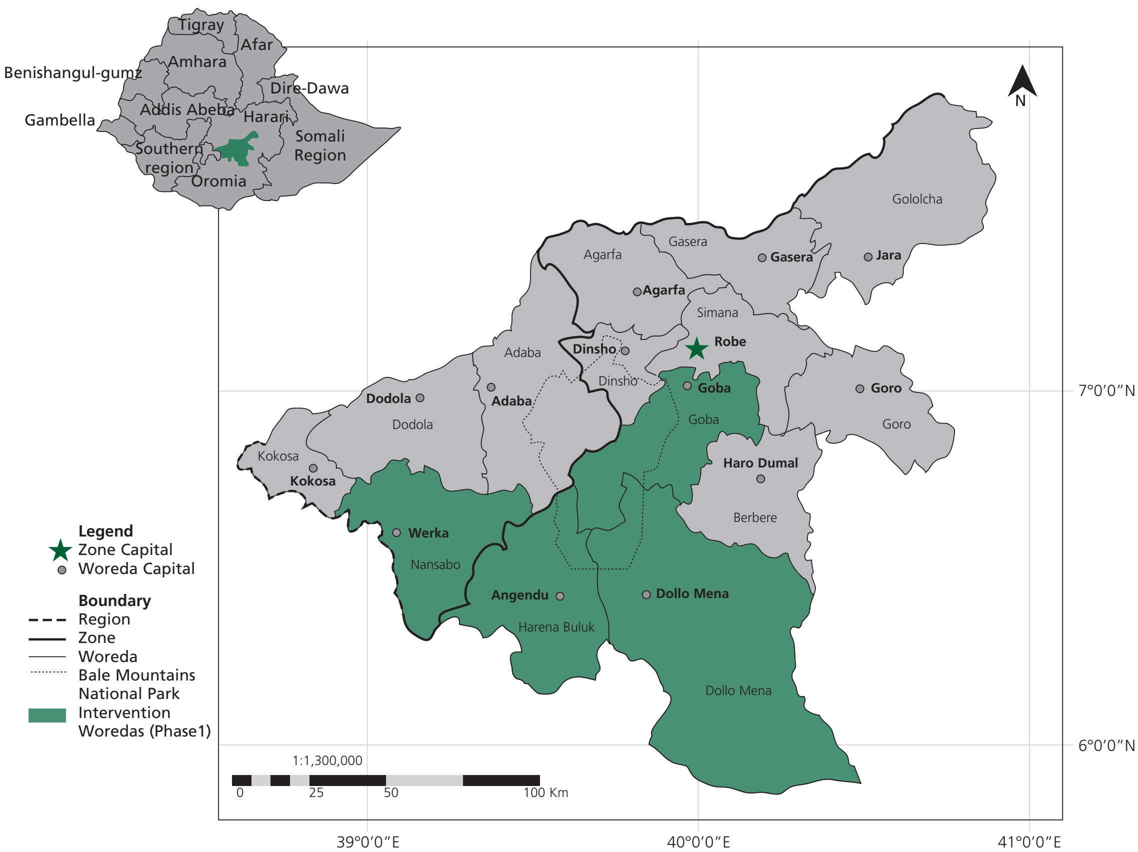
The REDD project is expected to generate around 18 million tCO_2 over a 20 year period from avoiding deforestation and an additional significant amount of credits from 'forest enhancement'. Obviously, due to the uncertainty related to methodologies, leakage and non-permanence rules (no-methodology is validated under the VCS so far), not all can be transacted currently. Revenue will be shared between communities and OFWE (communities and EWCA for the case of the Bale Mountains National Park) based on shares that are to be agreed.

Some of the major activities accomplished so far include:

- Contacting potential buyers, getting their feedback on project structuring and marketing.
- Understanding property rights of carbon reductions and relevant regional and national policies.

FIGURE 1

The Bale Mountains location and forest areas.



- Cooperatives being established to organizes local stakeholders.
- Legal and institutional frameworks elaborated at OFWE and branch offices including with JFM agreements.
- Draft due diligence prepared.
- Drivers of deforestation established and provisional deforestation baseline created in priority areas average 4 percent.
- Preliminary assessment of the household economy in order to address relocation of emission reductions and risks of non-permanence such as fire.
- Basic financial analysis of potential project costs and revenues.
- Substantial capacity and knowledge building/sharing in forest carbon for other project developers and intermediaries.
- A draft marketing strategy document prepared aiming at advance funding for:
  - Development, validation, and registration of project under the VCS/ CCBA
  - Monitoring and verification related to the first credit issuance

- Establishment of a REDD unit to oversee project implementation.
- Planting of trees for leakage mitigation purposes.

NEXT ACTIONS

The immediate next steps include working on benefit sharing arrangements together with an implementation modality. PFM cooperatives need to be scaled-up from the current eight to cover the entire forest area of the ecoregion. An in-depth forest inventory is going to be carriedout to establish a detailed deforestation baseline, including socio-economic drivers as well as the historical deforestation rate of the area. Monitoring, reporting and verification (MRV) systems will be developed which fulfil international standards for estimations of reductions. Analysis of the social aspects of the programme, including awareness raising on climate change and avoided deforestation, will be conducted with the local communities. Baseline (of carbon stocks within different strata) and Project Design Document (PDD) and validation will also be conducted.

Moreover, BERSMP will continue working with OFWE and EWCA to create modalities on combining the REDD project of the eco-region and the national park areas through establishing partnerships.

PFM as a basic building block for REDD

According to a change detection study in the Adaba-Dodola forest that compared the status of vegetation between 2002 and 2006 in community managed forest blocks, it was revealed that the forest cover has considerably increased by up to 15.6 percent in these blocks (Aklilu A., Neumann M and Tsegaye T., 2006). Based on such positive impacts of PFM on improvement of forest condition, it can be seen that PFM should be used as a strategy for REDD implementation. Obviously, the additional gains from REDD could be used as an incentive for forest conservation and this will in turn positively contribute to the success of PFM. REDD is also seen as a more cost effective way than other carbon sequestration methods. Watersheds are protected as a result of the restoration of forest areas and this has positive impacts on agriculture productivity. Expected revenues from REDD will create employment and new livelihoods. Pursuing REDD through PFM also allows the continued use of forest products by the communities involved and this could serve as a safety net for those who depend more on the forests and helps to maintain the traditional livelihoods and culture. Moreover, REDD also contributes to mitigation of climate change impacts. Some of the working modalities in PFM such as the protection, development and proper utilization including the organizational frameworks that are designed to lead to sustainable forest management could be a fundamental input for REDD implementation.

Currently, there is a gradually growing awareness towards climate change in general and REDD issues in particular. The problems related to climate change and the potential of the REDD mechanism is being felt at various levels. One of the recent events that contributed to this raised awareness is the strong presence of Ethiopia at the Copenhagen conference. The PFM scaling-up that was recently launched by MOARD and FARM-

Africa-SOS Sahel is also an opportunity to put even more areas under PFM, to which REDD can be added.

The outcomes of the COP 15 in Copenhagen regarding REDD, including the pledged finance that followed it, indicate the commitment from the international community. It is also likely that REDD will be included in the future compliance regime. Considering the current developments related to REDD+, there might be a time in the future when forest enhancements will earn carbon credits.

Carbon finance can contribute to a new source of recurrent revenues for government and also incentives for concerned communities, thereby supporting sustainable forests management.

CHALLENGES AND RISKS

Forest degradation in the context of climate change refers to the loss of carbon from within a forest due to thinning out of the biomass stock, without loss of forest area. Due to the difficulty in estimating this (particularly from remote sensing) and as forest inventory data also remains poor, degradation has generally been underestimated as a forest loss or as an emission source. Designing proper methods for assessing degradation, especially on large areas of forest, will pose a challenge.

Methodology development for REDD is still ongoing and challenging. The opportunity costs of community based forest management vs. the market price for carbon needs to be clearly worked out to ensure the gains are sufficient to be used as incentives. There needs to be a transparent system for administrating financial rewards when they come. A strong and reliable structure for benefit-sharing implementation is required for the system to operate smoothly.

It should also be noted that PFM even without REDD is already a demanding task. Additional activities such as monitoring, etc. require a strong commitment both from the communities and the forest department.

Some of the risks involved in REDD implementation include ‘leakage’ (meaning the displacement of deforestation from one area to another, without any net carbon savings). The entire project area needs to be conserved and the ‘leakage belt’ should also be managed. The other risk is ‘reversibility’ (or non-permanence). Incidences such as fire could cause non-permanence that result in failure to deliver the sequestration. Instability of forestry institutional frameworks could also be a risk. Unless structure provisions for succession of responsibilities in the event of institutional reorganizations are carefully considered, a long-term commitment could be difficult.

CONCLUSIONS

Carbon revenue should be considered as one of several possible benefits that PFM would bring. Projects should be followed up with care and it is necessary to avoid depending entirely on carbon revenues. Equitable sharing of benefits among participating stakeholders is crucial for the success of such schemes.

From the lessons learned so far, PFM that is being implemented jointly by community-based organizations and government (Forest Enterprise in Oromia and Bureau of Agriculture in other regions), have been demonstrated to be a viable tool that can reverse the historical deforestation trends in Ethiopia. Therefore PFM should be taken as part of the approach for REDD. REDD has the potential to generate substantial benefits in addition to the reduction of greenhouse gas emissions. These include positive impacts on biodiversity and on sustainable development, including poverty reduction and strengthening indigenous peoples' rights.

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PAPER 12

OPPORTUNITIES AND MODALITIES FOR CROP INSURANCE FOR CLIMATE CHANGE ADAPTATION FOR SMALLHOLDER FARMERS IN DRYLANDS

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INTRODUCTION

The impacts of changing climate are likely to be more pronounced in the least developed nations, where agricultural production and food security are already at risk and both are highly climate-sensitive. Agriculture, in particular, is the most climate sensitive sector as it depends on natural resources such as soil and water, which are seriously affected by the nature of weather conditions. As discussed by Davies, Oswald & Mitchell (2009), poorer countries are especially vulnerable to climate change because of their geographic exposure, low incomes and greater reliance on climate sensitive sectors, particularly agriculture. The World Food Programme (2005) further notes that there is a strong link between weather, the livelihoods of poor people and development-yet there are no effective *ex ante* solutions for weather risks in developing countries; and low-probability but high-impact weather risks are highly correlated geographically. A drought in Ethiopia often means a drought over the entire Horn of Africa or even sub-Saharan Africa as in 1984, which requires special financing and transfer to global markets where risks can be pooled and diversified and thus easily managed as part of international risk portfolios. Weather index-based insurance represents a viable form of transferring weather risks out of the agricultural community to insurance schemes (Degefa, 2010).

The existing evidence of changing climate and its impact on livelihoods of people, particularly those who are residing in rural areas with fragile ecosystem, necessitates the action of nations to sustain life and livelihoods. This has been addressed for so long with a varying degree and with a different option, technologies, and approaches based on the social, political, and economic setting of respective areas. Ethiopia being one of the severely affected countries by the impact of climate change, particularly drought, has been undertaking different interventions to tackle the problem. Local or indigenous knowledge in the resolution of the problem of climate change within the Ethiopian context has played significant role in tackling the problem which include crop diversification, mixed agriculture, water harvesting, improving soil fertility through different organic composting mechanisms, disease and pest control, shifting cultivation, strengthening social coherence and mutual assistance or solidarity mechanisms.

The Government-led early warning and response mechanisms, safety nets, natural resource management based adaptation mechanisms and the very recently piloted and tested weather insurance mechanisms are the leading examples of programming initiatives which aim to resolve the problems of the impacts of the changing climatic conditions. This paper, therefore, explains the history and implementation of weather insurance, climate change adaptation and the associated linkages and modalities of adaptation for smallholder drylands farmers.

CROP (WEATHER) INSURANCE PROGRAMMING AND HISTORY

Farming is generally regarded as a financially risky enterprise. Most agricultural production is subject to the vagaries of weather and the nature of agricultural supply and demand often results in volatile market prices (Shields, 2010). From evidence available, the USA initiated crop insurance in the 1990s. That crop insurance programme provides producers with risk management tools to address crop yield and/or revenue losses in their farms. Multi-peril crop insurance is a valuable risk management tool that allows growers to insure against losses due to adverse weather conditions and wild fire (New York State Department of Agriculture and markets, 2008).

It is important to note that crop insurance is not an investment tool. It is a risk management tool that is used to put a safety net under cash income. In times of low production and damaging weather such as hail storm, wind storms and drought, crop insurance enables farm families to meet their financial obligation, both business and personal and helps ensure the survival of the farm business (White, 2000). The crop insurance industry is providing more and more risk management tools to help producers deal with the increasing risk they face. As the number of alternative increases, so does their complexity (Stokes, Waller, & Outlaw, 1940). In USA, insurance policies are sold and completely serviced through 15 approved private insurance companies. Independent insurance agents are paid sales commission by the companies. The insurance companies' losses are reinsured by United States Department of Agriculture, and their administrative and operating costs are reimbursed by the federal government.

According to Iowa State University (2009), the following points need to be considered in the implementation of crop insurance:

- State closing date - which is the last date to apply for crop insurance coverage for any corporation.
- Earliest planting date- crops planted before the specified earliest panting date will not be eligible for payment.
- Final planting period - for certain crops, a late planting period begins after the final planting date and lasts for 25 days for areas planted after the beginning of this period, the value of the yield or revenue guarantee is reduced day by day. This reflects the lower yield potential for late-planted crops.

- After the late planting period ends, coverage remains at 60 percent of its original level.
- Area replanting date - producers must report the area of each insured crop that they have actually planted by this date within three days when they abandon intention to plant it.
- Billing date - although premiums are payable as soon as the crop is planted, the policy holder will not be billed until the premium billing date.
- End of insurance period - following this date, the farmer no longer has any production or revenue guarantee on the crop.
- Date of file notice of crop damage - this is the last date to report actual production or quality losses in order to receive an indemnity payment. Notice is required within 72 hours of the discovery of the damage, but not later than 15 days after the end of the insurance period.
- Policy termination date - if premiums are not paid by this date the insurance coverage of the following crop year will be terminated.
- Cancellation date - this is the last date to give written notice to the insurance company if the grower does not wish to carry crop insurance next year. Otherwise, the policy will automatically renew for another year.
- Production reporting date - this is the date to submit the most recent crop production records used to recalculate the actual production history yield.

In purchasing a policy, a producer growing an insurable crop selects a level of coverage and pays a portion of the premium, which increases as the level of coverage rises. The availability of crop insurance for a particular crop in a particular region is an administrative decision, which is made on a crop-by-crop and country-by-country basis, based on farmer demand for coverage and the level of risk associated with the crop in the region, among other factors.

The first system in developing a crop insurance programme is to establish your actual production history. This is used to set the guarantees under the actual production history. Establishing actual production history yield requires a minimum of four years of records for each crop and land unit to be insured. Crop insurance policies are usually either yield-based or revenue-based (Shields, 2010 and New York State Department of Agriculture and Markets, 2008).

Yield-based crop insurance coverage: actual production history insurance protects producers against losses due to natural causes such as drought, excessive moisture, hail, wind, frost, insects, and disease. When purchasing a crop insurance policy, a producer is assigned: (a) normal crop yield based on the producer's actual production history; (b) a price for his commodity based on estimated market conditions. The producer can then select a percentage of his normal yield to be insured and percentage of the price he wishes to receive when crop losses exceed the selected loss threshold.

Revenue-based insurance coverage - participating producers agree a target level of revenue based on market prices for the commodity and producer's production history. A farmer who opts for revenue insurance can receive an indemnity payment when his actual farm revenue (crop specific or entire farm, depending on the policy) falls below a certain percentage of the target level of revenue, regardless of whether the shortfall is caused by low prices or low production levels.

CROP (WEATHER) INSURANCE IN ETHIOPIA

From the diversity of the Ethiopian agro-ecological zones, the weather characteristics have significant variations which, mainly, are associated with the temperature and rainfall variations and patterns. Other factors such as altitude, terrain and natural resource coverage also have effects. The extreme weather events which have caused recurrent drought and sometimes floods have caused significant damage to lives and livelihoods, leading to reducing progress in development and/or stagnation of the national economy. In these extreme weather events, the agricultural sector is the first sector affected as it is the major mainstay of the majority of people living in rural areas. These events have forced the country to depend on food aid for almost the last three decades.

Ethiopia is a low-income food-deficit country. Chronic food insecurity affects 10 percent of the population; even in normal rainfall years these households cannot meet their food needs and rely partly on food aid (World Food Programme, 2005). To tackle the compounded effects of extreme weather events, the Government of Ethiopia in collaboration with the international humanitarian organizations and non-governmental organizations has developed and is implementing different food security programmes.

The main programmes are the:

- productive safety net programme, which is designed to address the problem of chronically food insecure households that have been under food aid for a prolonged period of time;
- rehabilitation of degraded ecosystem based MERET (Managing Environmental Resources to Enable Transition to more sustainable livelihoods) program which has been being implemented for almost three decades and is enhancing agricultural productivity;
- livelihood diversification through different income generation opportunities and building resilience of rural communities;
- overall sustainable land management interventions.

The notion of crop insurance was first piloted in 2006 through the collaboration of the World Food Programme, World Bank and the Disaster Risk Management and Food Security Sector of the Government (World Food Programme, 2005).

The objectives are to:

- demonstrate the possibility of transferring least developed country risks, especially Ethiopia's;
- enable price discovery for Ethiopian weather risk in international financial markets;
- set in motion a process for *ex ante* risk management in Ethiopia;
- put in place a small derivative contact to hedge against the effects of severe drought for Ethiopia's 2006 Agricultural season.

The following are the project strategies:

- Quantification of the risk *ex ante* needs assessment, establishing income losses and needs resulting from defined weather variations.

- Establishing the risk transfer structure as the basis for an *ex ante* experimental funding appeal; the pilot uses an index-based weather derivative contract to establish contingency funding for effective aid response in the event of contractually specified severe and catastrophic shortfalls in precipitation.
- As per the project design, the beneficiaries of the project are vulnerable populations who are not food insecure and so are not included in the safety net program, but are at risk to income and asset losses and consumption shocks resulting from severe natural disaster. The pilot project was implemented by Nyala Insurance Private Company in Bosset Woreda of East Shoa zone, Oromiya Region which. According to Degefa (2010) 137 farmers were insured against drought in the 2009 Meher (the main rainy season) for a total of 309 116.25 Birr which is 50 percent of the total sum insured

Crop (weather) insurance was piloted and tested to deal with averting risks resulting from weather variability particularly in arid and semi-arid areas where the rainfall pattern is unreliable and the results need to be further analysed. Agriculture in such areas is prone to weather related risks. Such an area is characterized by very fragile ecosystems including poorly structured soil, very scattered vegetation cover and with less moisture for vegetation and other biomasses to easily establish. The initiative requires being scaled-up, as initial results showed evidence of the potential for the initiative in protecting lives and livelihoods of the farming communities during crises resulting from extreme weather.

Degfa (2010) furthermore reported that results from interviews with farmers and focus groups showed that credits and insurance schemes could have a paramount importance to support farmers during crop failures resulting from failure of rain and other weather related problems.

The National Adaptation Programme of Action (NAPA) of Ethiopia has re-identified “promoting drought/crop insurance programs in Ethiopia” as one of its priority areas. Setting these priority areas implies that the country is ready to assist rural poor who are particularly reliant on agriculture, which is the most climate sensitive economic sector, as it uses finite natural resources. The International Food Policy Research Institute (IFPRI, 2009) discussed that agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security. The impacts of climate change are even stronger in Africa, where subsistence agriculture predominates and adaptive capacity is low. Additionally, the Center for African Development (2002) noted that most of the rural people of Africa rely on rainfed agriculture, which is particularly vulnerable to change in climate variability, including seasonal shifts and precipitation patterns. Furthermore, any amount of warming will result in increased water stress. One third of the income in Africa is generated by agriculture. Crop production and livestock husbandry account for half of household income. The poorest members of society are those who are most dependent on agriculture (a sector which is most climate sensitive) for jobs and income.

Therefore, it is crucial to increase the understanding of the actual climate change dynamics on agricultural activities and on the societies at the lower levels. This indicates that the initiation of priority areas of adaptation by the country is very critical to build the resilience of rural communities to adapt to the imminent problems to be imposed by the changing climate. Adaptation helps farmers achieve their food, income and livelihood security objectives in the face of changing climate and socio-economic conditions, including climate variability, extreme weather conditions such as droughts and floods and volatile, short-term changes in local large-scale markets (Hassen, 2008).

SMALLHOLDER DRYLANDS FARMING, WEATHER (CROP) INSURANCE

For smallholder drylands farmers, the impacts of climate change is particularly pronounced, as these areas are already characterized by moisture deficit, low level of vegetation cover and already suffer from exacerbated environmental degradation. As discussed by Kaihura, Stoking, & Murnaghan (2009), drylands farming areas in Africa are often characterized as being extremely degraded, vulnerable to external forces and low in productive output.

Tackling drylands degradation and promoting sustainable resource use are key challenges for both environment and development goals because:

- some of the world's poorest and most vulnerable people live in drylands;
- in many drylands environmental resources such as land, water and forests are being degraded or are under pressure;
- many poor people are critically dependent on such resources for their livelihoods (Irish Aid, 2010).

The already fragile ecosystem in drylands areas is likely to be affected by changing climate which critically is associated with the variability of rainfall. Being mainly rainfed, drylands farming is most vulnerable to the impacts of climate change and hence needs close attention. Some of the priority areas identified under the National Adaptation Programme of Action are projects that can enable drylands farmers to adapt to the negative impacts of the changing climate. These identified project options for adaptation need to be supported by a coherent technologies and information dissemination mechanism with well organized prediction on the variability of rainfall. To this end, The International Crops Research Institute for the Semi-Arid Tropics (2008), discussed that the following issues need to be strategically implemented for better adaptation:

- Climate risk analysis frameworks that provide a medium-term strategic understanding of the temporal and special distribution of current rainfall variability, and its impact on performance and profitability of existing and innovative agricultural practices.
- Short-term seasonal climate and agricultural forecasting that enables farmers and support agents to fine tune medium-term strategies and thus plan tactically and farm more effectively in the face of seasonally variable weather.
- Providing medium to long-term information on the extent to which climate change is likely to impact on the nature of climate variability, and the implications for rainfed farming system and their future development and productivity.

The contribution of crop (weather) insurance in building the resilience of drylands farmers is not debatable. Crop insurance will enable the drylands farmers to cope with crop failure resulting from extreme weather events, which will be exacerbated by the changing climate, by protecting household assets. Though the Ethiopian experience in using this innovation is in its infancy, it is clear that this innovation is one of the options for drylands farmers to adapt with the adverse impacts of climate change.

Index-based weather insurance instruments can provide a viable alternative to traditional insurance instruments for agriculture. They potentially offer advantages to households, businesses, and governments in developing countries. Their main benefits include creating income smoothing opportunities for farmers and enabling access to credit and therefore investment in higher-yielding crops, advanced technologies and potentially access to more profitable markets (United Nations, 2007), (Dumitru, 2008). Crop insurance, for example, is seen as a priority adaptation activity in the Ethiopian NAPA, and may reduce short-term vulnerability among socio-economic systems by addressing the risk of serious rainfall fluctuation between years. What it does not do, however, is address wider climate change issues that will alter production systems over the long-term, such as cultivation that moves higher into the hills as temperatures rise, or changing rainfall patterns that will affect where and how pastoral groups can graze livestock (Overseas Development Assistance, 2008).

Specific to the Ethiopian conditions, modalities for adaptation for smallholder drylands farmers is related with the rehabilitation of the degraded ecosystem to enhance the good and services, implementation of the priority areas identified as the National Adaptation Programme of Action with particular focus on water harvesting and intensifying small-scale irrigation, livelihood diversification, crop insurance being one of the options, enhancing land productivity through different land husbandry mechanisms.

CONCLUSION AND RECOMMENDATION

Smallholder drylands farmers are living in a very fragile ecosystem where the land resources are significantly over-exploited and land degradation significantly hampers the effort of farmers to achieve food security through agricultural. Furthermore, the problems posed by climate change are significantly increasing the likelihood of risks, through the enhanced vulnerabilities of these farmers to the adverse impacts of weather related hazards and shocks.

Crop (weather) insurance is one means of transferring risks from vulnerable smallholder farmers to companies and institutions, relieving farmers of the risk that they will lose their productive assets as a result of weather related disasters. This can be directly linked as a potential for climate change adaptation. Smallholder drylands farmers are highly susceptible to weather-related risks and disasters, crop insurance initiatives can enable them to withstand the loss that they most likely are facing as a result of seasonal fluctuations or rainfall variability. While climate change adaptation is a system shift to withstand weather related shocks and problems, crop insurance allows the farmers who are affected by these problems to resolve them. Both innovations are meant to tackle the problem that the smallholder drylands farmer is likely to face as a result of extreme weather impacts.

Specific to Ethiopian conditions in relation to crop insurance, it has been proved that there is a great potential for the innovation to avert the problem of crop failure as a result of weather related disasters, albeit the innovation is in its infancy. Likewise, a well established NAPA is in place which can be implemented under the realm of climate change adaptation. There is clear indication that crop insurance is one of the potential areas in climate change adaptation in smallholder drylands farmers.

It is advantageous to assess the potential convergence points of initiatives such as disaster risk reduction, social protection, safety nets etc. and link these initiatives with crop insurance and climate change adaptation. Additionally, it is highly recommended that research on the outputs of the different initiatives related with climate change adaptation that are linked with averting the problem of smallholder farmers to develop, and influence national policies, to have a comprehensive method of approaches to the problems of climate change than dichotomized and fragmented way of tackling the problem. In this regard, the different government intuitions and development partners need to be coordinated for a concerted and consolidated action to enhance service delivery.

The Government of Ethiopia needs to develop a clear climate change adaptation and mitigation strategy to guide the different institutions and international agencies to apply a concerted impact on the problem of climate change before it is too late to act.

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PAPER 13

HORN OF AFRICA RISK TRANSFER FOR ADAPTATION (HARITA): A WEATHER-INDEXED MICRO-INSURANCE PILOT PROJECT IN TIGRAY

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INTRODUCTION

Today, more than ever, agrarian communities in Ethiopia face the double crises of extreme poverty and climate change. Ethiopia's population is characterized by features including, but not limited to, low income levels and high economic vulnerability. For instance, "out of a total population of 79 million in 2005, 23 percent of Ethiopians lived on less than US$1 per day (PPP adjusted), while 76 percent lived on less than US$2 per day. Also, about 44 percent of the population live below the nationally defined poverty line of ETB 10751 (about US$107) per adult per year" (Smith and Chamberlain 2010). Other features of the country include low levels of formal employment (7.9 percent of the labour force as of 2005), large rural population (86 percent as of 2008), limited access to financial services with only 11 percent of adults using any form of financial product in 2009 and an inefficient agricultural sector, where 53 percent of rural households were net buyers of cereal as of 1996 (Smith and Chamberlain 2010).

These low income households are particularly exposed to risks including, but not limited to, natural disasters, property loss, diseases and death. For instance, in a survey of 1 450 Ethiopian rural households, living across the country, approximately half of the respondents reported that they had been affected by drought between 1999 and 2004 while 43 percent and 28 percent of the household stated death in the household and illnesses as major risks to their livelihoods (Dercon *et al.* 2005). The households also identified risks such as low selling prices, high input costs, crop pests and crime, which indicates the multidimensional nature of the threats they face (Dercon *et al.* 2005). Given the dependence of 85 percent of Ethiopia's population on subsistence, rainfed agriculture, it is not surprising that the majority of households in the survey identified drought as the primary risk to their livelihoods (Smith and Chamberlain 2010).

In the absence of formal insurance markets, the poor typically cope with economic crisis through self-insurance (e.g. savings, debt, and asset liquidation), informal community-based insurance arrangements and external assistance. For reasons well documented in micro-insurance literature, these risk-hedging strategies all too often fail and farmers are left vulnerable to the impacts of economic shocks. Unable to transfer risk to a third party or to know the coming season's rainfall pattern, they naturally opt for low risk, low yield practices (e.g. using drought resistant seeds). Risk aversion can also lead to suboptimal provision of credit on the supply side. Money lenders, both formal and informal, are often very aware of the risks of lending to the poor and often refuse to give loans on attractive terms. Recent studies have also confirmed the strong correlation between access to credit and farmers' adaptation to climate change. Devising financial products, particularly insurance that would enable the farmers to transfer risks associated with their agricultural production, would be an incentive that would enable them make optimal production decisions and also would be a grantee to financial institutions in the event of default so that they would be more willing to extend credit.

Over the last two years, Oxfam America brought together Ethiopian farmers, Swiss Re, the Relief Society of Tigray (REST), the International Research Institute for Climate and Society (IRI), Mekele University and over a half dozen other organizations to launch an innovative climate change resiliency project called Horn of Africa Risk Transfer for Adaptation (HARITA). Together, a risk management package for farmers in villages located in Ethiopia's northernmost state of Tigray has been designed and implemented. The project has broken new ground in the field of climate change resiliency by addressing the needs of small holder producers through an unusual mix of risk reduction, drought insurance, and credit. Under the HARITA risk management package, insurance complements context-dependent disaster risk reduction and long-term, sustainable investments in agriculture.

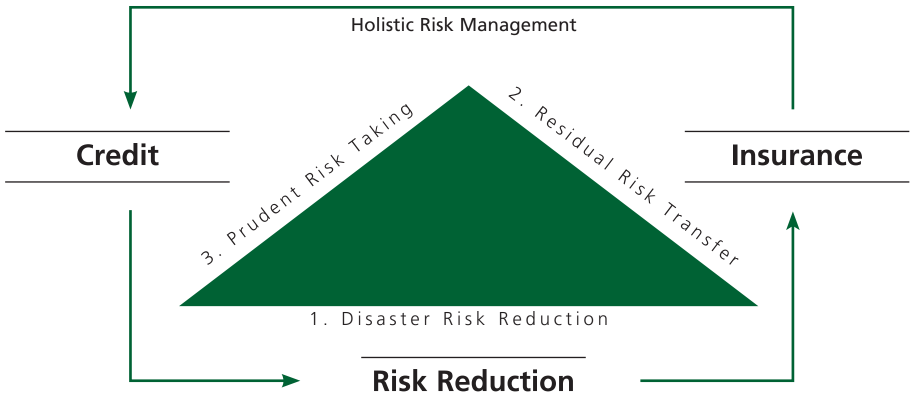
THE HARITA MODEL OF MANAGING CLIMATE RISK

The HARITA model is innovative in its holistic approach to risk management. Important grounds have been broken in finding ways to integrate risk transfer with risk reduction and gradually, credit. The HARITA approach aims to be flexible enough to adjust to differing risk conditions at the village-to-village level, while at the same time to help very poor families overcome cash constraints in purchasing insurance. The model consists of three main components: risk reduction, risk transfer, and prudent risk taking. In conjunction with appropriate government policies, accessible input and output markets, and agricultural research geared to benefit smallholders, we believe these three components can be scaled up to work synergistically. Working together, they can help promote livelihoods at the household level and greater resiliency to evolving threats, chief among them being climate change. (See Fig. 1 below.)

RISK REDUCTION: MINIMIZING VULNERABILITY

HARITA considers risk reduction the foundation of any holistic risk management approach. Risk reduction entails actions meant to promote resilience by minimizing

FIGURE 1
HARITA Conceptual Framework



vulnerability to and enhancing capacities *vis-à-vis* disaster risks. Farmers in Adi Ha participating in a community-wide vulnerability and capacity assessment (VCA) listed drought as the current, primary threat to their livelihoods and well-being. To limit the adverse impacts of drought and other important hazards, risk reduction in Adi Ha will require sustained use of locally appropriate farm, water and soil management techniques, as well as increased social awareness of preparedness for the climatic challenges ahead. HARITA's partners are cooperating to design a climate change risk reduction programme that is robust across a variety of climate scenarios and that is adapted to the specific needs of Adi Ha and Tigray. In cooperation with farmers, the University's scientists investigated ways to improve local soil fertility, to reduce threats from pests, and to reduce the crop's frequent need for weeding (an onerous task usually reserved for women). The results of the University's research, along with the results of the community VCA, are directly informing the types of risk reduction activities farmers are undertaking in Adi Ha today.

Most significantly, HARITA is exploring ways to build its risk reduction approach upon Ethiopia's Productive Safety Net Programme (PSNP), a well-established, government social protection programme serving 8 million 5 chronically food insecure households. In 2005, acknowledging that the current food aid system was broken, the Ethiopian Food Security Office established the PSNP as a system of transferring cash and food to vulnerable households before they reach a crisis point. As such, the motto of the PSNP is to provide predictable transfers for predictable needs. Assistance is coordinated through government and financial channels in exchange for beneficiaries' labour aimed at building community assets such as water harvesting structures or at reclaiming environmentally degraded areas. As of 2008, the PSNP had grown into one of the largest social protection programmes in Africa. Early impact studies suggest that the PSNP is superior to traditional, emergency food aid programmes in significantly increasing household welfare. HARITA applauds the many successes of the PSNP and seeks to build upon them.

RISK TRANSFER: WEATHER INDEX INSURANCE

HARITA could potentially strengthen the PSNP by addressing the non-chronic, unpredictable needs not covered under the programme. Through HARITA, farmers enrolled in the PSNP have the option to work extra days beyond those required for their normal payments, but instead of earning cash or grain for this additional labour, they earn an insurance certificate protecting them against deficit rainfall. In other words, through this premium-for-work arrangement, farmers can receive predictable transfers for unpredictable needs. (Note that richer farmers who do not participate in the PSNP are encouraged to purchase insurance with their own cash; as such, they constitute a potentially important subset of clients for the Ethiopian insurance industry).

The premium-for-work model obviously requires an independent source of financing, most likely from large governmental and multilateral donors (though at the moment, OA is playing this role). Once scaled-up, a HARITA-type risk management scheme could tap funds from emerging sources of climate change adaptation funds at the international level. From the perspective of donors, the HARITA approach multiplies the value of money by two: while a certain amount of aid could be used for either paying an insurance premium or for hiring labour to carry out risk reduction measures, with HARITA, the same amount of money results in both insurance and risk reduction simultaneously.

Over the last 18 months, the allied project partners cooperated on designing an affordable, drought insurance prototype package for teff. With IRI and Swiss Re in the lead at the international level, and Nyala Insurance Co. and Dedebit Credit & Savings Institution (DECSI) at the regional level, the team developed a weather index insurance product for Adi Ha. Weather index insurance entails risk transfer against events that cause loss. If a pre-defined weather event occurs during a pre-defined time, such as a shortage of rain during a crucial period in a crop's growth, this event triggers pre-determined payments to farmers who buy the policy. Index refers to the fact that the insurance is based on a proxy for loss and an objectively verifiable measure of weather.

Index insurance differs from traditional insurance where compensation to a policy-holder is based on the estimated value of what was actually lost. Traditional crop insurance is problematic because farmers have an incentive to neglect their crops in order to gain a higher payout. When properly designed, index insurance avoids this problem of moral hazard since the index cannot be influenced by farmers' behaviour. Index insurance also has lower administrative costs, because it is generally easier and cheaper to verify weather (e.g. rainfall levels) in a given region than to visit individual farms to assess damage. Because administrative costs are lower, index insurance packages are more affordable. Importantly, the payout can be setup to occur as soon as the loss-causing event is detected. In the case of insufficient rains, this gives farmers resources and time to manage a shortage in food production. Thus weather index insurance could help smallholder farmers by allowing them to stabilize their incomes and recover more quickly from climate-related shocks.

Insurance can also allow poor producers to make potentially optimal production decisions even in the face of uncertainty, meaning they can afford to plant high-yield seeds purchased on credit despite the uncertainty of future precipitation levels. Because the insurance contracts are priced from year to year, the premium charged can also reflect changing risks over time, including not only climate change trends but also seasonal rainfall predictions (Osgood *et al*., 2008). In this way, the market signals to farmers what production strategies are likely to succeed given the current conditions. Finally, insurance serves as a partial guarantee for banks and microfinance institutions that are reluctant to make substantial unsecured loans for inherently risky agricultural activities. In this way, formal risk transfer has the potential to reduce the interest rate on lending as well.

PRUDENT RISK TAKING: CREDIT

The final component of the HARITA model involves prudent risk taking, primarily in the form of credit for purposes of livelihood diversification (e.g. honey production), technology adoption (e.g. high-yield seed varieties, irrigation), and entrance into more value-added economic activities (e.g. producing high value horticultural crops like spices and vegetables). As mentioned earlier, risk aversion can exacerbate farmers' vulnerability, by making them less likely to make such investments even when affordable loans are available. Yet, credit for productive purposes can often lead to a better livelihood and gradual accumulation of wealth. In fact, a recent independent study commissioned by the Association of Ethiopian Microfinance Institutions found that 69.7 percent of the extremely needy clients of DECSI cited access to its lending programs as the reason for positive changes in their living conditions (Borchgrevink *et al.* 2005). For all these reasons, we are working with DECSI to increase access to credit by providing concessional loans to insured farmers who wish to make prudent investments in their livelihoods.

Insurance-based collateral could hardly be more welcome at this time, not only because of the increasing climate risks associated with agricultural lending, but also due to the current phase-out of Ethiopia's farmer loan guarantee fund. Beginning in 1994, regional governments in the country initiated a 100 percent credit guarantee programme to facilitate farmers' access to fertilizer, selected seeds, and other inputs. Under the system, approximately 90 percent of fertilizer and seeds were delivered to farmers on credit at below-market interest rates. Local governments entered into agreements with the Commercial Bank of Ethiopia (CBE), guaranteeing the farmers' purchases. In order to finance the loans, credit was then extended to farmers by the CBE through cooperatives, local government offices, MFIs and one cooperative bank. The loan guarantee programmehad reached some four million farmers with guaranteed credit of nearly US$70 million in recent years. While the programme benefited some farmers, it also came at considerable cost to the Ethiopian Government since farmers' had an incentive to default on these fertilizer and seed loans. The Government has therefore decided to phase out the loan guarantee fund (World Bank, 2006).

Without Government backing, most asset-poor farmers will only have access to their neighbours as collateral. Ethiopian MFIs heavily favour the group guarantee lending model or GGLM (Borchgrevink *et al*. 2005), where borrowers vouch for each other and cover defaults in the group. The GGLM is widely criticized by poor clients for stimulating conflict among borrowers; yet lenders will struggle to find an acceptable alternative once the loan guarantee fund is entirely eliminated. In this way, insurance could have a secondary benefit in providing an alternative to the GGLM. We are working hard to make an insurance-linked credit package for HARITA available for the 2010 growing season.

ACHIEVEMENTS

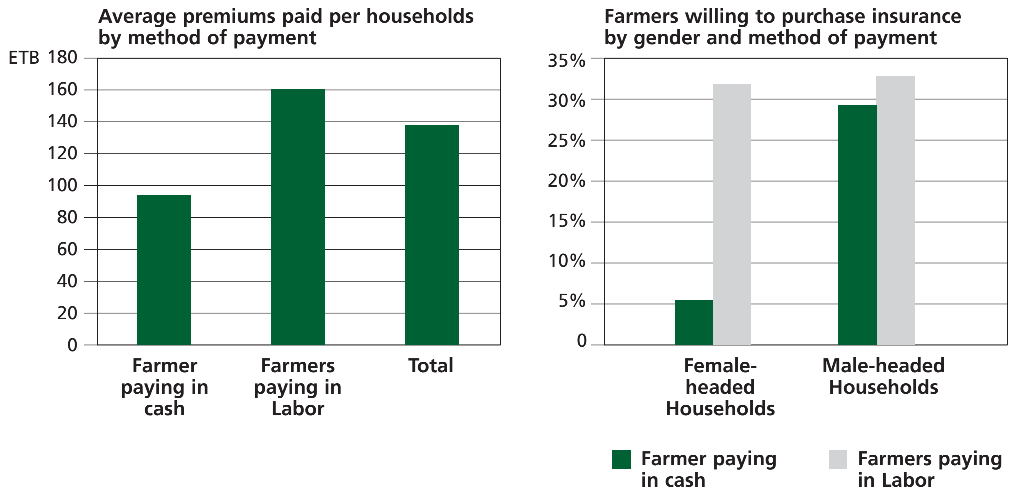
While some index insurance pilots have attracted solid demand from farmers, it is unclear why take-up has not been automatic or stronger given the many theoretical benefits of risk transfer. Academic research and index insurance pioneers have found that farmers struggle to understand complex financial products, much less afford them. HARITA has tried to overcome these two barriers by employing culturally appropriate popular education methods developed in conjunction with farmers, such as storytelling and participatory games. We also believe that in-kind premium payments allow poor clients, who may not be rich in cash but who are rich in labour, to purchase much more coverage than they could afford otherwise. Uptake of Wahisna3, the HARITA affiliated risk management package offered by Nyala Insurance Company in late May 2009, constituted a major test of our popular education and outreach efforts, as well as the attractiveness of the premium-for-work model.

Over the course of two days, approximately 600 farmers attended the enrolment activities and 200 households signed up for the package, representing roughly 20 percent of the village. We are extremely pleased that 38 percent of enrolees were female-headed households (recognized as the poorest of the productive poor) and 65 percent of enrolees were participants in the PSNP. By definition, these two groups constitute the most vulnerable farmers in Adi Ha. Our preliminary calculations show that 22 percent of all female-headed households purchased the package versus 18 percent of all male-headed households. At the outset of this project, the received wisdom was that agricultural risks for farmers this poor were nearly uninsurable, but our model involving in-kind premiums is a direct challenge to this notion. Over time, as livelihoods improve and farmers graduate from the PSNP, they become candidates for the commercial insurance market where they can pay for risk transfer in cash. Already, 35 percent of the enrolees (ones who are better off and not in the PSNP) did pay in cash, using the disposable assets they had built over time.

Adjusted for landholding, farmers (paying in cash or labour) paid an average of 138 Ethiopian Birr in premiums (approximately US$12.22), approximately 1.8 times the minimum option. The minimum purchase was 76 Birr (US$6.73), and the maximum was 229 Birr (US$20.28). Wahisna's percentage premium price was 22 percent plus a 2 percent administrative fee. Based on historical rainfall records, expected payout is just over 1 in 5. In 2008 the International Monetary Fund estimated Ethiopia's nominal, annual GDP per capita at US$324; as such, these numbers are substantial, especially considering that there was no price subsidy on the product. After community discussion of various options, farmers in the PSNP decided to earn their premiums through a small menu of activities. For example, farmers are learning to take advantage of the relatively abundant biomass in the area by making and using compost, critical for rebuilding soil nutrients and improving

FIGURE 2

Selected enrolment results of the Wahisna package, May 2009



soil moisture retention. In addition, they are engaging in agroforestry by constructing small scale water harvesting structures on farm land such as soil bunds and trenches, as well as planting nitrogen-rich trees and vetiver grasses to promote soil and water conservation and to provide fodder for cattle and flora for farmers' lucrative honey beekeeping. Finally, farmers are learning how to clean teff seeds before they sow them in order to boost productivity. Mekele University found that average yields for clean seeds were 50 percent higher than control plots using unclean seed (and no other productivity enhancements). If sustained, these risk reduction activities will help minimize vulnerability to drought and improve yields.

LESSONS LEARNED

- Ensure that insurance is just one component of a robust, holistic adaptation strategy. Adaptation is a highly complex process which involves action at the local to global level, financial commitments by governments and donors, also appropriate tools and technologies at various scales. Climate-related insurance is very important, but is not an end in itself. Insurance must be integrated with a broader programme of risk and poverty reduction in the context of a changing climate. For these reasons, the HARITA project integrates risk transfer with risk reduction and credit that also promote adaptation. Weather index insurance complements these strategies by addressing the climate scenarios for which it is relatively difficult to plan. For instance, rainfall harvesting structures can reduce risk by allowing farmers to conserve water in the long run, while drought index insurance can provide added protection if rainfall ends up unusually low in the short run (i.e. year to year). Weather index insurance can also promote critical credit-led investments in adaptation by helping make farmers more resilient to weather-related shocks.

- Make risk reduction the foundation of any insurance programme. Related to but distinct from the point above is the fact that many insurance proponents seem to forget that the best way to protect against negative risk is not to purchase insurance, but to reduce exposure in the first place. HARITA's primary risk management strategy therefore involves risk reduction. Farmers identify and implement ways of decreasing their exposure to the kind of small-scale climate risks that stand within their domain of relative control. For instance, relevant disaster-risk reduction (DRR) activities include small-scale water harvesting, increasing soil moisture retention, and others. As a complement to DRR, farmers then have the option of purchasing weather index insurance to address the insurable climate risks that cannot be sufficiently reduced.
- Risk layering: aim for product variety and flexible scale. There is a lot of debate about whether insurance for farmers is best purchased at the household, regional, or national level. We think it is important to establish complementary insurance and adaptation strategies at all three levels. For instance, households and insurance companies can absorb small-scale risks, while regional and national government can prepare for larger and more uncertain risks. In other words, multi-layered, insurance-related programmes cover the broad range of uncertainties and sizes of climate change-related disasters.
- Prioritize a community-driven adaptation process. Climate change effects will exert idiosyncratic effects on different people given differing levels of vulnerability, assets, and capacities. Although adaptation efforts must be consistent with and bolstered by regional, national, and global policies and strategies, the primary focus should be on communities who can tailor interventions as needed. Moreover, involving farmers in adaptation planning is not merely an exercise in political correctness - adaptation is as much about changing attitudes and behaviours as finding technical solutions. Moreover, this demand-driven process ensures effective product development and roll-out.
- Give farmers an opportunity to participate meaningfully in insurance design. The HARITA project involves a farmer-designed insurance product. Farmers were deeply involved in identifying their educational and risk management needs, as well as in brainstorming how weather index insurance could be made very attractive to the target client (e.g. by suggesting that insurance be payable in-kind). They also were trained in weather-data collection, which provided additional, critical datasets for understanding the nature and degree of basis risk around the village.
- Involve the private sector. Under the right circumstances, the private sector stimulates healthy economic growth. Moreover, most small-scale weather disasters, such as unreported droughts, do not attract any post-disaster aid, although they may cause serious financial losses. The cumulative effects of these small-scale disasters can result in devastating long-term impacts on the lives and livelihoods of those at risk. As private insurers are in a position to cover unreported disasters in addition to the large-scale and internationally visible ones, the private sector could

fill a critical gap in poor countries' risk management system. The private sector can also provide reinsurance (i.e. insurance for insurers). Given the fact that climate impacts are often spread across multiple communities, reinsurance is vital to prevent bankruptcy among micro-insurers when extreme weather leads to mass payouts. Involving the private sector from the outset ensures long-term sustainability.

- Build insurance on a foundation of trust. At its core, insurance is a simple promise, and nobody seen as unable or unwilling to honour that promise has a viable product. Potential insurers should consider working in partnership with entities that have a strong track record with farmers. Oxfam America and REST have been working with poor farmers in Tigray for decades.
- Remember that food security remains the primary and immediate concern. Farmers are concerned about coping with long-term climate change, but they are even more concerned about just surviving today. The HARITA model was piloted in 2009 in Adi Ha village with the Productive Safety Net Programme (PSNP) serving as the primary distribution mechanism. With annual funds of roughly US$500m from large international donors, the PSNP was established in 2004 as a system of transferring cash and food to vulnerable households before they reach a crisis point. This assistance is provided in exchange for beneficiaries' work to reduce risk, e.g. by building community assets such as water harvesting structures or reclaiming environmentally-degraded areas. By integrating insurance with a food security programme, farmers' immediate concerns begin to be addressed, allowing them the luxury of thinking about longer-term issues.
- Consider creative ways to make insurance affordable. HARITA's insurance-for-work (IFW) model allows very vulnerable farmers to pay their premiums in labour. IFW means that farmers benefit even when there is no payout - the risk reduction measures taken in their communities pay dividends, even during the good weather years. IFW is innovative in allowing insurance and credit to stand as independent components. In most index insurance pilots, farmers have been required to take insurance and loans as a package. Under HARITA, however, farmers may choose to bundle the two, but they are not required to do so. The independence of credit and risk transfer means that farmers retain access to insurance after they have repaid their loans, and farmers who do not want a loan can still obtain insurance. Labour is the most obvious in-kind currency available to low-income households. HARITA's experience is consistent with a study by Asfaw and Braun who examined poor Ethiopians' willingness to pay for health insurance. Interestingly, they found that for a premium level of ETB 3 per month per household, twice the number of respondents were willing to purchase community-based health insurance if premiums could be paid in terms of labour rather than in cash. On average, poor people were willing to contribute up to ETB 14 worth of labour, nearly five times more.
- Realize that women are the best long-term (and maybe even short-term) customers for insurance. Many people in the weather-index insurance industry assume that

women are not particularly good candidates for insurance because they usually have less disposable income, less education, and fewer assets to insure than men. Although women are generally poorer than men, the micro-finance industry has concluded that they are usually much better planners. We found this perception to hold true in our 2009 country-wide study ‘Estimating the Demand for Micro-insurance in Ethiopia’ (commissioned by the ILO). Women’s likely enthusiasm for insurance will be tempered by two facts: first, they tend to be more risk-averse than men (which is why they are better planners in the first place), and - to the degree that a new product like insurance is seen as risky - women are more likely to be put off. Moreover, women have less cash to purchase insurance. However, in the long run, as insurance and insurers become more familiar, and products become more affordable, women are likely to become the best customers. The HARITA model accelerates this process by addressing the trust issue through partnership with credible players and dealing with the cash-constraint by allowing the poorest farmers to pay in-kind. Given these two factors, in 2009 HARITA’s insurance clients were statistically more likely to be female than male.

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PAPER 14

INTEGRATED BACKYARD POND FISH FARMING FOR LIVELIHOOD DIVERSIFICATION: THE CASE OF NORTH WESTERN AMHARA, ETHIOPIA

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INTRODUCTION

Background and justification

Backyard ponds can be planned, designed and built for multipurpose use, including fish farming. The advantage of pond fish farming allows fish to utilize natural foods (Rakocy *et al*. 2005) and enable farmers to earn higher net returns from fish farming integrated with agricultural practices. Even small ponds can contribute to farm income or reduce family spending as fish are sold, bartered or eaten. Moreover, it can diversify livelihood and minimize risks. For example, this method is very popular in raising tilapia.

The various types of aquaculture form a critical component within agricultural and farming systems development that can contribute to reduce malnutrition by providing food of high nutritional value, have decreased productions risks, sustainable resource management and increase farm sustainability (Little and Edwards, 2003). Aquaculture, especially integrated aquaculture, is sustainable because it makes use of locally-available materials. Integration with other forms of agriculture diversifies farm productivity and provides opportunities for intensified production with more efficient allocation of land, water, equipment and other limited capital than practices which run independently. Fish culture integrated with garden irrigation, livestock watering and various domestic uses are all possible.

Fish as a cheap source of high quality protein is used as an alternative way to fulfil the protein requirement of the farm family. The production cost of fish, if the ponds are constructed once, is lower when compared to poultry, beef and sheep. Pond fish grow by efficiently converting food into flesh, as fish are essentially weightless in water, and thus expend little energy for locomotion or maintain a normal upright position. They are cold-blooded animals and do not expend energy to maintain a relatively high body temperature as other warm-blooded animals. Thus, the amount of energy required to produce one kg of fish is much less than the amount required producing an animal of equal weight.

Tilapia are extremely tough fish which thrive in poor quality water on low-cost feeds (Bronson, 2005), are fast-maturing, easy-to-keep, popular with consumers, provide nutritious white meat (CTA, 2007[1]) and thrive on kitchen scraps and other low-cost inputs (WFC 2007[2]; Economist 2007[3]). They exhibit maximum growth rates at temperatures between 25 and 30 °C (Bocek, 2003), thus tropical climates are most suitable. Nile tilapia (Oreochromis niloticus) is the most predominant species of tilapia in aquaculture (Gupta and Acosta 2004) and is well adapted to artificial culture environments, gains weight quickly at optimum conditions and reproduces on the farm without special management or infrastructure. Nile tilapias (O. niloticus) reach sexual maturity at about five to six months (Gupta and Acosta 2004).

If the natural productivity of a pond is increased through fertilization or manuring, increased production of tilapia can be obtained without supplemental feeds. To maximize fish production, manure from livestock should be added to the pond daily in amounts that do not reduce dissolved oxygen (DO) to harmful levels as it decays. A pond should be fertilized with the following quantities: 10 kg of cattle, equine and sheep/goat manure and 6-8 kg for pig and chicken manure in a 100 m² pond every week. The amounts depend on the quality of the manure, the oxygen supply in the pond and water temperature. The rate of fertilization should be increased gradually as the fish grow (Rakocy and McGinty, 2005). Liming (1000 to 2000 kg/ha) promoted phytoplankton growth and increased fish production.

The participants in these trials already had water sources on their property or stored on their farm land. In some areas small streams located in the backyard were barraged to irrigate tree nurseries and vegetable seedbeds. They also had cattle or small ruminants or chicken or both who can potentially produce the manure to be used to fertilize water stored in the pond. Fertilized water can provide live food for fish since multiplication and growth of important plankton species is enhanced. Today, aquaculture is responsible for an ever-increasing share of global aquatic food production, which has increased from 3.9 percent in 1970 to 31.9 percent in 2003 (Carballo *et al*. 2008)[4]. Despite these advantages,

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[3] The Economist. 2007. Fish versus AIDS. August 30. https://www.economist.com/world/africa/ Accessed July 28, 2010.

[4] Eira Carballo, Assiah van Eer, Ton van Schie, Aldin Hilbrands (2008).Small-scale freshwater fish farming. Agrodok 15. ISBN Agromisa: 978-90-8573-077-4

the farming family may suffer malnutrition and scarcity of protein food. The gap between supply and demand for fish is widening and natural fish stock in the region, and others in the country has declined as the demands of the human population continue to increase.

Since 2008, backyard fish farming has been researched in three zones (East Gojjam, Awi and West Gojjam) of the North Western Amhara. The present trials were undertaken to check whether it is possible to implement fish farming in the farmers' backyard.

Objectives of the trials

- To demonstrate production of tilapia fish in backyard ponds integrated with existing agricultural practices.
- To assess farmers' income generated by the integration of fish farming.

METHODOLOGY

Materials

Ponds

Backyard trial ponds were prepared at eight Woredas of the North Western Amhara Region; five in East Gojjam, two in west Gojjam and one in Awi Zone. The ponds were located at different altitudes (1 791 to 2 314 meters above sea level). All backyard fish ponds were earthen except the one at Dangila and another at Bahir Dar Zuria which were lined and plastered with hard plastic sheet (geo-membrane) cover as the area collects pond water.

Ponds were located on land with a gentle slope. Each were rectangular or square-shaped and had dikes, preventing entry of runoff water from the surrounding watershed. Side slopes varied from 2:1 or 3:1 (each meter of height needed 2 or 3 meter of horizontal distance) for easy access to the pond and minimized risks of erosion. Most of the ponds drained water partly when the fish were harvested. Ponds receiving water from surface sources did have an inlet pipe (PVC) or ditch or canal that let water in, and an outflow to remove water. Each pond was surrounded by a plot of land which enabled the farmer to perform different agricultural activities. One pond had a chicken shed for raising poultry.

Water

The source of water for the backyard ponds varied according to the resource found in the area. A majority of the ponds in East Gojjam had ground sources with water pumps. One farmer pumped water from Lake Tana to refill and refresh the pond while most of the farmers used already existing irrigation water sources.

Cultivable land

All the farmers integrated fish production with varied vegetable production, tree seedling and chicken rearing. Each farmer also had plot of land for cultivation, besides the fish pond varying in size from 300 to 500 m^2. Vegetables which were cultivated include cabbage (Brassica oleracea), carrots (Daucus carota), tomatoes (Lycopersicon esculentum), beetroot (Beta vulgaris) and peppers (Capsicum annum). Tree seedling species grown by the farmers included the eucalyptus tree (Eucalyptus globulus). The chickens species raised in these trial fish pond were the Red Island Red species.

Equipment and inputs used

The trials were carried out with a variety of instruments, equipment and processes:

- Global Positioning System (GPS) was used to navigate the location of each pond.
- Tape measures were used to delineate the pond area and to construct the pond.
- Large plastic jars, filled with water and equipped with oxygen supplier (aerator), were used to transfer fish fingerlings from the hatchery/natural water body to the farmers' ponds (grow out ponds).
- Seine net and/or gillnets of 6 and 8 cm mesh size, cast net, sensitive balance, measuring board and different scoops were used to collect and measure pond fish during sampling.
- Water quality parameter measuring field equipments including oxygen meter, pH meter and secchi disc were also used.
- Lime was applied at a rate of 100 grams/pond to make the pond bottom comfortable for fish and adjust the soil pH prior to filling the pond with water and stocking fish. Tilapia fish fingerlings (mixed sex) were used to stock each pond. Animal manure (mostly cow dung) was used to fertilize the pond water.

Methods

A total of 15 farmers (14 male and one female household) having a pond or two with an area of 100 m^2 and more, were selected for the trials. (Annex 1). Ponds were prepared at a depth of 1.25 m on the inlet and 1.75 m on the outlet side. Once the ponds were dug, lime was spread on the sides and bottom at a ratio of 10 kg per 100 m^2. Lime was applied and after the pond was filled with water, 15 kg a week of manure was added to fertilize it. (FAO, 1994)[5]. Once the pond was fertilized and live food available, fish fingerlings were collected from hatcheries or natural water body and stocked at a density of two fish per m^2. The fish used for this trial was mixed sex Tilapia fingerlings weighing 3-5 grams each. For ponds established in the basin area of Lake Tana, artificially-reared Nile Tilapia (Oreochromis niloticus) fingerlings were stocked to avoid contamination of the Lake with other Tilapia strains. It was recorded that fish fingerlings died during the first three days after stocking. Fish growth was checked every month using seine nets and gillnets with different mesh sizes (6, 8, and/or 10 cm). Once the fish reached the recommended table size (150 grams and more), they were collected from the pond and either eaten at home or sold at the market. During fish collection, the level of pond water decreased by 50 percent. The fertilized pond water was siphoned regularly and used to irrigate the cultivable plot of land. All the fish were collected once they reached the appropriate size. Records were kept using data recording sheets given to individual farmers to track the fish and agricultural products produced, consumed and/or sold, as well as expenses.

[5] Hand book on Small-Scale freshwater fish farming (1994). FAO Training series. Food and Agriculture Organization of the United Nations. Rome,1994.

RESULT AND DISCUSSION

Productions from the integration

Fish

The farmers selected to participate in these trials did not previously have fishponds. Currently, all of these farmers adapted the technology of fish farming integrating it with their existing and new farming practices. Each of the 15 trial household farmers prepared 16 fish ponds covering an area of 1 660 m^2. The total amount of fish produced from these ponds reached 2.89 quintals. According to Rakocy *et al* (2005) approximately 22 kg of fish per year can be produced in an acre of pond with local management, but this result can be increased by integrating with other cultivation. Farmers living in the lower elevated areas were able to produce more fish than those living at higher altitudes using the same size of backyard fish pond. The time taken to produce table size fish (150 gm and more) varied with elevation - the higher the elevation the longer it took. The time required to produce 13.9 kg of fish was 14 months at an altitude of 2 320 m., but a pond at an altitude of 1 791 m required only nine months to produce 17.82 kg of fish (Table 1) at an average temperature of 23.7 °C. The pond water temperature and source varied from place to place.

TABLE 1

Weight of 90 fish samples from ponds at different trial sites (altitude).

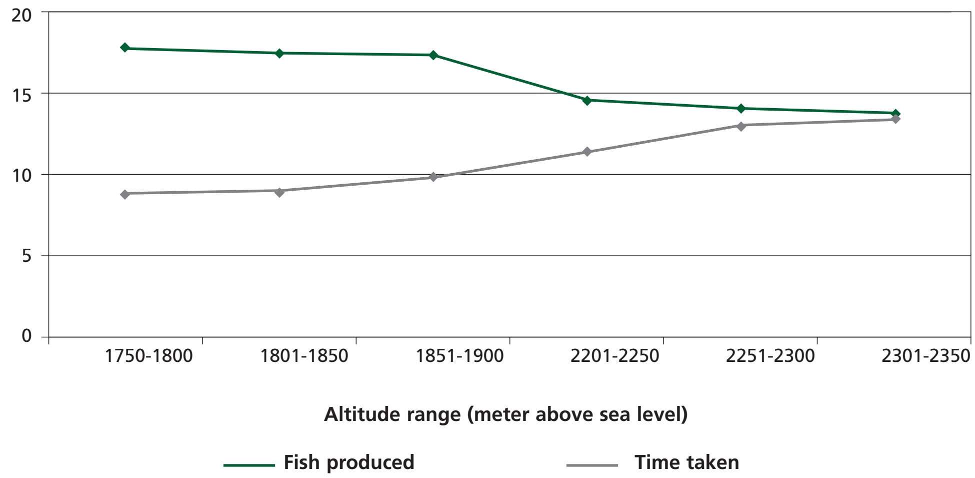
ELEVATION (m.a.s.l)	TIME TAKEN (MONTHS)	AVERAGE PRODUCTION (kg)/POND	AVERAGE POND WATER TEMPERATURE (°C)	POND SIZE (m^2)
1791	9	17.82	23.7	100
1845	9	17.46	23.2	100
1878	10	17.91	23.1	100
1898	10	17.01	21.3	120
2210	12	14.8	19.8	100
2219	10	15.03	21.3	120
2224	13	14.22	18.6	100
2235	11	14.67	21	100
2247	11	14.31	21	100
2275	13	14.13	19	100
2278	13	14.13	18.8	110
2314	14	13.95	18.7	100
2320	13	13.41	18.6	100

Note: - °C = Degree Celsius kg = kilo gram m = meter a.s.l. = above sea level

The data showed an inverse relation between both time required and altitude of the fish production area. The lower the altitude, the higher the production of fish within a shorter period of time. The higher the altitude, the longer it takes to produce a given amount of fish (Fig. 1).

FIGURE 1

Fish produced and time required with altitude



Two farmers raised fish fingerlings by supplementing the pond with locally-available fish feed mainly of food leftovers like injera (local bread), vegetables and fruits. The farmers benefited both socially and economically from these fingerlings. One farmer gave 240 fish fingerlings to relatives who wanted to adapt the technology. A farmer in Bahir Dar sold 1 200 fingerlings for Birr 400 and the other in the Enemay district sold 1 020 fingerlings for Birr 510.

Vegetables

The farmers, who participated in the trials, including those who had never previously raised fish, grew 168 to 2500 kg of vegetables using the fertilized pond water where fish were growing. Those farmers who had previous experience in producing vegetables increased their vegetable production more than those whose first experience was during the trials (Table 2). A total of 153 quintals of different vegetables were produced in a year (i.e. one fish production cycle). Most of the vegetables (more than 93 percent) produced in the farmers' plot of land were sold to the local market and about 6 percent (nearly 10 quintal) of the produce was used at home. Aside from their vegetables, two farmers produced 40 fruit and 15 000 tree seedlings for market.

Chicken

A farmer in Bahir Dar zuria Woreda constructed chicken houses and reared Rhode Island Red breeds in one season. Chicken manure was directly added to the pond water and the farmer planted some green feed for the chicken using pond water. The water was fertilized frequently and the multiplication and the plankton grew rapidly. Despite the scarcity of chickens, in general, it was possible to raise more in one fish production cycle as the fish in his pond needed about 9 months to reach table size. He bought 36 month-old chickens from breeding centre and kept them for three months and successfully raised and sold the chickens.

TABLE 2
Vegetables produced and sold by category of farmers

CATEGORY	NUMBER OF PARTICIPANTS	VEGETABLES PRODUCED (kg)	VEGETABLES SOLD (kg)	VEGETABLES CONSUMED (kg)
Experienced farmers	8	12,904	12,078	826
Non experienced (Starters)	7	2,428	2,258	170
Total	15	15,332	14,336	996

Market value of the products

Further to these trials it was discovered that it was possible to breed and use fish (for either domestic use or sale). Families can use the fish directly from the pond for use at home or sell them for a profit on the local market. More than 50 percent of the farmers in the trials (Table 2) had previously been producing vegetables (without integrating fish breeding) for four to five years preceding the trials.

TABLE 3
Income (Birr) generated from integrated farming

FARMER CODE*	COST OF PRODUCTION			GROSS INCOME			NET INCOME
	FISH	AGRICULTURE	TOTAL	FISH	AGRICULTURE	TOTAL	
01	187	230	417	254	3,360	3614	3197
02	187	230	417	280	3,200	3480	3063
03	122	340	462	338	4,500	4838	4376
04	127	230	357	184	600	784	427
05	110	360	470	1046	7,500	8546	8076
06	100	340	440	426	4,500	4926	4486
07	100	340	440	328	6,000	6328	5888
08	319	230	549	1080	1,600	2680	2131
09	228	230	458	418	5,000	5418	4960
10	162	230	392	302	2,000	2302	1910
11	160	230	390	236	3,000	3236	2846
12	198	340	538	300	1,620	1920	1382
13	161	230	391	284	450	734	343
14	150	230	380	470	3,200	3670	3290
15	178	980	1158	755	3,844	4599	3441

During these trials, farmers were able to produce a new product and obtain additional yield and income (sometimes up to Birr8 000 more) with low cost using the pond water from integrated farming system (Table 3). Those who began producing fish fingerlings by supplementing feed significantly improved their income than those waiting for the grow-out fish only.

The gross income of this integrated system reached more than Birr 57 000 and the fish farming contribution varied from 5 to 40 percent. The overall gross income contribution of vegetable production, chicken rearing and fish production was 84 percent, 3 percent and 12 percent respectively.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The trials indicated that integrating pond fish farming in the farmers' backyard can improve the nutritional status of the farm family and provide additional income. It was also proven that the technology can potentially sustain the livelihood of a family. This system helped the farmers to adapt new technology and acquire knowledge to their benefit.

Recommendation

In order to obtain optimal results, the species chosen for integration should be adapted to the site. As the produce of the integrated technology are mostly perishable, appropriate handling, processing and marketing systems should be arranged. Further research should be made on the implementation of the technology, especially on monosex fish fingerling production systems.

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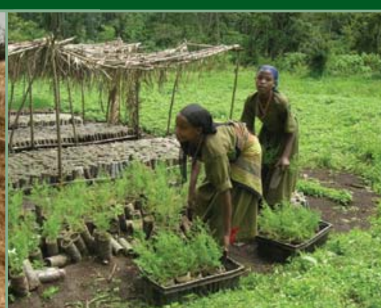
FAO and the Climate Change Forum (CCF-E), a national NGO, in close collaboration with the Ministry of Agriculture of Ethiopia, organized a Technical Workshop on 5-6 July 2010 in Nazreth, Ethiopia. The primary goal was to improve the knowledge base and raise national and local preparedness in addressing the impacts of climate change and its associated variability on agricultural-based livelihood systems (i.e. smallholders with rainfed agriculture, herders and agropastoralists, forest-dependent people). In addition, it provided the opportunity to explore best practices and options to increase awareness and preparedness for adaptation to climate change. The Workshop participants, representing various government and UN agencies, and NGOs, shared their experiences and lessons learned on good practices, options and policies in building the resilience of the rural poor and smallholders to cope with climate risks. This publication presents the discussions, presentations and contributions of the participants in the Workshop.



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