Adapting to climate change through land and water management in Eastern Africa

Results of pilot projects in Ethiopia, Kenya and Tanzania

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Foreword

Climate change and variability is a major challenge facing smallholder farmers and adaptation is now a priority in many countries of sub-Saharan Africa. Farmers, livestock keepers, and fisher-folk living in fragile environments such as drylands and mountain areas are directly exposed to the risks associated with climate change. This is particularly true in regions that already suffer from soil degradation, water scarcity and high exposure to climatic extremes, and where poverty and hunger persist.

FAO assists its member states in managing ecological, social and economic risks associated with agricultural sector production systems, and supports climate change adaptation in many countries. It focuses its attention on the vulnerable with few assets other than their labour and some land, who rely on farming to produce food for themselves and their families, and to secure their livelihoods.

This publication presents the findings of a project funded by the Swedish International Development Agency, aimed at strengthening the capacity of farmers to adapt to climate change through land and water management among rural communities in three countries of Eastern Africa- Ethiopia, Kenya and Tanzania. It focuses on the household level, where most adaptation and coping strategies are implemented. It stresses the importance of investing in better soil health and conservation of water, shows how income diversification contributes to enhanced resilience among local populations, and highlights the importance of strong local institutions and community-based organization in support to climate change adaptation.

Strengthening technical and institutional capacity and building resilience to climate change leads to a reduction in the exposure and sensitivity to climate risk. I trust that the lessons learned from practices tested on the ground in this project can provide insights and contribute to designing effective climate change adaptation programmes in sub-Saharan Africa and beyond.

Maria Helena Semedo
Deputy Director-General
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Acknowledgements

This report presents the results of a pilot project funded by the Swedish International Development Cooperation Agency (Sida) and implemented by FAO, aimed at building resilience to climate change among smallholder farmers in Ethiopia, Kenya and Tanzania. The project adopted a highly decentralised approach, relying on a team of experts, technicians and field operators in each country, while also promoting interactions and exchanges between teams.

At FAO, the project was implemented by a multidisciplinary team led by Alemneh Dejene, Jean-Marc Faurès, Sally Bunning and Meshack Malo, with support from Janie Rioux, Domitille Vallée, Julia Seitz and Liliane Kambirigi. Project implementation in the three pilot countries was coordinated by Meshack Malo.

In Ethiopia, pilot activities were coordinated by Getachew Debalkie with assistance from Brook Solomon. Staff involved in the two pilot sites included Chala Adere, Elias Kediro, Dingade Adungna, Hailu Adugna, Kebede Bayecha, Betiglu Abebe, Mintwab Shiferaw, Abiyot Hiwot, Adane Bekele, Ararsa Abate (for Haro Jila watershed), and Habtweld Tege, Moges Girma, Shambel Sharew, Solomon Tadesse, Tadesse Balhyider, Endalkachew Yeshigeta, Zewdu G/Yesus, Tenaye Akalu, Tilahun Wube, Woldamanuel Delelegne (for Wurba watershed).

In Kenya, Barrack Okoba (Kenya Agricultural Research Institution) coordinated the work with the assistance of Fredah W. Maina and Philip Kiruri Mwangi. Activities in the project sites were carried out in by INADES Formation International in Machakos County, Community Research in Environment and Development Initiatives (CREADIS) in Bungoma Country and Rangala Family Development Program (RFDP) in Siaya County. Rosila Adhiambo (RFDP), Sweeny Binsari Ogeto (INADES) and M. Waringa contributed to the case studies presented in this publication.

In Tanzania, Professor Henry Mahoo (Sokoine University) coordinated the national programme, with the assistance of Masakia Nicholas, Edith Kija, Pangapanga Charles, Pyumpa Geofrey and Pendo Edna Mahoo.

Ali Haji Ramadan (FAO national coordinator for Zanzibar) and James Wani (FAO Representation in South-Sudan) attended the writeshop organised in preparation for this report and provided useful comments and suggestions.

Anne Woodfine, FAO consultant, acted as overall editor for the preparation of the publication, coordinating authors' inputs during the writeshop and finalising the writing. Desktop publishing and graphic design were done by Nicoletta Forlano and Jim Morgan.

This report would not exist without the enthusiasm and dedication of the thousands of people in the communities of Shoa Robit and Sebeta Woredas, Siaya and Machakos Counties and Morogoro District who believed in the project, support it and made it happen. We hope that these positive lessons can help improve the design and targeting of appropriate climate change adaptation approaches in future projects and programmes, including for scaling-up in the three project countries and extending benefits to communities in South Sudan.

This project was funded by Sida through the FAO Multi-Partner Programme Support Mechanism Project FMM/GLO/006/MUL.

List of Acronyms and Abbreviations

AGM	average gross margin
AR4	Fourth Assessment Report (of IPCC)
CA	conservation agriculture
CC	climate change
CH4	methane
cm	centimetre
CO2	carbon dioxide
CREADIS	Community Resilience in Environment and Development Initiatives
CSA	climate smart agriculture
DTC	drought tolerant crop
EbA	ecosystem-based adaptation
e.g.	for example
FAO	Food and Agriculture Organization
FFS	farmer field school
FMM	FAO Multi-Partner Programme Support Mechanism
FRP	farmer resource person
GDP	gross domestic product
GHG	greenhouse gas
GM	gross margin
ha	hectare
HH	household
HIV / AIDS	human immunodeficiency virus infection / acquired immunodeficiency syndrome
IFPRI	International Food Policy Research Institute
IPCC	Inter-Governmental Panel on Climate Change
KARI	Kenya Agricultural Research Institute
KES	Kenyan shilling
kg	kilogram

km	kilometre
m^3	cubic metre
masl	metres above sea level
mm	millimetre
N	number / frequency
NAPA	national adaptation programme of actions
NGO	non-government organisation
N_2O	nitrous oxide
PADEP	Pennsylvania Department of Environmental Protection
PIWM	participatory integrated watershed management
RFDP	Rangala Farming Development Programme
SACCOs	Savings and Credit Cooperative Organizations
Sida	Swedish International Development Cooperation Agency
SPSS	Statistical Package for Social Science
SLM	sustainable land management
SOM	soil organic matter
SRA	Strategy for Revitalizing Agriculture (Kenya)
SRI	system of rice intensification
SSA	sub-Saharan Africa
SWC	soil and water conservation
SWMRG	Soil and Water Management Research Group (Sokoine University of Agriculture, Tanzania)
SWC	soil and water conservation
t	tonne
TAR	Third Assessment Report (of IPCC)
TMA	Tanzania Metrological Agency
ToT	Training of Trainers
Tshs	Tanzanian shilling
URT	United Republic of Tanzania
UWAUKI	Umoja wa Wamwagiliaji Kiroka
WCST	Wildlife Conservation Society of Tanzania
WWF	World Wildlife Fund

Summary

The Eastern African region (which includes Ethiopia, Kenya and Tanzania) is highly vulnerable to climate change and several of its major sectors (notably agriculture) that significantly contribute to the sub-region's economies are at risk. About 80% of the population in East Africa depend on agriculture, which contributes to 40% of the sub-region's GDP. Climate change will significantly affect the agricultural sector in ways that without adaptation will ultimately reduce yields of subsistence crops, cash crops and the livestock sector. Areas already facing water scarcity are predicted to become drier and thereby cause associated disputes and conflicts. The Eastern African highlands are also vulnerable to a range of climate-sensitive diseases including malaria, dengue fever, meningitis and rift valley fever-whose increased incidence and spread is driven by climate variability and will affect livelihoods.

FAO-Sida supported pilot project 'Strengthening capacity for climate change adaptation in land and water management' was a targeted intervention to strengthen community and individual producers for climate change adaptation using differing institutional training mechanisms from government to NGOs, depending on the respective country. The expected outcomes were to improve productivity, food security and livelihoods as well as building communities' and farmers' resilience to increasing weather variability and climate change.

This publication presents the results of the project activities in Ethiopia, Kenya and Tanzania, which are in line with many of the core principles identified by FAO-Adapt (FAO, 2011a) such as focus on food security, mainstreaming climate change into local and community development, support to country driven process and design and implementation of location-specific adaption activities.

The increase in resilience to climate change is being achieved through adoption of technologies which improve soil health and fertility and facilitate water conservation, through better diversification of sources of livelihood and income, and backed by strong institutional networks. From these pilots, it is clear that adaptation should be perceived as a continuum of approaches, ranging from activities that aim to address the drivers of vulnerability to measures explicitly targeting climate

change impacts. It is still early to determine the full effectiveness of the activities, but even within the short project period (two years), the findings show improvements in food security and livelihoods, which contribute to increasing the farmers' resilience to climate change.

This analysis of the results identifies which technologies have proved to be better suited to particular regions and agro-ecological zones. It is anticipated that these results will be used to improve the geographical targeting of land and water management techniques as part of efforts to promote farm-level adaptation to climate change.

The pilot experiences from East Africa underscores that a substantial boost in investment is needed to ensure enhanced, more sustainable and more resilient management of an already declining resource base. Adapting to climate change will require even more emphasis than is currently given to improving land and water management through supportive policies, capacity development and investments.

The publication is organized into two parts. Part 1 provides the framework consisting of the priority themes for climate change adaptation identified by FAO-Adapt (notably institutions and policies, sustainable management of land and water and technologies and practices for adaptations). Part 2 provides details of the pilot projects in the form of lessons learned, case studies and case stories, and forms the essential building blocks for Part 1.

Introduction

Why invest in climate change adaptation in Eastern Africa?

Agriculture is the most important sector in many countries of sub-Saharan Africa (SSA) and is central to the survival of millions of people. Most agriculture production in these developing countries is carried out on small land holdings, with approximately 80 percent of poor people in SSA continuing to depend on the agricultural sector for their livelihoods. However, unlike in other regions of the world, agriculture in sub-Saharan Africa is characterized by very low yields due to agroecological features, poor access to services, lack of knowledge and inputs, also low levels of investment in infrastructure and irrigation. In addition, high population growth rates, especially in rural areas, intensify pressure on agricultural production and natural resources, further complicating the challenge of reducing poverty (IFPRI, 2009).

Against this background, the IPCC Fourth Assessment Report (IPCC, 2007) emphasised that Africa is one of the regions that will be hardest hit by the impacts of climate change due to increased temperatures and changes in water availability. African governments now are placing top priority on adaptation, while at the same time recognizing the co-benefits and synergies with mitigation (Dejene and Malo, 2010).

The livelihoods and food security of the small-scale farmers of SSA are particularly threatened by climate change (including increasing weather variability and frequency of extreme events), as it is already having direct impacts on agricultural production and productivity (Malo *et al*., 2012). Climate change could cause serious deterioration of rural livelihoods and increase food insecurity in SSA. Given these multiple challenges, the region's small-scale farmers and pastoralists must adapt, in particular by adopting technologies to increase the productivity, the stability and the resilience of their production systems.

Action now is thus considered prudent insurance. Although it ought to first be based on farmers' understanding of the climate change evidence, experience demonstrates that small-scale farmers are not so much bothered by questions related to cause and effect, but rely more on their own perception and awareness of changes, specifically of season to season variations. Resilience, the capacity to anticipate, absorb, accommodate, or recover from the effects of hazardous events, is key to sustainable agricultural development in sub-Saharan Africa in the face of climate change.

Despite uncertainties on the directions and amplitude of climate changes, there is significant information and scientific evidence that indicates an increase in average temperature and in climate variability in the semi-arid tropics, with subsequent increases in the occurrence of droughts, floods and heat waves that affect people, their crops and their livestock (IPCC, 2001 and 2007).

Predictions of future climates for the countries of Eastern Africa vary, with high altitude areas of Ethiopia potentially benefiting from warming temperatures. However, without adequate adaptation measures, most of the region is likely to be deleteriously affected by rising temperatures leading to increasing rates of evaporation and transpiration, changes in the timing and reliability of rains, and, in many areas, an increase in the intensity of rainfall events and in the frequency and duration of droughts. Some of these changes are already being experienced across the region, others are predicted in the near future (Thornton *et al,* 2006; GoE, 2007; FAO, 2010; Oguge *et al*, 2011; World Bank, 2013).

IPCC (2007) notes "African farmers have developed several adaptation options to cope with current climate variability, but such adaptations may not be sufficient for future changes of climate (high confidence)".

The African leaders at the Copenhagen Climate Conference in December 2009 (UNFCC, COP-15) highlighted that adapting to the effects of climate change is the highest priority for Africa. This was reiterated by the African Conference on Agriculture, Food Security and Climate Change (Addis Ababa, 6-8 September 2010) and again at the Global Landscape Forum at COP-19 in Warsaw (November 2013). The call for action is reinforced by consideration that adapting to current increasing weather variability is likely to be the best initial step in preparing for future climate change.

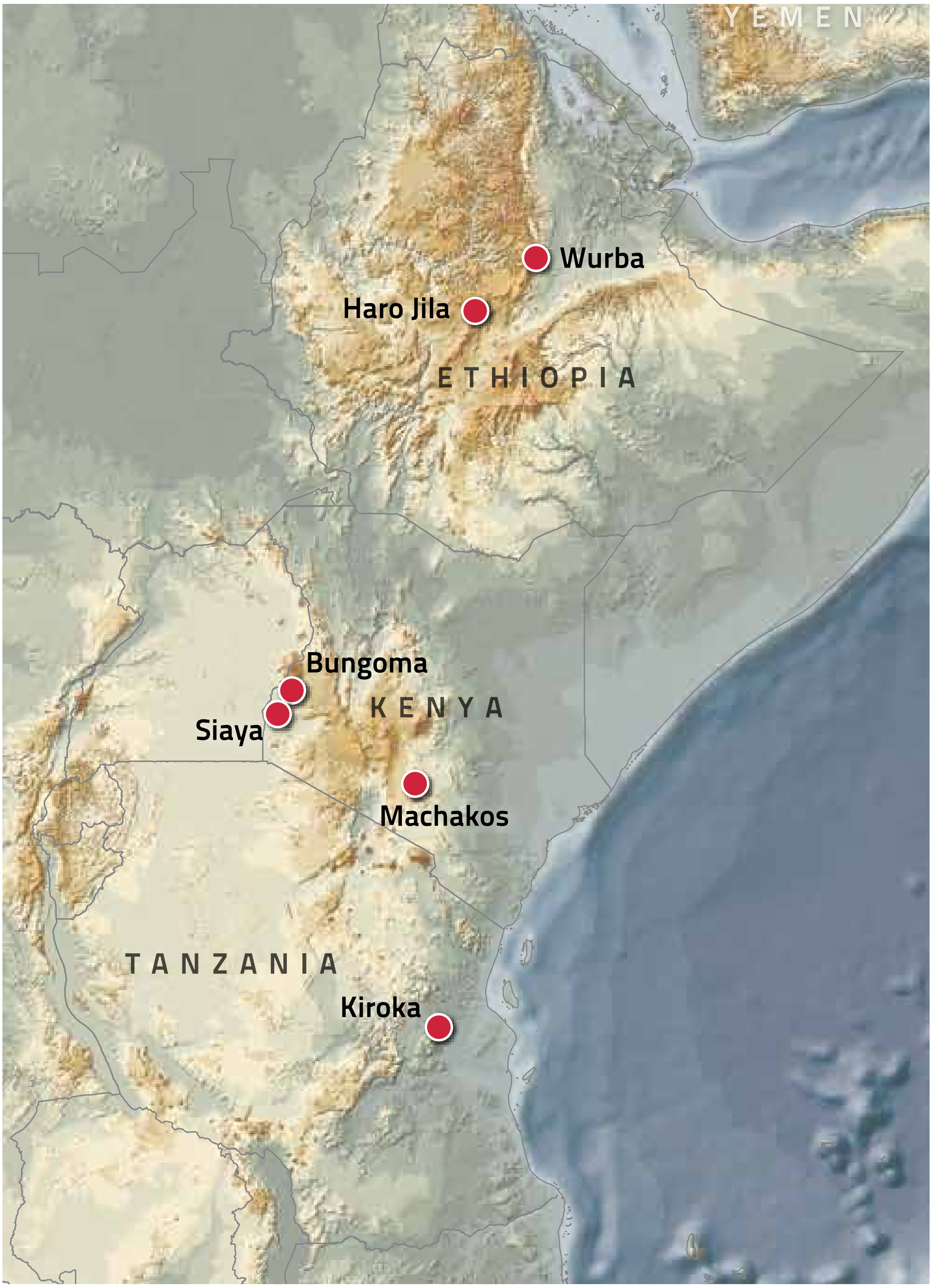
The project

In response, this project, facilitated by FAO and funded by Sida, was launched in 2011 in the three East African countries of Ethiopia, Kenya and Tanzania (Figure 1). The project aims to build and strengthen the capacities of small-holder farmers who are already caught in the vicious cycle of "poverty, food insecurity and natural resources degradation trap" to adapt to climate change, and thus decrease their vulnerability to the negative effects of the latter. The project responds to a demand from the ground to address the conditions of extreme vulnerability of local populations.

In the pilot sites (named in Figure 1), the project moved a step forward from seeking public understanding or appreciation on climate change to engagement, a process in which the farmers got to speak, plan and act. The project piloted activities in major food production and livelihood systems in highland and lowland areas of the three countries to test the potential of various practices and technologies to contribute to climate change adaptation. This is in recognition that climate conditions vary with altitude, landscape and livelihood conditions and that it is thus important to test technologies for climate change adaptation in various situations.

Although the full set of adaptation possibilities that are required in the long term under a particular climate change scenario at the community level are yet to be understood and tested in the context of agriculture, it is largely accepted that

Figure 1: Map showing the location of project pilot sites



improved management of land, water and agro-inputs would likely constitute a fundamental part of adaptation practices. Therefore, ensuring sustainable use of natural resources, such as soil, water and other resources, is crucial for strengthening capacity for climate change adaptation.

Many win-win solutions exist within the broader range of sustainable land and water management technologies (TerrAfrica, 2009; FAO, 2013a). Traditional as well as innovative practices, including those that are technically, ecologically, economically and socially sound, need to be tapped into.

The project focuses especially on identification, testing, demonstration and dissemination of best practices and technologies for soil and water management (better soil health / fertility and improved water management), as well as on water harvesting techniques which should help small-scale farmers to adapt to climate change.

This analysis of the results of the pilot projects seeks to identify those technologies that decrease crop and livestock production risk in particular regions and agroecological zones. It is anticipated that these results will then be used to improve the geographical targeting of land and water management techniques as part of efforts to promote farm-level and wider catchment or watershed adaptation to climate change.

To contribute to increased resilience, these practices are accompanied by a diversification of sources of livelihoods, to take full advantage of the available land and water resources and mitigate risks. Diversification is thus a crucial element for adapting to the negative impacts of climate change.

Finally, sustainable increase in resilience can only happen if and when farmers have the knowledge and capacity to organise themselves in response to climate change. Strengthened rural communities and the institutions that serve them therefore become central to climate change adaptation programmes.

Specific country context

Ethiopia

Smallholders in Ethiopia generally face widespread problems related to inappropriate cultivation, overgrazing and deforestation, resulting in soil erosion and soil fertility decline, water scarcity, lack of pasture and livestock feed, and fuel wood crisis. This vicious cycle of "poverty, food insecurity and natural resources degradation" is driven by population growth but is being exacerbated by increasing weather variability and climate change, requiring urgent action and different approaches in the drylands and highland areas.

Increasing weather variability and climate change are contributing to land and natural resource degradation by exposing soils to extreme conditions and straining the capacity of existing land management practices to maintain resource quality (Malo *et al*, 2012). Results include degradation of vegetation cover and loss of biodiversity, soil erosion, depletion of organic matter, reduced rainwater infiltration and water holding capacity of the soil and loss of productivity and effects on wider ecological functions.

In degraded watersheds, opportunities for water harvesting and management are few and of limited use; access roads are continuously damaged by runoff and erosion, access to clean water for domestic use is very difficult and incidence of water-borne diseases is very high. Unstable watersheds induce unstable production systems and inefficiency of input utilization, as erosion and inefficient use of rainwater also undermine efforts to enhance productivity.

Increased vulnerability to drought and food insecurity is directly linked to the degraded conditions of the watershed and their effects on limiting its capacity to support local livelihoods. The opposite occurs with protected and well managed watersheds, which generate multiple positive effects on people's livelihoods, the environment and for the overall economy of the area.

Kenya

Climate change is already having profound impacts in Kenya and there is great concern that the fragile ecosystems (humid/sub-humid and drylands areas) will undergo noticeable changes with profound effect on rural communities. This requires urgent action and approaches, notably in the arid and semi-arid agro-ecological zones and some of highland humid areas.

Agriculture is affected and contributes to climate change in various ways. Smallholder farmers, who form the majority of agricultural producers in Kenya, are highly vulnerable due to these changes. In 2011, for instance, maize production in Eastern Province dropped by 8% due to a poor harvest caused by early cessation of the 2011 short rains, attributed to changing climatic conditions.

Kenya has incorporated climate change adaptation strategies in its national planning documents. The climate change adaptation strategies pursued in Kenya have been classified as short-term and long-term measures. Some of the short-term measures include implementing a duty waiver on imported maize, conserving water, irrigation, constructing cattle troughs in various parts of the country for watering animals, providing seeds and fertilizer to farmers to improve production, implementing programs that provide emergency food supplies to vulnerable people, and providing emergency relief to hard-hit livestock keepers during drought season. Some of the long-term measures include sensitizing communities about efficient and effective use of water, supporting and encouraging the use of rainwater harvesting techniques, de-silting or building new water pans / dams, and adopting energy-saving technologies.

The project was launched to address these challenges by strengthening the capacities of small holders in vulnerable agro-ecological zones in the management of land and water resources. The project was based on the tenet that smallholder agriculture can be enhanced and transformed by increasing productivity of crops and livestock through application of sustainable land management (SLM) approaches, notably using rainwater harvesting technologies, soil conservation measures, applying conservation agriculture principles and including agroforestry/afforestation in crop-livestock systems in the cultivated watersheds.

The four counties selected for the implementation of project activities cover a rainfall gradient from semi-arid (Machakos and Embu), to sub-humid (Siaya and Bungoma).

Tanzania

Agriculture in Tanzania is mostly rainfed and thus the success of activities in the sector remains highly sensitive to weather, especially rainfall. Over the last four decades, Tanzania has been hit by a series of severe droughts and flood events. The observed increase in variability in Tanzania has increased the uncertainty in seasonal rainfall prediction. The increasing weather variability and climate change are calling for actions to overcome the resulting challenges and provide accurate and reliable weather and climate predictions that will enable the agricultural sector not only ensure food security of the majority of the population but also help them get out of poverty, which is in line with Tanzania's Vision 2025 and Kilimo Kwanza Policy.

Like many other parts of Tanzania, the project's pilot village of Kiroka is seen to be vulnerable to environmental change, particularly climate change. Such vulnerability is reflected in various impacts on food security, livestock and human health. Sound adaptation mechanisms are needed to address the consequences of climate change on agricultural production, food insecurity and health, which cause stress factors that affect livelihoods in rural communities such as Kiroka.

There is a considerable potential for both rainfed and irrigated agriculture around the project village of Kiroka. In the lowlands, the soils have good water holding capacity and remain moist for a long period during the dry season. There is also abundant water supply, good road access, markets (Morogoro and Dar es Salaam) are close and there is high market demand. Despite this, potential, land degradation (soil erosion, loss of soil fertility and bush fires) is widespread in the highland areas. One of the main reasons is that the poor land husbandry is being exacerbated by increasing weather variability and climate change. Furthermore, during the dry season, there are water shortages due to poor management of the water sources. In contrast, during the rainy season, flooding is experienced in the lowlands, causing damage to property and crops.

Climate change adaptations in watersheds or wider river basin systems rely to a great extent on encouraging upstream and downstream farmers and other land users and stakeholders to be partners in watershed / river basin management. Knowledge and practice to improve upstream and downstream management is available and needs to be implemented systematically. It is therefore important to strengthen the capacity of farmers in the upstream part of the catchment and the irrigation scheme downstream for climate change adaptation through enhancing land and water management both on-farm and in the wider landscape, increasing agricultural productivity through improved technology and more integrated farming systems and encouraging farmers to diversify their livelihoods. These should be backed up by strengthened local institutions to plan and respond to change.

FAO-Sida Intervention Options

With due consideration to the existing biophysical and human systems, the project teams selected a set of adaptation options based on land and water management and tested their on-the-ground effectiveness in strengthening land users' capacity to adapt. Particular attention was paid to identifying and promoting effective 'no-regrets' activities after the baseline context of selected sites were understood, through participatory planning with community members and stakeholders. Adaptation activities were selected with consideration for mitigation, though this was not directly targeted.

The project identified the following critical elements in strengthening capacity to adapt to climate change:

(i) *Increasing Soil Health:* In the selected sites, the project targeted building, boosting and managing healthy soils through soil and water conservation measure and practices aimed at increasing productivity on-farm and optimising the use and management of land and water resources at the catchment or watershed scale. As increasing weather / climatic variability and erratic rainfall or prolonged periods of drought are likely to reduce yields, any increase in productivity through better soil health and fertility will serve to moderate the impact of climate change on agricultural productivity. Moreover the risk of soil erosion, crop damage and flooding from increased rainfall intensity and storms can be moderated through catchment or watershed management, which optimizes and diversifies land use according to the terrain, enhances vegetation cover, rainwater capture and infiltration, and ensures safe discharge of excess runoff water in waterways and low-lying land.

(ii) *Water Conservation:* Substantial action is required in the case of sub-Saharan Africa to ensure water harvesting, storage and improve use efficiency of an increasingly variable resource. Adapting to climate change requires even more emphasis than is currently given to improving water management in both rainfed and irrigated systems. The project encouraged rainwater harvesting, provision of more water storage facilities to reduce exposure to dry spells, improving rainwater infiltration into soils and greater water use efficiency.

(iii) *Livelihood Diversification:* Capacity to cope in harsh climatic conditions and uncertain markets calls for diversification of farming systems. Better soils and water harvesting are the basis for enhanced diversification. The improved resource base (land and water) allowed building of assets through fishing, fruit growing, cover crops and crop diversification that support better diets and nutrition, while enabling more farmers to engage in marketing of cash crops, among other activities.

(iv) *Strengthening Local Institutions:* The project invested to create a mosaic of partners working together to leverage investment as a key component of adaptation strategies. With climate change, management of natural resources becomes more complex and involves more people, perspectives and specialized knowledge. The project worked directly with the Ethiopian Government, the Kenya Agriculture Research institute (KARI), Tanzania's Ministry of Agriculture and Food, Morogoro Country Council, Sokoine University in Tanzania and three local NGO's: INADES Kenya, Rangala Family Development Program (RFDP) and Community Research in Environment and Development Initiatives (CREADIS).

Linkages with FAO-Adapt

The project followed many of the core principles of FAO-Adapt (FAO, 2011a). FAO-Adapt is FAO's integrated framework programme which aims to expand work on climate change adaptation that proposes a multidisciplinary approach, builds on current activities and is consistent with the legal and political framework of the United Nations Framework Convention on Climate Change (UNFCCC) and the scientific work of the Intergovernmental Panel on Climate Change (IPCC). FAO-Adapt serves a double purpose. First, it systemizes the adaptation activities currently underway across the organization which serves to ensure that all efforts can move ahead toward a clear and unified goal. This, in turn, enables FAO to present a comprehensive body of work to the outside world – as it seeks support to expand its adaptation activities in response to the increasing needs of member countries.

The following are the core principles which guide FAO-Adapt (FAO, 2011a), and which have been used in shaping the activities of the project:

- Focus on food security;
- Mainstream climate change into development;
- Support country-driven processes;
- Build synergies between adaptation and mitigation;
- Promote ecosystem approach;
- Design participatory, gender-sensitive and location-specific adaptation activities;
- Deliver through partnerships and as ONE UN;
- Support transboundary collaboration;
- Develop a long-term programmatic approach.

FAO-Adapt consolidates five global priority themes and related actions that support adaptation. These themes and actions have been identified through analyzing adaptation needs in the agriculture, forestry and fisheries sectors at different scales:

- Data and knowledge for impact and vulnerability assessment and adaptation;
- Institutions, policies and financing to strengthen the capacity for adaptation;
- Sustainable and climate-smart management of land, water and biodiversity;

- Technologies, practices and processes for adaptation;
- Disaster risk management.

The watershed management approach was employed as the strategy for setting-up the various adaptation measures, aiming for an integrated approach at landscape and community level. Although in the short time-scale of the project this was not fully attained, the ideal would have been an integrated institutional response based on watershed or basin-wide planning that incorporated both integrated land and water resource management approaches and other components of spatial planning, such as planning for infrastructure and other rural development activities. Where this was obtained, to some extent in Ethiopia and partly in Tanzania, the advantages in terms of outcomes were clear.

Activities were identified through working with communities and stakeholders to locate alternative designs or management practices that may enable land users to better cope with increasing weather variability and climate change.

Options for adaptation were defined at the level of farm or catchment, dictated by the local context. The emphasis was on finding measures that increase resilience to climate change, but still make sense under the current weather patterns (i.e. 'no regrets' options). Activities selected were integrated but ranged from sustainable land management technologies to capacity building and policy development, to the introduction of new practices (see Table 1).

This publication is divided into two parts:

Part 1: Project Findings - an analysis of the results according to the four Pillars of the project, namely:

Pillar 1: Increasing Soil Health;

Pillar 2: Water Conservation;

Pillar 3: Livelihood Diversification;

Pillar 4: Strengthening Local Institutions.

Part 2: Country Case Studies - details of the results of the pilot projects, compiled by local project staff in the form of lessons learned, case studies and case stories, organised in groups according to the country of implementation.

Table 1: How the project relates to the themes of FAO-Adapt

FAO-Adapt Themes / FAO Sida Project Pillars	Pillar 1 Soil Health	Pillar 2 Water conservation	Pillar 3 Livelihood diversification	Pillar 4 Institutional strengthening
Data and knowledge[1]				
Institutions, policies and financing for capacity development	▪ Limit deforestation and forest fires.	▪ Develop zonal water conservation and demand management strategy.		▪ Initiate South Sudan National Adaptation Plan (NAPA). ▪ Enhance capacity of agriculturalists in adaptation planning.
Sustainable management of land, water and biodiversity	▪ Introduce minimum till practices, cover crops and rotation cycles (CA). ▪ Terracing.	▪ Terracing. ▪ Pond construction ▪ Rain water harvesting. ▪ Terracing.	▪ Develop national climate change adaptation manual for use by extension staff.	▪ Develop watershed management plans at community level. ▪ Build knowledge and capacity on adaptation. ▪ Build knowledge on rangeland management in a changing climate.
Technologies, practices and processes		▪ Construction of lined water ponds. ▪ Introduce the System of Rice Intensification (SRI). ▪ Introduce energy saving stoves.	▪ New disease-resilient chicken breeds. ▪ Construction of fish ponds. ▪ Modify hand held weeders for new system of rice intensification ▪ Develop aquaculture. ▪ Introduce or improve new fruit varieties -pineapples and bananas	
Disaster risk management	▪ Watershed management	▪ Watershed management		▪ Develop watershed management plans at community level.

[1] Data and knowledge are difficult to document systematically in pilot activities of few years but they remain an important area for future activities on adaptation.

Part 1
Project Findings

A Planning Framework for Adaptation at the Local Level

The growing body of literature on climate change contains what may be regarded as a bewildering array of terms: vulnerability, sensitivity, resilience, adaptation, adaptive capacity, hazard, coping, adaptation etc. (IPCC, 2001; Adger *et al*., 2003; Burton *et al*., 2002) (see Glossary). The relationships between these terms are often unclear and the same term may have different meanings when used in different contexts and by different people. Despite almost 20 years since the ratification of the UNFCCC[1], as of today, there is no universally accepted definition of these terms and of the relation between them (Gallopin, 2006).

[1] UNFCCC entered into force on 21 March 1994

Figure 2 presents a framework that offers the advantage of clearly indicating the key elements that contribute to the impacts of climate change on rural populations and therefore the different points of entry for action. In this case, vulnerability is understood as being related not only to the actual changes in weather and climate, but also the degree of exposure, the sensitivity of people's livelihoods – and their adaptive capacity, which is understood as "the ability of individuals and communities to anticipate, deal with and respond to change – both changing climate and development pressures – while maintaining (or improving) their wellbeing. Adaptive capacity refers to the potential of individuals and societies to respond to change" (ODI, 2011).

Adaptive capacity represents the set of both biophysical and socio-economic factors that determine people's ability to cope with stress or change in terms of the likelihood of occurrence and impacts of weather and climate related events (Nicholls *et al.*, 1999).

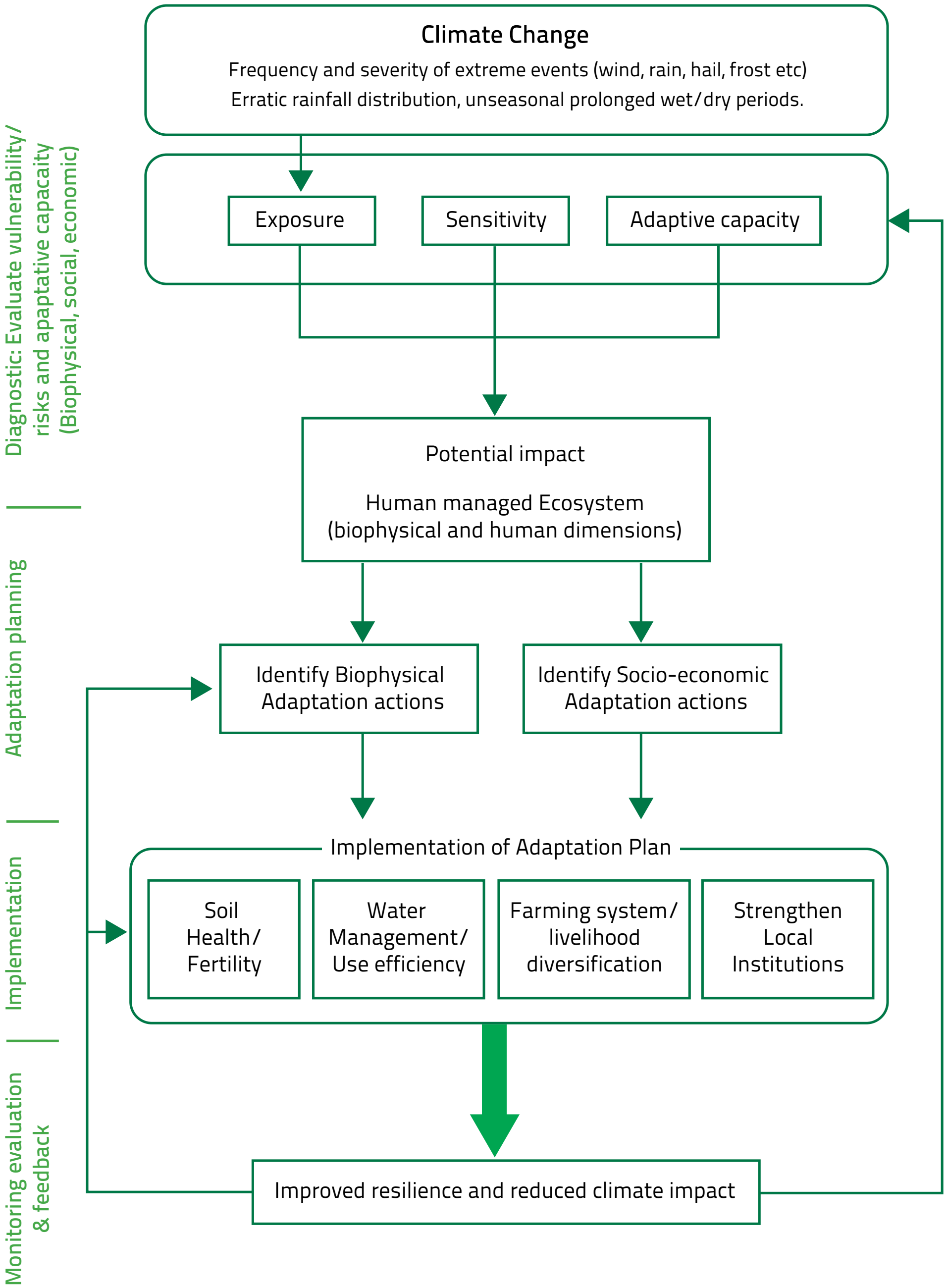
The Sida-FAO project viewed adaptation as a process focused on reducing vulnerability, which involved building adaptive capacity, particularly of the farmer, from an array of dimensions with land and water as a focal point. It described adaptive capacity as the ability or capacity of farmers to modify / change their behavior or actions so as to cope better with existing or anticipated changes in climate conditions.

The project adaptation planning required both an understanding of vulnerability and identifying where resilience could reside in each given farming system. This was analysed within the existing context in target villages in Ethiopia, Kenya and Tanzania to understand when and how resilience has/can be lost or gained. Existing biophysical and human systems were analysed to identify the possible points within the small-scale agriculture systems where interventions could increase human- managed system's resilience.

Pillar 1: Increasing Soil Health

Soils are formed over long periods of time (FAO, 2013a). They are made up of differing proportions of weathered rock, decayed plant and animal matter and a diversity of living plants and animals. Due to differences in local geology, topography, climate, vegetation and human management often over thousands of years,

Figure 2: The logical framework used for adaptation planning and implementation



soils are highly variable, both across landscapes and in depth. The diversity and abundance of life that exists within the soil is greater than in any other ecosystem. A handful of soil can contain billions of different organisms that play a critical role in maintaining soil structure, health and ensuring functioning, including incorporation and break-down of organic matter, which enhances soil and makes available nutrients for plant uptake (ibid.).

Soil health is a function of its capacity to provide the basic services for supporting plant growth and contributing to the regulation of nutrient, water, carbon and gaseous cycles. Soil health is widely linked to soil biodiversity.

Widely today soils are degraded due to repetitive tillage and cultivation over decades, with reduced or no fallow periods and removal of most organic matter after each harvest for fodder, forage or fuel, leading to a progressive diminution of soil organic matter (SOM) and essential nutrients for plant growth. Thus after each harvest most plant materials (that are largely made up of carbon and nitrogen) are removed from the land. As these have not been replaced over recent decades through appropriate organic matter management (addition of compost and / or manure), soils have become degraded, leading to declining productivity (due *inter alia* to soil acidification, loss of soil organisms and their biological functions that breakdown SOM, poor nutrient recycling, damage to soil structure and moisture infiltration / holding capacity) as plant growth is compromised. These degraded soils are prone to increased rates of runoff of valuable rainwater and as a result erosion of topsoil.

With climate change, rainfall levels are expected to decline in many places or to occur in more intense events, while both evaporation and transpiration rates are projected to increase (FAO, 2013a). These changes will reduce the availability of soil moisture for plant growth. The higher temperatures will also increase the rate of SOM decomposition, especially near the soil surface, which will affect the soil's potential capacity to sequester carbon, retain water (ibid.) and supply vital nutrients to plants. Figure 3 shows a farmer hand tilling his soil, which has been the traditional method of preparing land for planting by small-holders – but is now recognized not only as a very onerous task but also as opening up the soil to these degradation pressures.

There are already adapted proven land management practices which enhance the ability of soils to store nutrients and water (FAO, 2013a; TerrAfrica, 2009), improving soil health and thereby reducing the impacts of changes in weather and climate. Practices such as reduced tillage, improved soil cover and rotations that replenish soil organic matter and nutrients are associated with conservation agriculture systems. These practices when integrated and adapted to the farm-household context, can build resilience in farming systems and reduce vulnerability to climate or other shocks, and their widespread adoption has the potential to make major contributions to the achievement of food security local and national levels and to development goals.

The project has provided examples of how with relatively low-cost changes in management, the degraded soils in pilot areas are being restored, contributing to increasing crop / livestock yields and community resilience to the potentially adverse effects of climate change. This integrated management can provide optimum physical and biological conditions for crop production (food, fibre, fodder and trees).

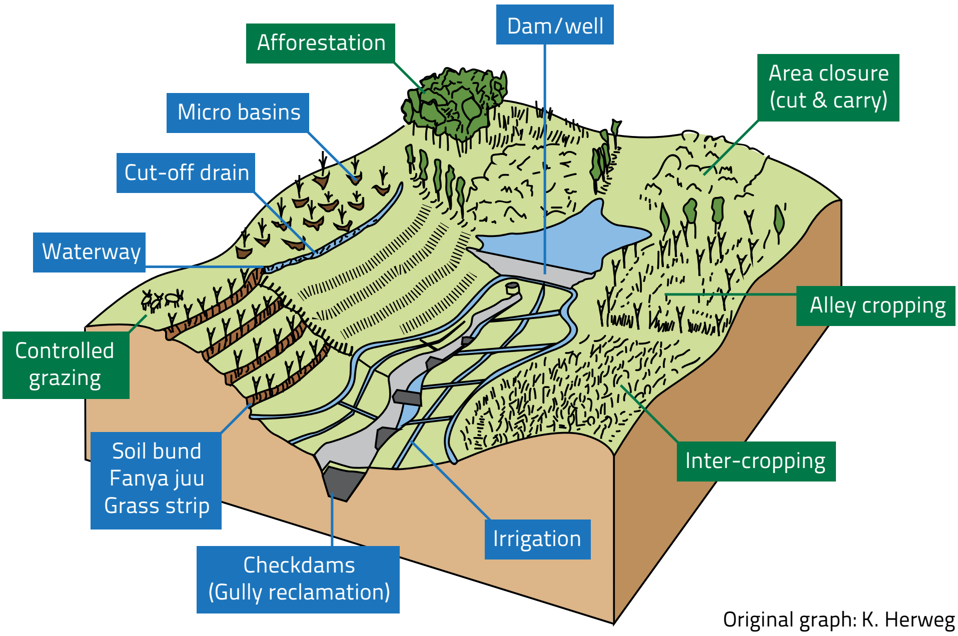
Figure 3: Land user in Kenya using traditional methods to till his soil

Photo: ©FAO

In grazing systems, SOM can be increased through controlled grazing, which reduces vegetation degradation and restores grassland diversity and productivity. Reducing burning to the absolute minimum also increases SOM, enhancing moisture holding capacity and contributing to climate change mitigation.

In **Ethiopia**, the project adopted a participatory integrated watershed management approach (see Figure 4) including a range of sustainable land management technologies to improve the health of the degraded soils and make more effective use of rainwater across the pilot watersheds. The lands of the **Wurba watershed** in **Shoa Robit Woreda** are associated with water scarcity, land degradation, deforestation, leading to decreased agricultural and pastoral productivity, also over-utilization of natural resources (Ethiopia Paper 1). A wide spatial variability in different forms of land degradation was noted within these watersheds. In most cases, the poor land is located at higher elevations within the watersheds, where the land is sloping and is less productive because of accelerated erosion. The low water holding capacity of the shallow soil at upper levels results in poor crop emergence and requires the crop to depend on unreliable frequent rains

Figure 4: Watershed planning considers the interrelations and combined effects of various measures



Original graph: K. Herweg

throughout the growing season. On lower slopes, overall rates of erosion seem lower – although gullies have formed in places, resulting in highly concentrated areas of high soil loss.

Some of the decisions taken by the communities like area closure works are taking effect, while the soil and water conservation works demonstrated and adopted by communities are showing improvements, reducing erosion from uplands. Good survival rates of the planted trees and forage seedlings and growth of grasses on areas that are being rehabilitated at both sites seem to be further motivating the farming communities to make efforts to change their environs. Similar activities in farm lands to improve productivity such as intercropping, crop rotations, composting and livelihood diversification activities like beekeeping, poultry farming and more commercial small ruminant systems that contribute to additional income generation were also motivating the communities.

The project-catalysed community-based integrated and participatory watershed development planning approach to land and water is currently enabling the farming communities to cope with the threat of increasing weather variability and climate change, and is expected to make their activities more resilient in the future.

The situation in **Haro Jila** watershed, Sebeta Woreda differs, as the area is becoming more prone to unpredictable floods (Ethiopia Paper 2). However, again area closure is being used to protect and restore the health of 250 ha of highly degraded land, which the community agreed to fully close to humans and livestock. Within the short period of the project, natural vegetation had begun to regenerate and the planted trees have begun to restore the forest cover.

The interventions to cope with the flooding also required physical works outside the closure area, including: the construction of soil and stone-faced bunds along the contour on the hillside (35 km); waterways (5 km) and cut-off drains (10 km); check dams (5 000 m^3); micro-trenches (5 000 m); percolation pits (150); ponds (2); fanayu-juu (6 km); 1 spring development for gravitational irrigation; and 3 micro-ponds for supplemental irrigation with treadle pumps. A substantial change was noted soon after the project started in agricultural productivity, attributed to the increased soil moisture retention and conservation of top soil.

Before the project, in the highland areas of **Kiroka village, Tanzania,** land users were not following good land husbandry practices. Despite steep slopes, farmers practice flat cultivation of maize, cassava, bananas and horticultural crops without any form of soil and water conservation (Tanzania Paper 2). This had led to soil erosion, loss of soil fertility and low crop production leading to food insecurity at household and local levels, also drying-up of rivers due to the loss of valuable rainwater as runoff and limited recharge of the groundwater. Uncontrolled bush fires in the highlands are rampant, especially during dry seasons. The causes include: slash and burn during land preparation; harvesting of wild honey; charcoal making; and hunting of small game. As a consequence, the land was left bare without any vegetation cover thus exposing it to the vagaries of weather.

However, according to the results of the baseline study, many farmers in **Kiroka village** reported that there was a great demand for conserving soil and water in their villages (Tanzania Baseline Paper). Farmers suggested they were interested in learning about afforestation, environmental conservation, avoiding bush fires, also avoiding farming along water courses, which they understood should be done in order to conserve soils. Moreover, they said that laws ensuring environmental conservation should be more strictly enforced and penalties should be given to people who break them.

Farmer field schools (FFS) (Tanzania Papers 1 and 2, also see FAO, 2013b) were set-up as a learning-by-doing approach to train groups of interested farmers in differing SLM technologies. The training was also reinforced by study tours to nearby areas where farmers were already practicing the technologies.

Rice is a staple food in **Kiroka village** and before the introduction of the system of rice intensification (SRI), yields were low, averaging between 1.35 and 2.3t/ha (Tanzania Paper 1). Various constraints contributed to these low rice yields, including: shortage of water: poor water distribution and management; and low use of improved technologies. Shortage of water was caused by environmental degradation and encroachment by farmers on water sources, leading to drying-up of rivers and streams. In addition, the irrigation infrastructure is not fully functional.

The system of rice intensification (SRI) was introduced using the FFS approach (FAO, 2013b), as a means of addressing these constraints. A total of 50 farmers were trained on SRI practices. Of the fifty trained farmers, 74% adopted the SRI technology. Yield data recorded in the 2012/2013 cultivation season (December-June) showed an increase in rice yield from farmers' plots from 1.65 t/ha without SRI to 11.6 t/ha with SRI. Apart from grain yield, there was also increased biomass yield. The biomass yield is illustrated by improved root development, which will contribute to increased resilience to drought and longer-term soil health.

In recognition of the importance of reversing the wider landscape-level land degradation caused by cutting of trees for fuel, resulting in alarming rates of deforestation, the project also introduced to villagers in **Kiroka** clean burning, energy efficient stoves to replace traditional inefficient cook stoves. Householders were trained to make and use their own affordable energy saving stoves, cutting consumption of firewood and charcoal, which will reduce the pressure on natural forests and trees in the landscape. In addition, this component of the project is reducing air pollution in houses and improving the health condition for women and children.

In **Kenya**, the project particularly encouraged farmers to restore gullies to increase the land available for food production. Through relevant training on reclaiming gully land through building of gabions, agroforestry and other better farming practices, participating beneficiary farmers have been able to rehabilitate and recover eroded gullies. The reclamation efforts varied from farmer to farmer, however there were common measures that contributed to the success, notably the use of hardy yellow sisal varieties, and stone rows and gunny bags to stabilize the soils and check the run-off speed. In an effort to ensure sustainability of these reclamation practices, farmers have been using a combination of locally available materials such as tree logs, branches and stones to construct barriers across the gullies. The efforts have greatly rewarded the people who are not only able to reclaim land for arable use but also hold the river-bed sand and retain water, which they use for domestic purposes and livestock.

A major on-going challenge for the work in **Kenya** is the disorderly sand harvesting practice which is still being carried-out by a number of farmers across the watersheds. This challenge drags back the reclamation effort of the rest of the community members and is a great discouragement to the members of the community in working to restore gullies. In some regions the yellow sisal variety that the farmers have been using to recover the land has also recently suffered a severe attack from a certain, currently unidentified pest. This variety of sisal has been more effective in the reclamation practices due to its prolific and hardy nature, but the new adversary is posing a serious threat to its survival in the region. Taking a community-based approach as opposed to a group approach in issues like sand harvesting would be helpful in better assessing problems and identifying viable solutions.

It is believed that land rehabilitation using agroforestry to further check erosion and restore soil organic matter and fertility will continue to contribute to a very large extent to the efforts towards more effective soil and land management. Application of simple and affordable rehabilitation techniques is desirable. Local communities are more likely to adopt simple and cost-effective technologies; making up-scaling to other watersheds easier.

Pillar 2: Water Conservation

Climate change affects directly or indirectly all the elements of the water cycle. An increase in temperature results in an increase in evaporation and evapotranspiration. While there are large uncertainties on the impact of climate change on precipitation, models converge in predicting more variability in rainfall patterns, with increased occurrence of extreme events like intense precipitation or longer periods of dry weather (FAO, 2011b). These two factors contribute to disruption of the water cycle which affects the soil water holding capacity, leading to longer periods of water deficit and more frequent floods.

Such changes will affect rainfed farming, and through increased variations in river runoff and groundwater recharge will also affect irrigated agriculture, as well as livestock feeding and watering. Because of this, the design of climate-proof farming practices needs to be viewed through a *water lens* (FAO, 2013a).

While some changes, like increase or decrease in average precipitation, may become relevant in the long run, temperature increase, and, more importantly, increases in the variability of weather and the frequency of extreme events are already being felt today by farming communities. They are therefore the best entry point for designing climate adaptation programmes.

Indeed, 'no regret options' for climate change adaptation in sub-Saharan Africa (i.e. options that increase the resilience of communities, not only to climate change but to any type of shock) have the highest probability of success both in the short and in the long term. In the semi-arid tropics, vulnerability to water shortage or to the effects of intense precipitation events is likely to be high in rural communities and any action that reduces sensitivity and exposure to these hazards, or increases the capacity to respond or react will have a positive impact on resilience. These options include, in particular, improvements in soil moisture storage, the reduction of the erosive capacity of runoff and all options that help storing water, either in ponds, small reservoirs or in the ground. Interventions need to be considered at different scales, from the household to the watershed.

The variety of water-related interventions in the project sites in the three countries show the centrality of water in developing the capacity of communities to adapt to climate change and increase resilience to climate-related shocks. In **Wurba watershed, Shoa Robit Woreda** (Ethiopia Paper 1), most interventions have focused on water. They include practices that retain the surface runoff in the uplands and improve water holding capacity of the soil, also practices that increase groundwater recharge and protect the top soil. This was achieved by constructing hillside terraces with trenches, stone check dams on hillside, cut-off drains, trenches and micro-basins.

In addition, water harvesting methods were undertaken in an attempt to reduce the number of months without water and diversify livelihoods (Shoa Robit). This included excavation of ponds on homesteads and farm land, lined with geo-membrane, in which water was stored and used for domestic purposes, to water animals and for horticulture (Figure 5). The project also provided cisterns for rooftop water harvesting, as no source of water is available locally during the dry

Figure 5: Pond constructed during the project in Shoa Robit Woreda, Ethiopia

Photo: ©FAO

season. These interventions have decreased the time and labour required to fetch water, while also increasing the household income through the availability of high value horticultural products.

Similar activities have been carried out in **Kenya**, where small lined ponds have provided opportunities for diversification, both through crops and livestock. In all cases, water storage is seen by the population as a major improvement in their livelihood and protection from climate variability.

Protection against erosion is also key to better water control and reduced expo-sure to the impacts of intense precipitation events. In **Haro Jila watershed, Sebeta Woreda** (Ethiopia Paper 2), an area of 250 ha in the upper part of the watershed was fully closed and protected from any intervention, in particular livestock grazing. Combined with a mixed of biological and physical interventions (including soil bunds on hillside, cut-off drains, check dams, micro trenches, percolation pits and the planting of indigenous and exotic drought tolerant tree varieties), it resulted in substantial reduction in gully erosion and downstream flooding. Better infiltration will be contributing to the recharge of local groundwater, showed by a subsequent increase in the number of springs and much longer periods of base-flow in the local watercourses, offering new opportunities for irrigation for the farming communities in the lower part of the watershed.

Similar results were obtained, although at much smaller scale, in the remote hill-sides of **Mwala in Machakos, Kenya** (Kenya Paper 4), where gully control resulted in reduced damage downstream and the storage of water in small ponds, which is used for domestic purposes and for livestock watering. In Kiroka village, Morogoro Tanzania, tree planting was promoted in order to reduce erosion, increase infiltration and protect springs (Tanzania Paper 2), although results will probably be observed only after several years.

Water is also central to farming in **Kiroko village, Morogoro District, Tanzania**. Here, rice is the staple food, but shortages of water caused by environmental degradation and encroachment of water sources lead to drying-up of water in rivers and streams, resulting in low yield and crop failure. The System of Rice Intensification (SRI) was introduced by as a means of addressing the above constraints. SRI, a package of interventions for increasing rice productivity, includes changes in crop, water and nutrients management (Tanzania Paper 1). With SRI, water does not stagnate in the paddy fields, thus resulting in a substantial reduction in water requirements for irrigation.

In conclusion, water is central to any climate change adaptation programme in most of sub-Saharan Africa. This is particularly true in sub-humid and semi-arid areas, as well as is large parts of mountain areas, where increased variability of rainfall directly affects crop and animal production. In all the project sites, farming communities have stressed the need to be able to store water so as to reduce dependency on increasingly variable rainfall.

Water storage has multiple benefits, not only for crop production and diversification but to alleviate the burden of collecting domestic water supply, also to provide water for animals and for small income generating activities.

Most water-related interventions are planned in the broader framework of watershed management. Watershed management is the integrated use and management of land, vegetation and water resources in a geographically discrete catchment or drainage area through people-centred approaches with all stakeholders, for the benefit of residents and wider society, through enhancing productivity and livelihoods and maintaining the range of ecosystem services, in particular the hydrological services that the watershed provides, and reducing or avoiding negative downstream or groundwater impacts. FAO proposes 12 principles for successful watershed management (Box 1).

Box 1: FAO's 12 key principles for successful watershed management

1. **Treat underlying causes** (not just symptoms)
2. **Generate scientific evidence** (soil health, water quality, biodiversity effects, climate effects and resilience)
3. **Adopt an integrated approach** (multi-sector and multi-stakeholder)
4. **Ensure holistic planning and implementation** (watershed plan)
5. **Look for co-financing and low-cost interventions** (wider adoption)
6. **Ensure institutional arrangements at all levels** (local-national)
7. **Plan for capacity development at all levels**
8. **Combine bottom up & top down process** (local empowerment; policy)
9. **Ensure gender balance in decision making and actions that lead to better gender equality**
10. **Design support and incentive measures to adopt SLM** (PES, access to finance, investment)
11. **Make monitoring and evaluation an integrative part of the process** (demonstrate multiple benefits and impacts including climate resilience)
12. **Plan for flexible, adaptive, long-term program /partnership**

Source: FAO. 2006. The new generation of watershed management programmes and projects. FAO Forestry Paper 150, Rome.

This participatory, people centred, wider-scale watershed approach requires identification of adapted technologies and investment and policy support for their promotion and wide adoption including:

i) soil and water conservation measures and afforestation in the upper catchment and on steep slopes to optimise vegetation cover, water capture and infiltration for replenishing soil moisture in the plant root zone and recharging the groundwater table;

ii) soil restoration through integrated soil fertility management (organic matter management backed up by fertilizers to address specific nutrient deficiencies), water harvesting and efficient use of water for irrigation, household and livestock use mid-slope and downstream;

iii) protection of waterways and low-lying wetlands for flood control; and

iv) use of a systems approach to diversify and optimise land use according to the soils, terrain and altitude and to sustain the range of ecosystem services (soil health, hydrology -water supply and quality, vegetation cover and biomass, and diversity of habitat, plant and animal species, crop varieties, animal breeds and associated beneficial species (pollinators, earthworms and predators of pests).

The key to successful uptake by farmers and other land users of improved practices both on-farm and across the wider catchment or watershed management requires demonstration of the effective and multiple benefits of watershed approaches in terms of productivity and income, climate change adaptation and mitigation, as well as socio-cultural wellbeing including aesthetics and recreation, tourism and heritage conservation.

Pillar 3: Livelihood Diversification

Smallholders in the pilot areas (Figure 1) and more widely across SSA are highly dependent on subsistence agriculture for their livelihoods. These livelihoods are being placed in jeopardy in the 21st century as increasing weather variability and climate change are affecting yields.

Diversification is defined in FAO (2011c), one of a series of booklets which focus on the subject as: "on farm or non-farm enterprise that can be integrated into small farms to increase incomes and enhance livelihoods". Options for diversification should be selected as being "suitable for smallholder farmers in terms of resource requirements, additional costs, exposure to risk and complexity. The products or services generated by the enterprises are suitable for meeting demand on a growing, or already strong, local market and are not dependent on an export market".

To improve the adaptive capacity of smallholders, the project intervened to assist smallholders in **Ethiopia** to diversify income sources. Seeds for horticultural crops were supplied to 82 households (HHs) (1 kg of tomato, 5 kg of cabbage, 10 kg of carrots) and 40 HHs were supplied with 200 tropical seedlings (mango and banana plantlets). As an additional source of income, poultry raising and beekeeping were promoted amongst female members of HHs by allocating 100 HHs five chickens each and supplying 30 modern beehives to 30 HHs. All these activities are already proving profitable. The practice of fattening small and large ruminants has increased during the project period, as smallholders are now taking the opportunity to use crop residues and waste from high value horticultural crop as feed sources (see all Ethiopia Papers).

In **Tanzania**, the project aimed to provide additional incentives for participatory forest management through encouraging diversification into beekeeping, which is suitable for smallholders as it involves low investment costs and promising high returns in the immediate and longer term (Tanzania Paper 4). The project aimed to train farmers on the principles of beekeeping and how to construct beehives. A two-days training session on the principles of beekeeping was organized for a group of seven farmers (six men and one woman). The training covered the following topics:

- Importance of beekeeping on environmental conservation, food security and income generating;
- How to construct beehives;
- How to attract bees into beehives to establish their colony;
- Economic benefits of bee keeping.

Each farmer is now planning to establish a beekeeping farm with a target for each farmer to start with a minimum of ten beehives. Furthermore, the farmers have established a nursery comprising of 4,000 tree seedlings - of which 72% are indigenous species. These seedlings will be distributed amongst the group members for planting in their individual farms.

Farmers attended a study tour in Lushoto District in Tanga Region to strengthen their learning and it is concluded that such inter-community exchange and mutual learning approaches are important tools for capacity strengthening, as participants can see how planned actions are improving other people's livelihoods. Empowerment at grass roots level goes hand-in-hand with participation and sharing of skills. A case of 'learning by doing' practiced on making beehives has been a success, such that the Kiloka farmers have become trainers and suppliers of beehives to other community members.

The progress attained within a six months period (March to September 2013) has shown positive impacts in the realization of the project objectives. Positive '*lessons learned*' and the '*good agricultural practices*' that have been observed in the course of this intervention will be applied in up-scaling of the project interventions within and beyond the borders of Kiroka village. Wherever applicable, use of cheap and available local resources should be emphasized.

In **Kenya** during a participatory meeting in June 2012, the farmers in the three watershed groups (in Siaya, west Kenya) identified priority crops that would help them achieve both food and income security. This was a bottom-up approach that provided an opportunity for the community to make their own choices. The objective of identifying a preferred enterprise was to use it as an entry point to disseminate appropriate sustainable land and water management options.

Demonstration plots were set up as field schools to promote learning of adaptive technology in banana farming. Banana and fruit tree production were identified by the farmers as the preferred option, partly because their own bananas were diseased and had low levels of productivity. In response, the project invested in several activities to ensure the farmers understood the importance of good management practices in banana production. This in turn would ensure that the banana plantlets provided by the project would actually benefit the farmers in the medium- to long-term.

The practices demonstrated to farmers included:

- Training on tillage practices (minimum tillage);
- Training on cover cropping and mulching for moisture retention and weed control using locally available materials (e.g. Tithonia, maize stovers, grass etc.);
- Training on making compost and appropriate materials to use;
- Training on banana production – preparing the pits for planting, manure and water application, mulching and use of cover crops (e.g. *Tithonia*);
- Run-off water harvesting for banana production;
- Other in-situ water harvesting techniques.

The targeted outcome was diversified sources of income from fruit sales, improved household nutrition and reduced labour requirement once the system was established. By October 2013, over 2,500 disease-free banana plantlets had been distributed to 66 farmers in the three watersheds, with at least 40 farmers in Nyusi watershed group accessing an average of 40 banana plantlets each. The Nyusi group had the highest number of women and vulnerable farmers.

A sample of ten of the farmers who received the banana plantlets were followed-up and showed that in less than two years, the ten have not only kept growing their banana stools, but also been able to sell or given away banana plantlets valued at US$ 600 at an average price of US$ 1.2 per banana plantlet. Those that have given away plantlets gave to neighboring vulnerable farmers, including 200 banana plantlets to a group of physically disabled people within the county.

It is evident that banana production in **Siaya County, Kenya** is a good crop diversification to enhance food supplies and incomes. The farmers, who at the start of the project activities could not adopt most of the simple technologies demonstrated on the demonstration fields, are now able to raise and share plantlets, as well as selling plantlets and banana bunches commercially.

Fish farming proved a very successful way for some farmers in **Siaya County** to increase their sources of income and food security, diversifying their near subsistence livelihoods. Fish is a rich source of dietary protein and selling surplus provides additional income for purchasing food and non-food items.

The land area needed for fish farming is small compared to other farming enterprises. In addition, farmers who also fish farm are now utilizing the water they harvested to irrigate their vegetables during dry periods, which is ensuring a steady source of food and income. In Siaya County, with periodic rainfall, this irrigation does not reduce the water levels needed for fish farming. However, the rainfall in between the rain seasons is often not sufficient to sustain crop production. Hence harvesting water enables the farmers to use it for both fish farming and irrigation.

The farmers who were able to have fish farming as an enterprise were limited to those that have a suitable water source on their farms. Others farmers who had permanent water source, but sandy and highly permeable soils, required expensive lining materials to maintain water in ponds, while others had no access to a reliable water source. Since fish pond excavation was found to be labor-intensive, in cases where ponds were not located in riverine areas, only a few farmers managed to benefit from this project support.

Diversification is not new to smallholder farmers, but its importance is growing and will require timely promotion of increased market participation, which will provide incentives for farmers to spread their risks and intensify their more diverse activities, bringing wider livelihood benefits. Successful diversification (and intensification) can create a buffer against and reduce climatic risks associated with agricultural production and augment income levels, which is needed to make investments that help to reduce dependence on the natural resource base and to conserve it. Diversification can also reduce dependence on risky agriculture and help to employ factors of production more fully (Figures 6 and 7). Wider promotion of market participation will need both infrastructure investments and institutional reforms (Paavola, 2008).

Pillar 4: Strengthening Local Institutions

Farmers are at the center of the process of resilience building. They need to be given the tools and incentives to build stronger and more resilient communities. These tools and incentives rely heavily on better local institutions, capable of giving them the knowledge and helping develop their skills.

Figure 6: Farmer in Kenya benefiting from diversifying to high income crops and other income generating activities

Photo: ©FAO

Figure 7: Smallholder in Kenya marketing produce

Photo: ©FAO

Yet gaps in capacity, knowledge and experience are common in rural Africa, and the dissemination of concepts and experiences on effective adaptive strategies is still lacking in most places (see Tanzania Paper 5). Measures and approaches to help farmers to adopt innovative and climate-smart agricultural practices exist but they are not practiced systematically. Changing the mindsets of farmers to adopt innovation is the most crucial facet that assists the transformational journey.

In the project, a range of practical approaches were used to help land users test-out these novel technologies. These included developing demonstration plots and learning-by-doing / farmer field school approaches. In addition, understanding of the win-win benefits of the new technologies and methods was reinforced with study tours to communities already practicing the technologies. For instance, in **Tanzania**, the project has shown that majority of farmers in Kiroka lacked knowledge on the innovations that are used for reducing the impacts of climate change. In that case, training and field visits have proved to be the most successful approaches to help disseminate adaptive practices among farmers.

In **Ethiopia**, the study tour organized between the two pilot sites has opened the eyes of many farmers who could see and discuss the adoption of adaptive technologies and practices. Although there are substantial differences between the agro-ecological conditions of the two sites, many approaches, and in particular those related to farmers organization, were relevant to both sites.

The same applied to study tours organized by the project between the three countries (one study tour was organized in each country). In each case, technicians and field operators were invited to join yearly project meetings, and were exposed to different approaches to soil and water management. This led to the testing of different approaches when they returned to their home country.

The range of activities to develop land users' knowledge and skills which this pilot has shown to be successfully contributing to building resilient communities include:

- Learning new agricultural skills, including: the system for rice intensification (SRI – Tanzania Paper 1), marketable banana production (Kenya Paper 2); enhancing seed security (Kenya Paper 1); crop diversification towards more drought tolerant crops (Kenya Paper 5); rangeland closure (Ethiopia Papers 1 and 2); and tree planting (Ethiopia Paper 1 and Tanzania Papers 2 and 4);
- Sharing information on the use of SWC / landscape-level approaches, including: integrated watershed approaches to cope with both increased drought and increased flooding (Ethiopia Papers 1 and 2); gully reclamation (Kenya Paper 4); SWC (Tanzania Paper 2); construction of ponds to store rainwater and use it to irrigate horticultural crops (Ethiopia Paper 1);
- Teaching new income generating activities, including: fish farming (Kenya Paper 3); beekeeping (Tanzania Paper 4); building energy saving stoves to reduce fuelwood use and thus reduce pressure on local forests (Tanzania Paper 3).

Another important element of resilience building is local development activities of relevance to the whole community. In the project, communities were encouraged to plan and implement climate change adaptation interventions at wider levels than individual plots (Figure 8), as it is continually found that planning at wider landscape levels can improve ecosystem functioning, for example increasing rain-water infiltration and hence availability of water for plant growth, reducing runoff (overland flow) rates and volume from intense rainfall, which causes erosion and downstream flooding. Catchment or watershed management was found to be most effective where existing land ownership patterns were communal and with a tradition of community work (e.g. Ethiopia), and more challenging to implement in Kenya where the land is privately owned. This latter result is a key finding which should be used to improve the design and targeting of appropriate climate change adaptation approaches in future projects and programmes.

Figure 8: Farmers in Tanzania discussing climate change adaptation among themselves

Photo: ©FAO

Lessons Learned

Climate change is already having deleterious impacts on agriculture and food security as a result of increased occurrence of extreme events and increased unpredictability of weather patterns (FAO, 2013a). These changes include: increases of mean temperature; changes in rain patterns; increased variability both in temperature and rain patterns; changes in water availability; increases in the frequency and intensity of extreme events; perturbations in ecosystems, all of which will have profound impacts on agriculture, forestry and fisheries (Gornall, 2010; IPCC, 2007; Beddington, *et al*,. 2012; HLPE, 2011; Thornton *et al*., 2012). The extent of these impacts depends not only on the intensity and timing (periodicity) of the changes but also on their combination(s), which are more uncertain and dependent on local conditions.

Smallholder farmers and pastoralists in developing countries, many of whom are already coping with a degraded natural resource base, are being especially hard hit by these changes. They often lack knowledge about potential options for adapting their production systems. Their situation is further exacerbated as they have limited assets and risk-taking capacity to access and use technologies and financial services.

The following summarizes the lessons learned on adaptation to climate change during the implementation of the Sida project.

Ethiopia

The proactive measures taken with community-based participatory integrated watershed management approaches can begin to strengthen communities' abilities to adapt and cope with the growing threats of climate change and improve their livelihoods.

Notably, the communities decided to enforce area closure to rehabilitate degraded grazing lands and within two years (2012 and 2013), the benefits are already clear. Activities on farm lands to improve the productivity of the land (intercropping with nitrogen-fixing beans, rotations and composting), also integrated livelihood diversification activities (beekeeping, poultry farming and fattening of small ruminants) as additional income generating activities are motivating the communities to scale-up activities.

The practical demonstrations and learning-by-doing approaches, reinforced by study tours, have been shown to be particularly effective in supporting up-take of the interventions. It is further shown that capacity building should include not only practical training, but endeavour to increase provision of agricultural tools, also equipment like GPS, cameras for monitoring and stationary to record results. Implementation of the overall watershed development program through full participation of local communities and government's involvement is showing that strengthening the linkage between communities and extension staff is crucially important to ensure success.

At the start of the project, some of the farmers had poor levels of education and lacked awareness of the issues of climate change or options to adapt – which made some of them reluctant to participate in the watershed-wide planning activities, notably in soil and water conservation. Some farmers were unwilling to cooperate, particularly to give their land for area closure. However, many farmers living in the watershed did agree to work together and share experiences to implement the project activities.

Generally, a community-based integrated and participatory watershed development planning approach to land and water is really a way to slow down population migration towards the city and is leading to income generation and increasing the adaptive capacity of beneficiary farmers to cope with the alarming threat of climate change and variability and improving livelihoods.

More dissemination of physical and biological SWC options is still required for other neighbouring watersheds which are similarly being affected by climate change to uptake the improved practices and benefit from associated support measures.

Kenya

It was concluded that it is possible to alleviate most of the present challenges of increasing weather variability facing the vulnerable farming community in Siaya County through identifying, disseminating and supporting appropriate technologies. It is felt this will better prepare them to adapt to longer-term climate change. Special attention needs to be paid to addressing the particular needs of the vulnerable, to make them more resilience to climatic shocks. In particular, special attention should be placed on developing their human and social capital for the longer-term, along with the selective support which will enable them adapt their farming to the immediate threats of climate change. The project has shown that it is possible to raise their self-esteem of vulnerable households through building their capacity to adapt to climate change, especially in food and nutrition security. Conservation agriculture principles have been emphasized in all crop and land management to improve soil fertility and increase water availability to the growing crops, which will address labor shortages and rehabilitate degraded land.

Diversification of crop production is important to reduce the risks of food insecurity attributed to increasing weather variability and climate change – if one crop fails due to a drought, or flood, or disease outbreak, the farmers will have other foods to fall back on. Diversification of the crops grown also helps the vulnerable to improve diets and reduce malnutrition.

The project beneficiaries are now also able to generate a sustained income from the sale of tissue culture banana plantlets, cooking and ripening bananas, sweet potato vines and tubers, cassava cuttings and tubers. School fees for the orphaned children may no longer a burden that requires external support. They can also afford to buy quality seed and fertilizers for planting in the subsequent season. It is evident that banana production in Siaya County is a good crop diversification to enhance food supplies and incomes. The farmers, who at the start of the project activities could not adopt most of the simple technologies demonstrated on the demonstration fields, are now able to raise and share plantlets, as well as selling plantlets and banana bunches commercially. Particularly successful approaches included:

- Mentoring farmers and using them as mentors, to strengthen farmer to farmer learning;

- Working with farmers in organized groups, which creates more impact;
- Exchange visits promote learning and adopting of new technology;
- The 'pass on' system of sharing banana plantlets promotes distribution of the new disease resistant varieties;
- The adaptive banana practices have 'quietly' broken the cultural barrier of women being prohibited from planting bananas.

Fish farming is another option which has proved to be successful for some famers in Siaya to increase their sources of income and food security, diversifying their near subsistence livelihoods. Fish is a rich source of dietary protein and selling surplus provides additional income for purchasing food and non-food items. The land area needed for fish farming is small compared to other farming enterprises. Farmers who fish farm are now utilizing harvested water to irrigate their vegetables during dry spells, which is ensuring a steady source of food and income. In Siaya County, with periodic rainfall, this irrigation does not reduce the water levels needed for fish farming. However, the rainfall in between the rain seasons is often not sufficient to sustain crop production. Hence harvesting the water enables the farmers to use it for both fish farming and irrigation.

Application of simple and affordable rehabilitation techniques is desirable to restore gullied areas in Mwala watershed. Local communities are more likely to adopt the simple and cost-effective technologies demonstrated by the project; making up-scaling to other watersheds easier. Land rehabilitation using agroforestry to check further erosion and restore soil organic matter and fertility contributed to the efforts towards more effective soil and land management.

Taking a community-based approach as opposed to a group approach in various issues, especially sand harvesting is proving more helpful in assessing problems and identifying more viable solutions.

Three key factors are concluded to have particularly contributed to the success of the project encouraging the growing of drought tolerant crops (DTCs):

- An action-research approach was taken at the demonstration sites, which identified and assessed local practices, facilitated onsite training, encouraged farmers to watch what their neighbours were doing, let farmers choose without added incentives and supported them in fine- tuning their preferred DTC varieties;

- Production of DTC is an easy, cheap, traditional technology that yields a harvest despite poor rainfall and can easily be replicated by farmers;
- DTCs is a technology that could be adapted to suit the changing local context and is highly favourable (in comparison to maize) to the unpredictable and uneven rainfall patterns in the target areas.

Other factors key to the success included the following:

- The participatory baseline survey at the beginning of the project helped establish relevant stakeholders and relevant climate change concerns;
- If well conducted, demonstration plots can be one of the strongest dissemination techniques for convincing farmers that a technology works;
- Establishing and empowering community structures (committees) at different levels ensures cooperation, acceptability and sustainability of projects;
- The adoption rate of this practice and the crop varieties chosen by farmers differed from one watershed to another, due to different perceptions by the targeted farmers.

Tanzania

The System for Rice Intensification (SRI) technology has proved that even under moisture stress conditions, rice yields can be improved considerably better in comparison to yields harvested through other technological packages.
Farmers have learned a great deal about the importance of managing and conserving soils and water (SWC) in their village using the approach adopted by the project. However, although during the project inception, farmers had a lot of enthusiasm, during the period of implementation; great efforts are needed to encourage more participation in sustainable soil and water conservation activities in the highland areas.

Energy saving stove (ESS) technology is easily adopted because it is simple to practice and all the materials for construction are both cheap and locally available. The project has been able to help householders make their own energy saving stoves, giving them training on construction, operation and maintenance to ensure proper and extended use. Farmers are now able to make and repair all types of energy saving stove on their own. Simple, affordable and locally produced energy saving stoves can ensure speedy adaptation of this technology. The successful promotion of ESSs is improving local conservation by reducing the amount of wood harvested for fuel. In addition it is reducing indoor air pollution and improving the health condition for women and children.

Beekeeping activity has a potential to increase resilience of the farming communities as a means of livelihood diversification. Also, the beekeeping has potentially low investment costs and promising high returns in the immediate and longer term. Thus promoting beekeeping leads towards sustainable livelihood options, household food security and improved incomes of the Kiroka communities and beyond.

The success and sustainability of achievements and services depends in large part on capacity building. Therefore, the trainings, study visits and the participatory approaches used by the project during implementation were able to build the capacities of Kiroka farmers to adopt a range of technologies as means of reducing the impacts of climate change in the area. Inter-community exchanges and mutual learning among communities are important tools to strengthen capacity, notably study tours.

As capacity and education on the use of agricultural innovations has been already provided as means to adapt to effects of climate change, laws and regulations should also be formulated and enforced for sustainable use of land and water in the village. Kiroka local government in partnership with non-governmental institutions and farmers themselves should work together to enhance effective capacity to adapt to the impacts of increasing weather variability and climate change through promoting existing and other possible adaptation strategies. Awareness creation and trainings will be required into the future to reach all members of the communities.

PostScript

This short duration project has piloted a range of activities across the major food production and livelihood systems in highland and lowland areas of the countries to test the potential of various practices and technologies to contribute to climate change adaptation.

The project has succeeded in building and strengthening the capacities of smallholder farmers, who are already caught in the reinforcing cycle of 'poverty, food insecurity and natural resources degradation trap' to adapt to climate change. This will contribute to decreasing their vulnerability to the adverse effects of increasing weather variability, frequency of extreme events and climate change.

The project has demonstrated that one-size does not fit all; different local factors determine the most appropriate technologies and approaches. The local factors include:

- Biophysical factors;
- Socio-economic factors;
- Land ownership.

Scaling-Up

The findings and lessons learned from the project lead to the following priorities for scaling-up adaptation in the respective countries and countries in similar agro-ecological zones for adaptation to take root in sub-Saharan Africa.

Increasing Soil Health

- Soil conservation needs to be enhanced to check on soil degradation, which is being exacerbated by climate change.
- Due to widespread low soil fertility, there is need for adoption of techniques and practices that enhance soil fertility and restore soil organic matter to increase crop productivity (for example agroforestry and application of composts).
- Soil and water conservation (SWC) is a longer-term intervention, needing time and commitment for implementation. There remains a need to change the mind set of farmers and convince them on the long-term benefits of SWC. Sending them to study tours to see how other farmers are benefiting from SWC on their farms can play an important role in this sense.
- Annual maintenance of the soil (and water) conservation structures and area closure works are expected to continue in the areas where the project has already intervened, as the involved communities are motivated to sustain their achievements.
- Since labour is a limiting factor of production in vulnerable households, there is need to promote labour saving techniques, for example conservation agriculture. Minimum tillage, with use of selected safe herbicides, will reduce the time taken in carrying-out land preparation and also save on cash compared to conventional way of land preparation and weeding.
- Advocacy is needed on awareness on the deleterious effects of for example sand harvesting and rangeland burning on the environment. Sand harvesting

in the pilot area of Kenya is a huge contributor to poor soil and water management measures on farms, especially affecting the people living downstream in the catchment areas. Burning of highland areas accelerates rainfall run-off, leading to higher rates of erosion and flooding downstream. Solving the problems requires a community-based approach as opposed to the group approach, since it is a community resource.

- Integrating scientific with traditional knowledge, for example in Kenya for alternative ways to control the pests of the yellow sisal, seems more likely to overcome problems than relying on one source of knowledge only.
- There is need to research the valuation and socio-economic aspects of the rehabilitated areas, as this will be useful to encourage future rehabilitation efforts.

Water Conservation

- Applying sustainable practices that increase water storage in ponds, soil, groundwater and at homesteads and reduce water losses are important.
- Use of harvested rainwater through micro-irrigation efficiently provides water for plants (e.g. horticultural crops) into the dry season in areas of water shortage. This has been shown to be an effective means to stabilize yields and improve food security.
- In areas such as Siaya, where the rate of evapotranspiration is high, limiting soil water available to plants, there is need to maintain soil vegetative cover in cropland to conserve water for plant establishment and development.
- There is a need to build the capacity of the farmers on efficient utilization of the fish pond water for irrigating their vegetables, tree nurseries and other viable enterprises. This will ensure a greater diversity in food and income generation sources using the pond water, as well as ensuring sufficient water for fish farming. Use of manual ('money-maker') pumps and hosepipes makes the irrigation process easier and more targeted.
- Efforts are required to ensure that most farmers in rice growing areas are encouraged to adopt the SRI technology, particularly the improved water management, as this is a beneficial adaptation to increasing weather variability, reduced water supply and the predicted impacts of climate change. SRI technology should also be spread nation-wide by institutionalizing it into district- and national-level plans where irrigation is practiced. This should be supported by wider dissemination and sensitization through brochures, newspapers, farmer field days and exhibitions.

Livelihood Diversification

- Diversification will be an important strategy for farmers in the future in Eastern Africa and more widely in sub-Saharan Africa. There is need for farmers to diversify rather than relying on production of a small number or a single crop (e.g. maize and beans only in Kenya).
- More emphasis should be on inclusion of crops such as sweet potato, sorghum, millet and early maturing cassava which are short term crops, better suited to variable rainfall and shorter rainy seasons. The yields of these crops are far greater than that of maize and beans.
- With the project's experience in handling the vulnerable farmers in communities in Kenya, there is a need to advance support to other vulnerable farmers with starter planting materials (crop seeds, vines) and farm inputs (fertilizers) if they are to be supported towards a state of food sufficiency and sustainable income generation in the face of climate change.
- Banana production should also be promoted, as these perennials are less vulnerable to the impacts of increasing weather variability, thus contribute to long-term food security and income generation. Farmers need to be linked to external markets. Marketing will also require capacity building and adoption of other techniques (e.g. ripening chambers, preservation boxes) to ensure the quality that meets market demands. The banana growers in Ugunja also wish to add value to their produce through processing (e.g. products like banana chips and wine).
- Fish farming can enhance incomes and food security, and thus contributes to adapting to climate change. Fish is a good source of protein and its inclusion in the diet improves health and nutrition.
- Since not all farmers are endowed with soils that can retain water for long enough periods to sustain fish farming, there is need for farmers who are disadvantaged by this to be supported in fish farming, where economically feasible, by the provision of pond lining material. In some cases, the project has shown that the cost of the pond lining material is recoverable within the first cycle of fish farming.
- More funds are required to train more farmers on constructing and using energy saving stoves – an environmentally friendly technology. The energy saving stove technology should be disseminated to all the households in Kiroka and neighboring villages, to make sure that energy saving stoves replace the traditional open stove. Energy saving stoves should also be introduced to the different institution (hospital, school, churches and other

institution), as these are significant consumers of firewood. This will greatly help in saving the environment and financial status to households in Kiroka and more widely. The Government and other stakeholders should intervene to promote ESS technology more widely for its multiple benefits, including contributing to climate change resilience.

- Beekeeping has been shown to be a low cost income generating activity which can produce rapid returns on relatively investments in hives and minimal processing equipment. Farmers can easily adopt beekeeping as an additional activity which will diversify their sources of income – and encourages land users to manage forest and woodlands better, therefore has win-win-win benefits.

Strengthening Local Institutions

- Community members need considerable skills in planning and implementation of appropriate techniques /technologies to adapt to climate change.
- Knowledge- and experience-sharing amongst farmers and focal experts needs to be catalyzed.
- Continuous support should be provided at early stages of such initiatives (e.g. by woreda experts in Ethiopia) and follow-up provided beyond the intervention phase.
- Experience sharing amongst farmers and technical staff is effective in increasing the adaptive capacity of smallholders to adapt to climate change (e.g. well-planned and coordinated exchange visits, farmer field school, etc.).
- Farmers can be organized in cooperatives to enhance marketing of the bananas and other crops.
- Access to credit will be vital to farmers who intend to have more fish ponds to enhance their incomes and food security from a fish farming enterprise. A starter revolving loaning system could be developed through this project to increase the number of farmers engaging in fish farming on their farms.

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Part 2
Country Case Studies

The following three sets of papers (for each country, a background paper followed by two or more specific case studies) have been written by individual or groups of authors drawn from the project's country technical teams. They document on-the-ground experiences, mainly from the perspective of the land user / project beneficiary, in some cases written-up as case stories.

Ethiopia

Community-based, participatory integrated watershed management as an approach to climate change adaptation in Haro Jila and Wurba watersheds

G. Debalkie and B. Solomon

Introduction

Smallholders in Ethiopia face widespread problems related to inappropriate cultivation, overgrazing and deforestation, resulting in soil erosion and soil fertility decline, water scarcity, lack of pasture and livestock feed, and a fuelwood crisis.

There is a long record of practices to adapt to the impacts of weather as well as natural climate variability on seasonal to inter annual time-scales in Ethiopia. Examples of adaptation practices include:

Proactive measures such as crop and livelihood diversification, seasonal climate forecasting, community-based disaster risk reduction, famine early warning systems, insurance, water storage, supplementary irrigation and improved land management (e.g. erosion control and soil protection through tree planting).

Reactive or **ex-post adaptations**, for example emergency response, disaster recovery and migration (Sperling and Szekely, 2005).

In view of increasing weather variability, frequency of extreme events and predicted climate change, the challenges are growing. It is even more important in any local-level adaptation intervention to increase the individual or community's adaptive capacity.

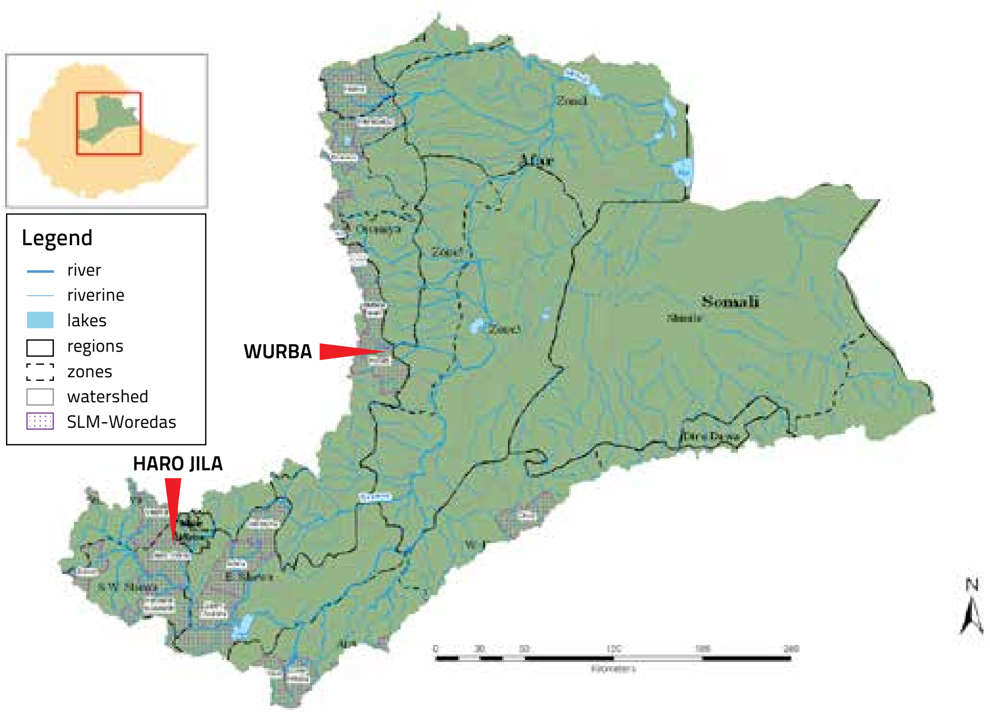
A series of studies has shown that successful community-based resource management can potentially enhance the resilience of communities to the impacts of climate change, as well as maintaining ecosystem services and ecosystem resilience (Tompkins and Adger, 2004; Manuta and Lebel, 2005; Owuor *et al.*, 2005; Ford *et al.*, 2006) from IPCC (2007).

Thus, the approach chosen to adapt to the impacts of climate change in the pilot areas of Ethiopia was through proactive measures with community-based participatory integrated watershed management (PIWM) approaches to strengthen the communities' abilities to adapt and cope with the growing threats of climate change and improving their livelihoods.

Project Objective

The core objective was to reduce the impacts of climate change (including increased weather variability) on smallholder farmers through sustainable land management (SLM) and contribute to improvement of agricultural productivity, livelihood and ecosystem resilience of two priority vulnerable watersheds within the Awash Basin (see Figure 1 below).

Figure 1: Project location map showing selected watershed sites (in red arrows) within the Awash River Basin in Amhara and Oromiya Regions, Ethiopia.



Approach and Methodology

Community-Based Participatory Integrated Watershed Management

The challenge of managing the environments in which people live becomes more complex and difficult as human populations increase, demands on the natural resources increase and new technologies are developed that let people – knowingly or unknowingly – destroy their environment at a more rapid rate and with less effort than in the past. People have learned through experience that what we do to upstream watersheds can drastically affect large numbers of people and their lands and water downstream.

At the same time that the challenges for land and water management increase, there are opportunities to halt the degradation and destruction and, in doing so, create more sustainable environments in which people can live and satisfy their basic needs. However, while many of these opportunities might exist on paper, the reality is that local political units (states, provinces, towns, cities, villages and communities) determine what happens within their jurisdictions. Almost invariably, these jurisdictions are situated within, but are not coincident with, the boundaries of a watershed or a river basin. Nevertheless, while water flows downstream, many of the natural processes associated with the flowing water occur without regard for political boundaries. This means that for the opportunities for sustainable land and water husbandry to be realized, political units and civil society must come together to cooperate and think broadly and collectively (Gregersen *et al.*, 2007).

The two fundamental questions to be addressed are:

1. What mechanisms exist to ensure that people in a watershed have a common and positive overall goal of land and water use and that their actions do not adversely affect land and water resources for future generations?
2. How do we best enable stakeholders to act in a cooperative and coordinated fashion to achieve these goals?

These questions can only be answered if we have good knowledge of the biophysical realities of the watershed and the biophysical interactions that take place within it in response to natural forces and the actions of humans. We also need an understanding of the institutional dynamics of the communities that exist within its boundaries, the interactions that exist between them at present and the motivations of the various stakeholders and the incentives that would influence them to change their motivations and actions that adversely affect the watersheds within which they live and work.

The watershed-focused approach ensures site-specific application of suitable interventions and active participation of the community. In addition to FAO, several NGOs and bilateral organizations have also played a relevant role in promoting watershed management planning in Ethiopia, in close collaboration with government partners in Ethiopia in various regions and woredas.

The collective experience comprising different approaches, combined with the need to have a common and standardized more effective approach to the country as a whole has led to the current community-based participatory watershed development guidelines.

However, there is no systematic body of knowledge on location specific climate change adaptation practices available in Ethiopia. This project tested and documented a range of location-specific management practices in terms of their capacity to adapt to and mitigate actual and potential weather variability and climate change, to ensure sustainable natural resources management in the short and long term and to generate socioeconomic and livelihood benefits for the land user. Thus, a participatory integrated watershed management (PIWM) approach was adapted, based on the needs and adaptive capacity of the two sites.

Depending on the situation, therefore, the objectives of PIWM are likely to be one or more of the following:

- conserving soil, rainwater and vegetation effectively for productive uses;
- harvesting surplus water to create water sources in addition to ground water recharge;
- promoting sustainable farming and stabilizing crop yields by adopting suitable soil, water, nutrient and crop management practices;
- rehabilitating and reclaiming marginal lands through appropriate conservation measures and mixes of trees, shrubs and grasses, based on land potential;
- enhancing the income of individuals by diversified agriculture produce, increased employment opportunities and cottage enterprises, particularly for the most vulnerable, linked to the sustained use of natural resources.

All over Ethiopia, watershed logic governs water regimes, erosion levels, biomass availability, productivity levels, the quality of infrastructure and countless other activities. In degraded watersheds, opportunities for water harvesting and management are few and of limited use; access roads are continuously damaged or they are not suited for construction, access to clean water for domestic use is very difficult and incidence of water-borne diseases is very high. Unstable watersheds induce unstable production systems and inefficiency of input utilization, as erosion also undermines efforts to enhance productivity. Moreover, income generating opportunities linked to introduction of cash crops, bee-keeping, livestock fattening or dairy, and others, largely depend on the condition or 'health' of the watersheds. They depend as well on the interactions between communities and the different levels of the watershed units.

Increased vulnerability to drought and food insecurity is directly linked to the conditions of the watershed and its limited capacity to support local livelihoods. The opposite occurs with protected and developed watershed systems, which generate multiple positive effects on people's livelihoods, the environment and for the overall economy of the area.

Many of these objectives are also associated with soil and water conservation practices aimed at local farmers, livestock producers, foresters, engineers or others who exploit natural resources on a watershed for different purposes. Indeed, soil and water conservation represents an integral part of watershed management. *However, what distinguishes the PIWM approach from other land management practices is its holistic consideration of the linkages among all of the activities within a watershed and how these linkages affect each other and the sustainability of the natural resource base on which people depend.* Achieving the goals of PIWM requires planning for the effective and efficient use of the land, water and other natural resources, coordinating the management activities and benefits among different groups of people, dealing with many land uses, and, quite often, working within more than one political jurisdiction.

These management practices are the core of the act locally part of PIWM. People carry-out these management practices to obtain the outputs needed for their survival, well-being and incomes. In rainfed agriculture, water is the key constraint for improving agricultural productivity owing to the extreme variability of rainfall, long dry seasons, recurrent droughts, and frequency of floods and dry spells in the same season – all of which are increasing due to climate change. Thus, a key to obtaining all or combinations of the anticipated objectives is managing, developing and/or increasing supplies of the high-quality water that are necessary for improving food security and other welfare benefits for people living both on upland watershed and downstream areas.

The approach chosen to achieve the stated objective in our project was through proactive measures with community-based participatory integrated watershed management interventions to strengthen the project communities' abilities to adapt and cope with the alarming threats of climate change and improving the livelihoods.

Site Selection

The selection process for the pilot sites was completed in close consultation with the Ministry of Agriculture, regional and Woreda administrators, sustainable land management focal points, other experts and relevant FAO staff, both in Ethiopia and at HQ.

- The first stage selection criteria for the pilot sites focused on the priority sustainable land management (SLM) Woreda identified by the national SLM platform;
- The second stage in the selection involved identifying representative districts within the FAO water scarcity project, to create synergy;
- Third stage was in consultation with Woreda SLM focal points and other experts, who in collaboration have identified representative watersheds for this project.

Size of the Watershed

The term catchment or sub-watershed is used to refer to smaller units that contain all lands and waterways that drain to a given common point within a larger watershed. For example a catchment may be only a few hectares as the drainage area for small water harvesting structures or a few hundred square kilometres in area for small streams or rivers. The size of the catchment or watershed to be used for land resources planning and management should be based on the community or communities that depend on the natural resources in the watershed.

A suitable watershed size is required for effective planning for conservation and maximum production. Efficient management of watershed resources is possible through an appropriate unit, so that the resources are managed and handled effectively, collectively and simultaneously. The maximum size of the watershed that should be taken as a planning unit is suggested to range from 200 to 500ha. Some exceptions on the upper side may occur, particularly in drier areas where villages are scattered within larger watershed units and natural resource development is possible only if larger units are considered. In this case in Ethiopia, however, sub-watershed units were be identified and prioritized for key interventions.

Based on the experience of various countries, a watershed size of 500ha creates homogeneity in most aspects, facilitating better planning and implementation (it is also the maximum size recommended in community-based participatory watershed development guidelines) (Lakew *et al.*, 2005). When the size is larger, it is difficult to organize the community to undertake the surveying, planning, implementing, and monitoring tasks. Those watersheds with high and diverse development potential will tend to be smaller than those in the arid and pastoral areas, which have limited agricultural potential.

Site Descriptions

The Haro Jila watershed is located in the highlands of the Oromia region in the Sebeta Woreda (Figures 1 and 2). It lies in a moist agro-climatic zone, with an average altitude of 2,660 masl, with a mean rainfall of 1,200 mm. The watershed occupies 736ha, of which 472.75ha is under arable use and 263.25 ha which is non-arable (mostly used for grazing and fuel wood). The Haro Jila watershed has 477 households (HHs) with a total population of 2,832 people, with an average land holding of 1.5ha. This site is densely populated and practices traditional agricultural methods and free-grazing, which greatly contributes to deforestation, soil and wider land degradation. Unlike the Wurba scheme (see details below), Haro Jila is naturally endowed with resources and faces potential vulnerability to climate change due to erratic and high intensity rainfall, which results in flooding causing serious soil erosion, loss of crops and damage to homestead areas.

Figure 2: Panoramic view of Haro Jila climate change adaptation project site before project implementation

Photo: © FAO / G. Debalkie

The Wurba watershed is located in the lowlands of the Amhara Region in the Shoa Robit Woreda (district) (Figure 1 and 3). It is located in the dry agro-climatic zone, with an average altitude of 1,420 masl, a mean rainfall of 900 mm and currently a 5 year rate of drought recurrence. The watershed occupies 612.8 ha, of which 506.3 is arable land 106.5 ha of which is non-arable (mostly used for grazing and fuel wood). The Wurba watershed has 380 households and a total population of 1,520 people, with an average land hold size of 1.6 ha. This site is characterised by severe water scarcity and drought induced by land mismanagement, which is further exacerbated by climate shocks such as untimely and erratic rainfall. The communities' farm land is located at the foot of the hill and due to the human-induced erosion, the result of irrational use and poor management such as inappropriate agricultural practices, overgrazing and removal or overexploitation of the natural vegetation from uplands, the low-lying farm land was exposed to the gradual loss of the most essential fertile top soil and covered with coarse surface fragments (stones), inhibiting moisture retention in the soil profile, which is necessary to support maturing crops, resulting in loss of productivity.

Figure 3: Panoramic view of Wurba climate change adaptation project site before project implementation

Photo: © FAO / G. Debalkie

The project office and the woreda agricultural officers were involved in selection of appropriate sites and studied community-based participatory watershed development guidelines and the project document to select appropriate interventions suited to local conditions in both highland and lowland areas.

A survey team was setup, including Government staff from the Administration Office and from the Agricultural and Rural Development Office (including specialists in: soil conservation; forestry/ agroforestry; agronomy; land use and administration expert; irrigation; livestock; food security; cooperative/marketing and inputs; rural road construction; plant sciences; natural resources; and livestock). All of these officers are focal and technical members of woreda sustainable land management (SLM) or watershed team. Direct beneficiary farmers were represented by members of the Kebele Peasant Association, including both men and women of the full range of age-groups and participated in the process. The survey team worked with the project office staff, adopting different methodologies for conducting the baseline socio-economic and bio-physical surveys.

Briefings and Meetings in the Project Areas

The survey team gave briefings to woreda agricultural and rural development officers on the objectives of the project, its programme areas and the development interventions proposed for the woredas.

In order to receive as much information as possible on the overall development situation of the project sites, the survey team made several visits to the sites and conducted fruitful discussions with the direct beneficiaries. Technical personnel of the woreda agriculture offices and development agents were instrumental in arranging the contacts with the communities.

Surveys of the Project Watersheds

Socio-economic and bio-physical surveys of the two watersheds were carried-out to draw-up feasible plans. The surveys were conducted using community-based participatory watershed development plan questionnaire formats, adapted from the guidelines (Lakew *et al*., 2005). The various project stakeholders (beneficiary communities, relevant government offices at the woreda and the regional levels and project office) were closely involved in the socio-economic and bio-physical surveys, also the drawing –up of a community action plan, as follows:

a) **Socio-Economic Survey** The socio-economic elements and characteristics of a watershed involved assessment of the population, farming systems, social set-ups, economic activities, vulnerability profile, gender, etc. Watershed development planning is a principle approach that fits community level planning. It aims to improve the livelihood of the community, men and women alike. It embraces the views of various categories of people in the watersheds. Although all community members are expected to benefit from watershed development, specific attention is required to address problems of resource poor and vulnerable families and promote the empowerment of women.

The survey mainly focused on discussions with the beneficiary communities in the target area and include:

- **Trend analysis** - the trend of the natural resources of the area was analyzed from the stand point of what things were like in the past, their present status and what will happen if the present situation is allowed to continue. With this understanding, the communities at both sites explained about the trend of their natural resources;
- **Village mapping** - one man from the men's group and one woman from the women's group took the initiative to sketch a map of their peasant association area, including drainage lines, homesteads/ villages, cultivated land, grazing land and forest land on the ground while the remaining group members encircled them and contributed enriching ideas. Amid such active participation, both groups sketched the map of the area, which was transferred onto paper. This sketch map is in essence not something simple to use, as it shows the mental map of resources on which the community depend. However, it is also an indication of the knowledge they have about the resources that exist in their peasant association area. The map is instrumental in sound planning - it provides the basis for subsequent mapping of the catchment and territory used by the community for crops, water, grazing, fuel, medicinal plants etc throughout the year;
- **Vision of change** -this exercise was done by dividing the communities into male and female groups and allowing the two groups sit separately and having done their **dream** (this is the first part of the vision of change exercise in which both the male and female groups were persuaded by facilitators to come up with a dreamed proposal on what they would like their peasant association area/watershed to look like in the ideal situation where resources are not considered as limitations) and **realization** (this is the second part of the vision of change exercise dealing with the realization of the dreamed proposals as the name also implies);
- **Problem identification and ranking** - men and women remained in separate groups and each group was persuaded to carry out the problem identification and ranking exercise separately. Finally based on the problems identified and ranked by each group, the final ranking was made based on consensus of both groups as an input for final planning purpose.

b) **Biophysical (water, land, vegetation) Survey** This survey dealt with field assessments (i.e. **observation and mapping**) of the natural resources. During the survey both the **transect walk** and bio–physical survey of the targeted watershed were conducted simultaneously. A transect walk (walking up and down crossing rivers for a distance of more than 5 km) around the watershed to observe the topography, drainage pattern, natural resources, major land use types, assess the soil depth, soil texture, slopes, degree of erosion, deforestation level and other of relevance, two routes with high biodiversity were selected and accordingly the transect walk undertaken along the routes.

Data gathered during the transect walk were transferred to a base map developed from a digital map of the project site. Comparisons and cross-checking was carried-out of the results of both the socio-economic and the bio-physical surveys, to produce consolidated findings. The results of the two surveys were more or less similar and reinforce each other.

Comparatively the two surveys were conducted smoothly and successfully. All the information and data required for the intended subsequent planning purpose were believed to have been collected and these were subsequently processed.

The next step was planning the interventions and activities that would bring about change based on the findings of the surveys. This included working out the quantity of the various measures that must be implemented based on existing standard work norms, estimating the direct and indirect costs required for implementation and preparing the multi-year development map of the project.

c) **Physical and Financial Community Watershed Development Action Plan** was prepared with the full participation of the Agricultural and Rural Development Office, Land Administration, Cooperative and Livestock Agency Offices experts, also the project office, according to the findings of the two surveys (mentioned above) and the proposed recommendations that are vitally important for the formulation of the actual project plan.

As the survey findings depict that rehabilitation of the alarmingly degraded environmental condition and improving the livelihoods of the population living in the project area is essential to reverse the situation.

Obviously, the most feasible, dependable and sustainable solution to address this issue is by strengthening capacity of the beneficiary communities for climate change adaptation focusing on sustainable land management based on the findings of the two surveys conducted in the area on a watershed basis.

Against this background and through a rigorous screening process, an integrated watershed management action plan was devised with a focus on; area closures and soil conservation measures consisting of fertility management and *in situ* moisture conservation; management of excess runoff; crop-livestock integration practices consisting of rotational and zero grazing; improved livestock feed on cropland, grazing lands and homesteads; agroforestry practices through establishment of nurseries; introduction of suitable and drought tolerant multipurpose trees for cash income; planting of fodder species for livestock fed; tree planting for household energy and for drought mitigation; water harvesting methods such as spring development, and community and household ponds; livelihood diversification practices such as introduction of horticulture crops; beekeeping; allocation of small ruminants and chicken; and distribution of energy saving stoves.
To support capacity building, agricultural tools and field equipment (including GPS, cameras for photo monitoring and stationery), study tours and training were provided for effective implementation of the project.

Conclusions

Watershed logic governs water regimes, erosion levels, biomass availability, productivity levels, the quality of infrastructure and countless other activities in rural areas. In degraded watersheds, opportunities for water harvesting and management are few and of limited use; access roads are continuously damaged or they are not suited for construction; access to clean water for domestic use is very difficult and the incidence of water-borne diseases is very high. Unstable watersheds induce unstable production systems and inefficiency of input utilization, as erosion also erodes efforts to enhance productivity. Moreover, income generation opportunities linked to introduction of cash crops, bee-keeping, livestock fattening or dairy, and others, largely depend on the conditions or 'health' of the watersheds. They depend as well on the interactions between communities and the different levels of the watershed units (upstream-downstream). Increased vulnerability to drought and food insecurity is directly linked to the condition of the watershed and degraded watersheds have limited capacity to support local livelihoods. The opposite occurs with protected and developed watershed systems, which generate multiple positive effects on people's livelihoods, the environment and for the overall economy of the area.

Climate change is a serious threat to the sustainability of rainfed agriculture in the selected watershed schemes (and more widely in Ethiopia). Among the most serious problems threatening both project areas was found to be land degradation due to deforestation and poor natural resource management practices. The emerging threats of climate change such as erratic rainfall and flooding are further exacerbating the situation, causing increased loss of crops and property damage, also claiming the lives of humans and livestock. Rainfed agricultural production in both schemes is already constrained by scarcity of water and nutrient stress - any increase in the rate of land degradation will further aggravate the problem.

A wide spatial variability in different forms of land degradation was noted within these watersheds. In most cases, the poor land is located at higher elevations within the watersheds, where the land is sloping and is less productive because of accelerated erosion. The low water holding capacity of the shallow soil at upper levels results in poor crop emergence and requires the crop to depend on unreliable frequent rains throughout the growing season. At lower levels, overall rates of erosion seem lower – although gullies have formed in places, resulting in highly concentrated areas of high soil loss.

Degradation, including erosion, seems to be well understood by farmers. Their cropping system, dominated by sorghum, wheat and teff is a nutrient mining system. Intercropping with legumes is not common. Not only were the farmers aware of both gully and sheet erosion, even on nearly flat land, but they also were aware of nutrient mining and other kinds of degradation like the decline of soil organisms (specifically earthworms).

Therefore the selected entry point for project implementation was increasing farmers' knowledge about their natural environment and integrating this with experience-sharing study tours in support of the 'seeing is believing' philosophy.

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Ethiopia Paper 1

Improving adaptive capacities of farmers through rainwater harvesting in Wurba watershed, Shoa Robit Woreda, Ethiopia

M. Girma and E. Yeshigeta

Introduction

The study site, Wurba watershed, is located in the lowlands of the Amhara Region in the Shoa Robit Woreda as described in Part 1, (see Figure 1 of Ethiopia Background paper) and Box 1, with an average altitude of 1,420 masl.

Box 1: Summary of key facts on Wurba watershed

Agroecological zone	Watershed Area and Land Cover	Watershed Population
dry zone	612.8 ha total	1,520 people
900 mm mean annual rainfall	506.3 ha arable (annual crops)	380 households
5 year drought recurrence rate	106.5 ha other (mainly grazing and woodlands, harvested for fuel)	average land holding - 1.6 ha.

The major impact of climate change being experienced in the Wurba watershed is associated with water scarcity, exacerbated by land degradation, deforestation, which are leading to decreased agricultural production (crop yields average 18 quintals i.e. 881 kg per ha) and pastoral productivity, also over-utilization of natural resources (Figure 1). The water scarcity in the Wurba watershed has resulted in human and livestock malnutrition attributable to loss of arable land and decreased agricultural productivity – leading in some cases to migration of local farmers to less harsh areas and declining numbers of wildlife. The area's rainfall is no longer seasonal but has become erratic, which leads to severe erosion after droughts, resulting in the development of numerous gullies of different extents and depth across the landscape.

Figure 1: View of Wurba watershed before and after project implementation

The planned intervention for the Wurba watershed was to strengthen the capacity of smallholder farmers through sustainable integrated watershed management. This was to be achieved through integrated improvements in agricultural productivity, livelihood diversification and ecosystem resilience with a focus on rainwater harvesting technologies to reduce the impacts of increasing weather variability and climate change. Participatory approaches were to be used in order to reach all members of the local community.

Figure 2: Women and young girls fetching water from the Sewer River (4 km from their homes)

Figure 3: Women labouring to dig trenches on farmland

The main objective of the intervention, rainwater harvesting, was to create a more conducive environment by avoiding the scarcity of water in the area for both animals and humans (Figure 2).

Project Interventions

The interventions selected for the Wurba watershed were chosen as those suitable for dry and drought prone areas. These included practices that retain the surface runoff in the uplands and improve water holding capacity of the soil, practices that recharge the ground water and protect the top soil removal in farm lands. Community members were assisted to construct hillside terraces with trenches (Figure 3), stone check dams on hillside, cut-off drains, micro trenches, deep trenches and micro basins. In addition, rainwater harvesting methods suitable for arid areas were undertaken to decrease the number of dry months and diversify sources of income for local people. These included excavation of ponds close to homesteads and on farm land. The ponds were lined with geo-membrane to prevent seepage loss – these now provide water for several months into the dry season for drinking (human and livestock) and supplemental irrigation for horticulture (Figure 4). As an integrated water management measure, roof-top rainwater harvesting and drip irrigation equipment were purchased and distributed to some households (e.g. roof-top rainwater harvesting required iron roofs).

Figure 4: Rainwater harvesting ponds lined with geo-membrane

As a crop livestock integration practice, farmers were recommended to adopt rotational and zero grazing practices, which was assisted by the introduction of improved livestock feed on farmland, around homesteads and on grazing lands. This included: 20,000 elephant grass plants on farm lands; 50 kg of Sesbania seeds which were directly sown on constructed terraces; and 2.5 km of Vetiver grass which was planted as a hedge along contours on farmland.

Further biological conservation works included the planting of 1,650,000 indigenous and exotic tree varieties which are drought tolerant and therefore will cope with anticipated climate shocks. These included multipurpose tree species which provide construction material, timber, forage for livestock, also species the leaves and seeds of which can be harvested as a source of food and for medicinal value. In addition, a community bylaw was prepared as a basis to regulate 123 ha of the community's communal land from any human and livestock intervention. The bylaw is enforced by the judiciary office in the local government and has been adopted by the communities.

To sustain the green environment and to reduce deforestation, energy saving stoves (including dual stoves, suitable for preparing injera – the traditional teff pancakes – Figure 5) were purchased by the project and distributed to 220 households.

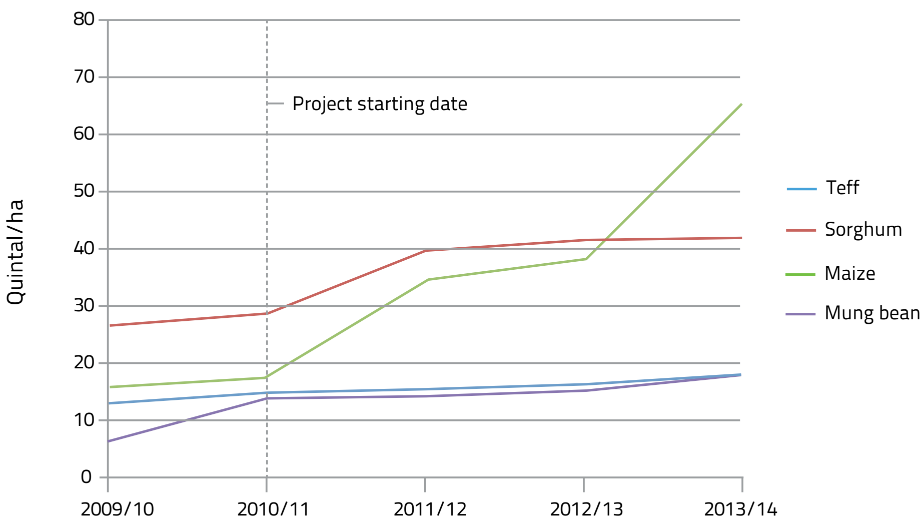
Figure 5: **Energy saving dual stove, including a locally essential injera cooking space**

To improve the adaptive capacity of smallholders, it was essential to diversify smallholders' income sources. Seeds for horticultural crops were supplied to 82 HHs (1 kg of tomato, 5 kg of cabbage, 10 kg of carrots) and 40 HHs were supplied with 200 tropical seedlings (mango and banana plantlets). As an additional source of income, poultry raising and beekeeping were promoted amongst female members of HHs by allocating 100 HHs five chickens each and supplying 30 modern beehives to 30 HHs. These activities were backed up by training.

Achievements so far

Crop production provides a good way to measure improvements made from the project intervention. Starting from the 2011/12 cropping season, an annual assessment was made for three consecutive years with 20 farmers to verify productivity improvements in cereal crop production. The results are shown in Figure 6.

Figure 6: **Productivity improvement for major crops**



Result and Discussion

A total of 380 households were supported and were able to overcome issues of water scarcity using a range of rainwater harvesting practices.

The impacts of the project activities have been immediate. The community report that already there is improved rainwater capture on the 506 ha of farmland in the Wurba watershed, which has helped to increase crop yields. Land users report having produced an average of 2,300 kg of grain crops (sorghum / teff) per season (compared to 881 kg per ha before the project). Specifically, following the project's activities on their land, Mr Hussen Arabu sowed sorghum on 0.75 ha and produced 4,500 kg (6t/ha); and Mr Ahmed Arabu produced 1,000 kg of tef from 0.5 ha (2 t/ha; over 2 times the average yield!)– vital contributions to ensuring their households have sufficient food for the year. Clearly it is early days to assess the long-term impacts of the interventions, but the community already considered that the risk of crop failures has now been reduced.

Hillside closure has increased biodiversity. With the recovery of vegetation cover, (including native plant species and also tree species including acacia), the crucial functioning of the soil and hydrological systems are improving. Wild animals including monkeys and apes are also returning to the area.

Water harvesting practices such as trenches and the practice of tied-ridges have considerably decreased occurrence of downstream waterlogging and flash floods, which over the longer-term will reduce soil erosion.

The rainwater harvesting structures (including 113 ponds lined with geo-membrane) have enabled smallholders to diversify their sources of income by decreasing the time and labor previously required to fetch water (Figure 2), also increasing household income through making available water to irrigate horticultural crops and for other income generating practices (e.g. poultry production and beekeeping) (Figure 7).

The practice of fattening small/large ruminants has increased during the project period, as smallholders use crop residues and waste from high value horticultural crop as feed sources.

Diversification is considered a clear sign of increased resilience to the effects of climate variability.

Figure 7: Two examples of new income generating activities in Shoa Robit

Local people are coming to recognise the true value of land and water since the start of the project, prioritizing its use sequentially for drinking, cooking and cleaning. If there is left-over water after watering small and large animals, soil can then be watered for garden vegetables, followed by watering tree crops and forage.

The trend of households practicing rainwater harvesting and other income-generating activities has begun and will continue to increase in the future. Prior to the promotion of rainwater harvesting, farmers did not have the adequate cash at hand - they now have.
Experience sharing amongst farmers has diversified knowledge on water harvesting methods, allowing more small-holders to plan and effectively adapt to and mitigate climate change threats. Thus, in Wurba, rainwater harvesting methods have proven to be a very viable approach to increase the adaptive capacity of small-holders to adapt to climate change.

Water is now not only collected for short-term use during the rainy season, but is also effectively made available for several months into the dry season. Excavation and lining with geo-membrane of ponds has reportedly decreased the period of drought by an average of 3 months.

The local community already report that there has been a considerable decrease in migration (by nearly 75%) and child labor has also decreased. Children who were once sent away from home for labor employment can now be sent instead to elementary and secondary schools. [This testimony only covers the very short time-period of the project and should be treated with caution, as this may be a seasonal effect.]

Further opportunities to satisfy water demand are continuously being created as more households adopt the good practices introduced by the project.

Conclusions and Recommendations

Throughout the course of the project, certain limitations were encountered due to the lack of knowledge- and experience-sharing amongst farmers and focal experts. In addition, some farmers were unwilling or uncooperative when implementing physical and biological works, especially when it came to labor intensive participation. In conclusion, for enhanced performance and scaling-up of the project to increase the community's adaptive capacity to combat climate change in the future, the following points should be considered:

- Applying sustainable practices that reduce water usage and increase water storage in soil, groundwater and at homesteads are important;
- Community members need considerable skills in planning and implementation appropriate techniques to adapt to climate change;
- Continuous support should be provided at early stages of such initiatives (e.g. by woreda experts) on harvesting rainwater for use in the production of various horticultural crops, household use and livestock use (for drinking);
- Use of harvested rainwater through micro-irrigation efficiently provides water for plants (e.g. horticultural crops) into the dry season in areas of water shortage;
- Experience sharing amongst farmers and technical staff is effective in increasing the adaptive capacity of smallholders to adapt to climate change (e.g. well-planned and coordinated exchange visits);
- Continuously ensuring that technologies advocated are appropriate (e.g. through research) is necessary – given the changing nature of weather patterns and uncertainties in the rates and patterns of predictions for climate change.

Ethiopia Paper 2

Protecting farm land and homestead areas from unpredictable floods: a case study on the experience of smallholder farmers, Haro Jila watershed, Sebeta Woreda, Ethiopia

C. Adare and N.Gelashe

Introduction

The study site, Haro Jila watershed, is located in Sebeta Woreda in Oromiya Region, as described in Part 1 (see Figure 1 of Ethiopia Background paper) and Box 1, with an average altitude of 2,660 masl.

Box 1: Summary of key facts on Haro Jila watershed

Agroecological zone	Watershed Area and Land Cover	Watershed Population
moist zone	736 ha total	2,832 people
1,200 mm mean annual rainfall	472.75 ha arable (annual crops)	477 households
	263.25 ha other (mainly grazing and woodlands, harvested for fuel)	average land holding - 1.5 ha.

The project area is well endowed with natural resources, but faces vulnerability to climate change shock due to current land mismanagement. The major issues in the Haro Jila watershed are associated with the high density of the local population, who practice traditional agricultural methods and free-grazing which are contributing to deforestation, soil and land degradation. The areas is already being affected by climate change, with increasingly erratic and high intensity rainfall, leading to flooding causing high rates of soil erosion, loss of crops and damage to homestead area.

Accelerated soil erosion in the area primarily arises from practices that over-exploit the land, leaving the soil unprotected from erosive agents. The planned interventions for the watershed were to strengthen the capacity of smallholders to adapt to increasing climate change threats through an integrated sustainable watershed management and through improvement of agricultural productivity, livelihood diversification and ecosystem resilience. Due to the severe damage caused locally due to flooding, there was a significant focus on flood mitigation through soil and water conservation (SWC).

The major objective of the project was to implement SWC to:

- Protect the watershed area from heavy flooding by implementing soil and water conservation structures and biological measures;
- Improve the adaptive capacity of smallholders to cope against threats of climate change.

Methodology

The project approach was designed to strengthen adaptive capacity of farmers on participatory integrated watershed management. The farmers were trained on watershed management, on soil and water conservation, livestock management, on the win-win benefits of using energy saving stoves, also growing high value fruits and vegetables (Table 1).

Table 1: How the project relates to the themes of FAO-Adapt

Activities held on training	Male	Female	Total
Soil and water conservation	354	123	477
Livestock management	80	67	147
Energy saving stoves	0	210	210
High value crop	41	10	51
Vegetable production	34	17	51

After participating in the different training courses, farmers were given different hand tools to enable them to undertake the physical work to put their knowledge and skills into practice.

Result and Analysis

Within the watershed area, 250 ha of highly degraded land was fully closed and protected from any human and livestock intervention. The photographs in Figure 1 demonstrate that within a short period, natural vegetation had begun to regenerate and the planted trees begun to restore the vegetation cover.

Figure 1: Parts of the closed area after 12 months of closure

The physical work included the construction of 35 km of soil and stone-faced soil bunds on hillsides (Figure 2), 5 km of waterways and 10 km of cut-off drains, 5,000 m^3 of check dams, 5000 micro-trenches, 150 percolation pits, 2 ponds (Figure 3), 14 km of soil bunds, 6 km of fanya-juu, 1 spring development for gravitational irrigation and 3 micro-ponds for supplemental irrigation with treadle pumps.

Biological conservation works across the watershed involved planting 1,650,000 indigenous and exotic tree seedlings, the varieties chosen for their ability to cope with climate change. In addition, 20,000 elephant grass plants were planted on farm lands, 50 kg of Sesbania was directly sown on newly constructed terraces and 2.5 km of Vetiver grass was planted as hedging on farmland.
As a component of the integrated watershed management scheme to reduce damage to soil and vegetation due to trampling and over-grazing, project workers raised awareness of the benefits of crop livestock integration, by advising farmers to adopt zero grazing practices (Figure 4).

As an income generating source, horticulture crop seeds were supplied to 30 HHs (3 kg of tomato, 4 kg of cabbage, 1 kg of carrots and 2 kg of beet root). In addition, 52 HHs were supplied with apples, 36 HHs with 10 chickens each, 50 HHs with 3 sheep each and 170 modern beehives to 85 HHs (Table 2).

To further reduce environmental degradation, farmers were supplied with energy saving stoves to reduce the consumption of fuel wood and therefore mitigate deforestation and also decrease labour for fuel wood collection. Based on the interviews, farmers testified that the energy saving stoves have considerably decreased the amount of wood used and confirm the reduction in labour and time required for collecting fuel wood (Table 2). It would be interesting to quantify these benefits in more detail.

Figure 2: Soil and stone faced bunds

Figure 3: Rainwater harvesting pond, with geo-membrane lining to reduce seepage loss

Figure 4: A child following the new cut and carry system and modern beehives replacing the traditional ones

Table 2: Numbers of project activities implemented

Activity	Unit	Achieved
Multipurpose trees, shrubs and forage trees planting	Million	1.65
Plantation pits	Million	1.65
Stone faced soil bund	Km	151
Waterways	km	5
Cut of drains	km	10
Trenches	No.	5400
Improved crops	No.	30
▪ Course Participants	No.	10
Temperate fruit seedlings (apple)	Seed	436
▪ Course Participants	No.	52 (43 men, 9 women)
Spring developments	No.	1
Pond constructions	No.	2
Adoption of modern beehives	No.	170
▪ Course Participants	No.	85 (80 men, 5 women)
Promoting poultry raising	No.	360
▪ Course Participants	No.	40 (28 men, 12 women)
Promoting sheep raising	No.	150
▪ Course Participants	No.	50 (18 men, 32 women)
Promoting the use of energy saving stoves	No.	210 (all women)

Challenges and Lesson Learned

At the start of the project, the farmers who had poor levels of education lacked of awareness of the issues of climate change or options to adapt – which made some of them disinclined to participate in the watershed-wide planning activities, notably in soil and water conservation. Some farmers were unwilling to cooperate, particularly to give their land for area closure.

However, many farmers living in the watershed did agree to work together and share experiences to implement the project activities.

Conclusions and Recommendations

As an integrated watershed management scheme, physical and biological measures were undertaken to rehabilitate the degraded land and to strengthen the adaptive capacity of small-holders to cope with increasing weather variability, occurrences of extreme events and climate change, especially floods, through increasing their range of livelihood options and crop productivity. Through these physical and biological activities, a substantial change was noted very soon after the project started in agricultural productivity, due to the increased soil moisture retention and decreased erosion of top soil.

Best practices in soil and water conservation have been demonstrated and are being scaled-up in the area. However, more dissemination of physical and biological SWC options is still required for other neighbouring watersheds which are similarly being affected by climate change to uptake the improved practices and benefit from associated support measures.

Kenya

Strengthening capacity for climate change adaptation in sustainable land and water management: diversifying farmers' livelihoods in Siaya and Machakos Counties, Kenya

F.W. Maina, B. Okoba, P. Mwangi and M. Waringa

Introduction

In Kenya there is great concern that the fragile ecosystems (humid/sub-humid and drylands areas) will undergo noticeable changes due to climate change, with profound effect on rural communities. A reinforcing cycle of 'poverty, food insecurity and natural resources degradation' will be exacerbated by increasing weather variability and climate change. This requires urgent action and approaches, notably in the arid and semi-arid agro-ecological zones and some of highland humid areas of Kenya.

According to national statistics, the agricultural and rural sector is the top ranked contributor to national development in Kenya. The sector contributes over 80% of employment and 60% of national income directly and indirectly. It accounts for some 24.3% of the national gross domestic product (GDP) directly and 50% of export earnings (Government of Kenya statistics). Close to 80% of Kenya's population live in rural areas and derive much of their livelihood from the land through crop and livestock production, fishing and forestry activities.

Kenya has incorporated climate change adaptation strategies in its national planning documents. The climate change adaptation strategies pursued in Kenya have been classified as short-term and long-term measures. Some of the short-term measures include implementing a duty waiver on imported maize, irrigation, constructing cattle troughs in various parts of the country for watering animals, providing seeds and fertilizer to farmers to improve production and adopting energy-saving technologies. Some of the long-term measures include sensitizing communities about efficient and effective use of water, supporting and encouraging the use of rainwater harvesting techniques, de-silting water pans / dams and building new ones, implementing programs that provide emergency food supplies to vulnerable people, providing emergency relief to hard-hit livestock keepers during droughts, conserving water, especially by protecting water towers in towns and rural areas.

Agriculture is affected and contributes to climate change in various ways. Smallholder farmers, who form the majority of agricultural producers in Kenya, are highly vulnerable due to these changes. In 2011, maize production in Eastern Province dropped by 8% due to a poor harvest caused by early cessation of the 2011 short rains, attributed to changing climatic conditions. On the other hand, according to the Ministry of Agriculture (2012), there was an increase in cowpeas and green gram production in Eastern Province both in area under production and output in Eastern Province, including Machakos County. The increase in maize production in Western Kenya and Nyanza Provinces in 2011 by 13% and 16%, respectively, was attributed to increased use of fertilizer, expansion of more land under maize and more farmers shifting to maize from tobacco production. Hence, changes in weather and climate are important factors affecting cereal production in the country.

The project "Strengthening Capacity for Climate Change Adaptation in Sustainable Land and Water Management" set-out to support transformation of the Strategy for Revitalizing Agriculture (SRA) of Kenya 2010-2015 and the Kenya's Vision 2030; which aims to enhance and transform smallholder agriculture productivity.
Land ownership in the targeted areas is individual and hence efforts to improve land and water management have to be dealt with both at community and individual levels. At individual level, since watershed effects are the cumulative effects of all the individuals in the watershed, and at community level, to ensure similar enforcement of community by-laws.

The Study Counties

Selection of study counties

The selection of the four counties for the implementation of project activities was informed by two baseline studies conducted between January 2009 and November 2011 (Bryan *et al*, 2010; Maina *et al* 2012). The selected counties are Bungoma (Bungoma South and Bungoma West Districts), Machakos (Mwala District), Siaya (Ugunja District) and Embu (Mbeere South District). Mwala and Mbeere South

Districts are both mainly semi-arid. Bungoma is classified as sub-humid while Siaya is semi-humid to semi-arid.

The following Kenya papers (1-5) cover selected success stories from Siaya (representing sub-humid) and Machakos (representing semi-arid) Counties (Part 1 Figure 1).

Background of the counties

Machakos County, situated in Eastern Kenya, is classified as semi-arid with rainfall ranging between 400 – 800 mm per annum. Mwala District is among the very dry sub-counties in Machakos County. The district is highly agricultural with a bimodal rainfall pattern. The October – January season is more reliable and is considered the main cropping season in the district. However, the district is characterized by frequent crop loss due to drought and reliance on food relief.

Siaya County is in south west Kenya and is characterized by having moderate to low fertile soils (mainly ferrasols with underlying plinthite 'murram') with poor water retention, which can support crop production if provided with nutrient support (i.e. fertiliser). The county is characterized mainly as semi-humid to semi-arid with average between 800 – 1000 mm, which comes in bimodal pattern which is becoming increasingly erratic. Despite rainfall variability (frequency and quantity), the total amount received per annum is sufficient for crop production providing land users make good use of traditional rainwater harvesting practices.

Baseline characteristics of the study areas

The household baseline studies were conducted in the two areas to establish farmers' perceptions to climate change and to identify the current food crop and livestock production levels. A total of 96 and 77 households were sampled in Siaya and Mwala sub-counties, respectively.

From the baseline studies, it was discovered that the income level of the farmers in the study sub-counties averaged less than US$ 1,250 per year from both crop and livestock activities. However, some 11% of farmers in Siaya County are better-off and earned at least US$ 2,500 from both crop and livestock activities. The farmers earned more income from crop activities compared to the livestock activities.

Farmers in both study areas perceived that in the last 20 years temperatures had increased. In Mwala, 97% indicated that there was more rainfall variability than before. In Siaya, 76% indicated that annual rainfall had increased, with 92% observing that there was more rainfall variability than before.

Over the years, the farmers indicated that they had changed the crop variety or crop type grown due to the changing weather patterns. Very few farmers (8%) in the two study districts indicated they had not made any adjustments to the crop and livestock farming practices in the face of climate change.

In addition to the adjustments made, there were other adjustments that the farmers desired to make to cope with the changing climate, but were unable to make these for various reasons. The adjustments they wished to make included: planting trees; diversifying to higher value crops; and introducing/increasing areas under irrigation.

Project implementation in the counties

(a) Machakos County

In Machakos County, the project was implemented in three watersheds in Mwala District. Each of the watersheds constitutes a location (several villages make up a sub-location, several of which make up a location). The three watersheds in Mwala (Kibao, Maweli, and Kathama) have become characterised by continuous crop failure, as large areas are under production of maize – which is not drought-tolerant. At least 95% of the farmers surveyed during the baseline study grew maize as the priority crop and experienced crop failure in the study year. This threatens food security – but most of the farmers did not grow pulses (e.g. cowpeas, green grams etc.) that would perform better in the study area as indicated earlier. There was clearly a need to promote food crop diversity.

It was also observed that one of the major impediments to successful crop and livestock management was the serious development of gullies in both Kibao and Kathama watersheds. It was observed that the gullies were as a result of poor cultivation practices (including cultivation on steep slopes, deforestation and sand mining) and overstocking.

The farmers who attended a project training of trainers' workshop in January 2012 identified cost-effective ways of addressing the gulley problem. These included planting of fast growing sisal and building gabions using locally available materials to over time halt the gullies from expanding downstream. Use of proper land management practices was also identified as a way of reducing gully erosion originating from the farmers' fields. However, a community approach is also needed to address gully formation caused by deforestation and cultivation of steep slopes upstream of farmers' fields.

(b) Siaya County

The county is inhabited by the Luo people, who traditionally depended on fishing as their main livelihood. During recent decades, high rates of depletion of fish populations have been observed in the local water bodies (Rivers Yala and Nzoia, swampy waters and Lake Victoria) within Siaya County. The community has been forced to look for alternative livelihood sources such as farming and business activities.

In Ugunja Sub-County of Siaya County, project implementation was through a watershed approach. The Ugunja Sub-County is characterised by low and declining soil fertility, high incidence of soil erosion, food and nutrition insecurity among the population and high incidence of HIV/AIDS. Three watersheds were selected in Ugunja District in a participatory process with partners. The watersheds are Sidindi (constituting 3 villages – Madeya, Markuny and Sidindi), Nyusi (constituting 3 villages – Nyadhi, Uyoma and Sirongo), and Cham kidiyo watershed (meaning "eat as you save your output", which is in Simerro village). A total of 104 farmers were targeted directly, with efforts that have begun to scale-up to reach the approximately 2,000 farmers in the surrounding watersheds.

During a community meeting, farmers expressed their desire for specific adaptations to climate change including: introduction and expansion of the number of trees (including fruit trees); establishment of soil and water conservation measures; introducing/expanding irrigation of crops; change of crop types; and diversifying to high value enterprises. Demonstration plots were used to show some of the land management practices including: planting maize and legumes using conservation agriculture; production of high value vegetables using irrigation from permanent streams and harvested runoff; and various soil and water conservation measures.

As an entry into the community, farmers in the study area were taken on a visit to fellow farmers within the watershed who were already practicing irrigation using streams and runoff water, fruit production, fish farming among others. Following this visit, the farmers developed an interest in the dual benefits of fish farming and vegetable/tree nursery irrigation. With the presence of streams in the study area and lots of runoff water, but hindered by inability to meet the costs of fish farming, the farmers requested assistance to purchase fingerlings. Their contribution would be to ensure that the fish ponds were excavated according to provided guidelines.

As implementation of project activities progressed, it was acknowledged that whereas the majority of the farmers actively participated in the group demonstration plots and acknowledged the benefits, the uptake of the practices on individual farms was slow. A quick appraisal of the member farmers revealed that some of them were quite vulnerable, especially due to the effects/impacts of HIV/AIDS, which left most of them having more dependents than they were able to feed. The vulnerable farmers typically had to save and sow their maize and beans seeds from previous seasons, resulting in very low harvests (i.e. not able to purchase improved or hybrid seeds which may give higher yields). These farmers also grew local cassava varieties, which take more than two years to mature (and are toxic if eaten before maturity). The high number of young dependents also meant that farm labour was scarce.

The project implementers resolved to target assistance to the vulnerable with essential seeds and fertilizer, in addition to building their capacity on appropriate cultivation methods. The objective was to ensure that at the end of the season, the households' immediate food needs could be met. Through linkages with the State Department of Agriculture and other successful farmers in the region, the vulnerable farmers also received planting materials for tissue-cultured banana (for ripening and cooking varieties), orange-fleshed sweet potatoes and early maturing cassava. Bananas, sweet potato and cassava are important food and income security crops in the long run in the study area.

The initial outcomes of these efforts are documented in succeeding papers.

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Kenya Paper 1

Enhancing seed and food security and cash income for vulnerable farmers of Siaya County, Kenya

B. Okoba, P. Mwangi and M. Waringa

Introduction

Each of the three watershed groups was sub-divided into two or three sub-groups for ease of management and to increase participation of the members. Through participatory group discussions, priority areas of need were identified by the farmers and relevant technologies/practices were introduced to the group through the group-plot approach. In this approach, each sub-group had a group plot where the project technical team demonstrated the various technologies and/or practices that the group could learn from. The group members were expected to each adopt on their individual plots the practices that were attractive to them. Watershed committee members were identified and trained on climate change adaptation to assist the project in monitoring project activities at individual farmer level.

As described in the background paper, the project established that most of the farmers who did not join the groups were highly vulnerable in many respects – and the decision was taken to particularly support them.

Approach targeting vulnerable farmers

Vulnerable farmers are here defined as *"those farmers who cannot afford at least two meals per day, cannot afford to purchase certified seeds and fertilizers and are not resilient to climatic shocks. They are also either HIV/AIDS infected or affected"*. Using these criteria, the community leaders within the three watersheds held several household meetings and identified this vulnerable group. A total of 26 farmers were identified as the first group for support. The vulnerable farmers were each given certified seeds (either: 2 kg of maize and/or 2 kg of sorghum; also 2 kg of beans) and 20 kg of each of planting and top dressing fertilizers. Depending on their ability to maintain and sufficiency of size of land, they were also given one or more of the following: a half bag of orange fleshed sweet potato vines (300 vines); 200 cuttings of an early maturing cassava variety; and tissue culture banana (plantlets) seedlings – depending on the beneficiary's ability to prepare the planting pits and provide manure.

Challenges faced by the vulnerable households

Most of the vulnerable households are women headed and are either HIV/AIDS infected or affected. Most of these households consist of only the elderly and their orphaned grandchildren. In some households, it is only the elderly who engage in farming, as most youths have migrated to towns in search of jobs. As a result, labour becomes a major constraint in carrying-out farm operations. Even though most of the vulnerable group are not limited by size of land, but by shortage of farm labour thus only able to utilize/cultivate a very small area of land. Cultivating such small land sizes are uneconomical and cannot produce enough food to meet their food needs.

Characteristic of these vulnerable households is the general inability/lack of capital to purchase hybrid or improved seeds and organic or inorganic fertilizers to improve farm productivity. This forces them to plant local seeds which are often very low yielding - without fertilizers; hence these households suffer from food deficit. As a tradition, these farmers grow only a limited range of crops (local maize and beans) and in the face of climate change crop failure is becoming more frequent, leading to even greater food deficit. Some of these farmers also grow local cassava, which is prone to diseases.

The low diversity of crop grown by the vulnerable farmers makes more vulnerable to climatic shocks than farmers growing a wider range of crops.

During the analysis of these vulnerable farmers, it was identified that they had no access to/could not afford improved varieties of early maturing cassava, orange flesh sweet potato, millet and sorghum. Local cassava which takes about three years to mature and is highly toxic (even fatal) when eaten raw or boiled and can only be used for flour is not comparable to the improved cassava varieties, which take about six months to mature and can be eaten raw, eaten when boiled or ground for flour. Orange flesh sweet potato has higher levels of vitamin A, which is deficient in many local diets. Millet and sorghum are more drought tolerant than maize. The vulnerable were found to lack the appropriate skills and knowledge on proper crop husbandry.

Objective of supporting the vulnerable farmers

The objective was to enhance the capacity of the vulnerable farmers in Siaya County to grow sufficient food crops, secure their own seed and generate incomes to become more resilient in the face of climate change.

Testimony of beneficiaries: Case story of Jenifer Atieno

Jenifer Atieno is a mother of six children and all of these children totally depend on her. Her husband abandoned her, disappearing into urban areas and she has never heard of him for the last 13 years. Though her parcel of land is eight acres (3.24ha), she only utilizes less than one acre (less than 0.4 ha). Before the project intervention, she could only afford one meal per day and her family was in severe food deficit for seven months each year. From the local variety of maize she planted, the maximum she could harvest on cultivated land of 0.05 ha was about 800 kg/ha. She spent most of her time engaged in casual labour on neighbours' farms, but her earnings could barely provide enough food to feed her family. The project assisted her with two (2) kg of maize seed, two (2) kg of beans seed, two (2) kg of sorghum

Figure 1: Jenifer tending her orange flesh sweet potato

Figure 2: Jenifer weeding her improved cassava

seed, a half-bag of orange flesh sweet potato vines, 200 cassava cuttings, 25 plantlets of tissue culture banana, 20 kg of NPK and 20 kg of CAN fertilizers. Jenifer intercropped maize and beans -; on the 0.05 ha; sorghum was established on another 0.05 ha, while orange flesh sweet potato vines (Figure 1) and cassava cuttings (Figure 2) were both established on another 0.05 ha of land.

From the support Jenifer has received from the project, during long rain season of year 2013 she managed to harvest four (90 kg) bags of maize, four and a half (90 kg) bags of sorghum and one (90 kg) bag of beans. She is yet to harvest the sweet potato and cassava which will be maturing in due course. Currently, she is a very proud bread winner for her family as she can afford three meals per day from the maize, beans and sorghum she has harvested. From the orange flesh sweet potato, she anticipates she will harvest and sell six bags of vines (valued at US$ 70), while maintaining her own vine seeds for re-planting and also improving her diet from eating the orange flesh potato tuber and sell about five bags of the tubers (valued at US$ 115). The cassava will improve her diet; generate income by selling cassava cuttings worth US$25 and orange flesh potatoes worth US$ 70. She will also have enough cassava cuttings for use as planting material for next season on her farm. The banana plantlets she planted have started producing plantlets and she intends to have at least 50 stools of banana, so that she can have enough for her family and some for selling. In the next three months (October to December, 2013) she anticipates to be able to sell 250 plantlets worth US$ 290 and a 100 bananas worth US$ 580.

According to Jenifer, from this income, she will be able to: purchase certified seeds of maize, inorganic fertilizers and other household food; pay for school fees and clothes for her six children; hire casuals to work on her farm so as to increase land area under production to at least four acres (about 2ha); purchase a dairy cow among others. She does not need to purchase sorghum and bean seeds as these seed do not easily lose their yield potential, so she can save and plant from her own harvest in subsequent seasons. The project has enabled Jennifer to learn to select and bank seeds. Due to the excitement she has as a result of being food secure and anticipating income generation, she foresees herself dedicating all her efforts in increasing the area under cultivation to increase food production in her farm rather than seeking casual engagement in neighbouring farms.

Jenifer confesses that the little help she received was an eye opener. Though originally a member of Nyadhi sub-group in Nyusi watershed, she remembers how she had to pull-out of the group due to lack of esteem, failing to participate in group meetings well as she felt out of place, but now she has confidence and has applied to be considered to become an active member of the group.

The project support in assisting the 26 vulnerable farmers has enabled these farmers to be food secure, reduce greatly the number of months they were food deficit and / or generate income. With more funding, more vulnerable farmers will be capacitated to feed their families and generate income, following in Jennifer's footsteps.

Overall Impact/Progress on supported vulnerable farmers

Whereas the orange flesh sweet potato, cassava and banana are yet to be harvested, the following analysis and graphs show the maize and sorghum production trends among the supported farmers.

Figures 3 and 4 show that changing from local to hybrid maize and sorghum crops has benefited the project farmers in terms of yields. Before the project, the vulnerable farmers planted their local seeds without fertilizers, as they cannot afford to purchase hybrid seeds or inputs (Input costs for hybrid Maize are 172 US$/ha against 11.5 US$/ha for local Maize, and 182 US$/ha for improved Sorghum against 21 US$/ha for local Sorghum). The advantage of using the fertilizers is that the farmers enrich the soil, unlike where the farmer plants without any fertilizer input, which leads to continuous mining of the inherent soil nutrients.

The observed production pattern shows that using the project-supported certified planting materials and fertilizers the vulnerable farmers were able to double or triple their maize and sorghum yields. This implies that if initially the farmer was faced by six months of severe food deficit and was able to double the yield, he/she has managed to reduce this to three months with maize and sorghum alone without considering the banana, sweet potato and cassava food sources. After satisfying food needs at household level, farmers can now sale excess food for meeting other household needs.

Figure 3: Comparison between local and improved maize yields (kg/ha) in vulnerable farmers' field (in 2013 long rains)

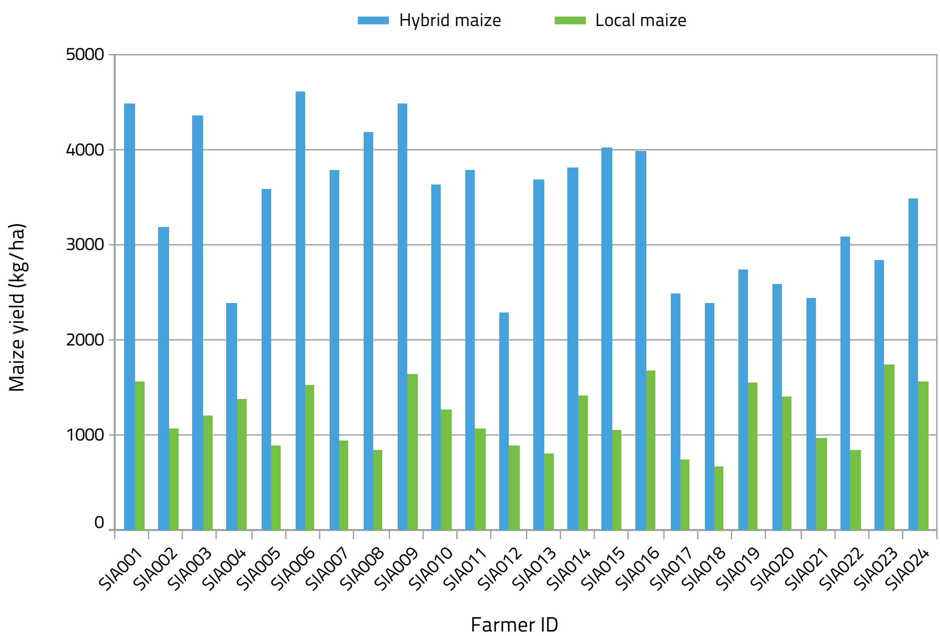
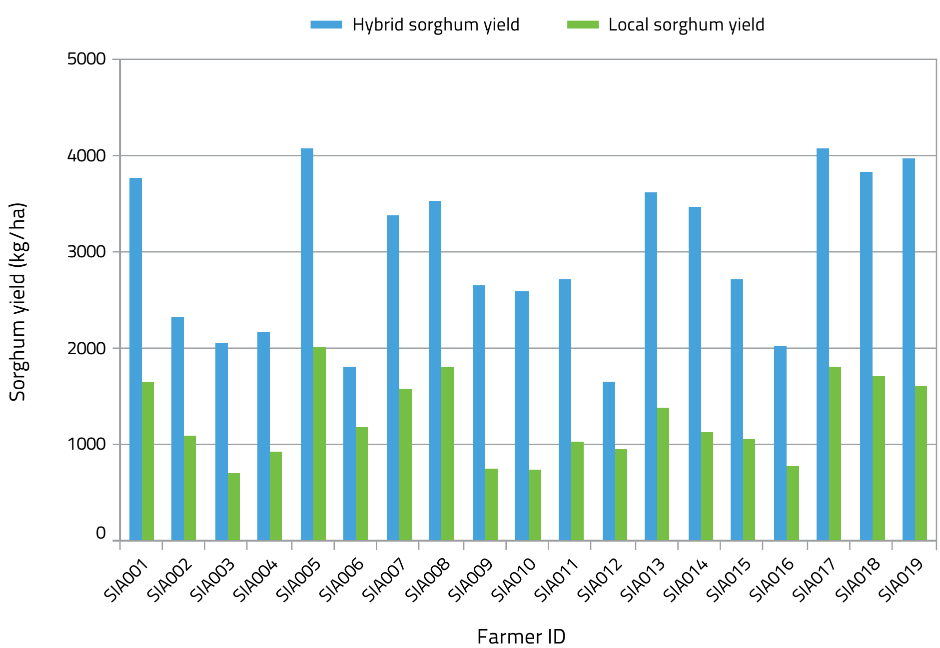


Figure 4: Comparison between local and improved sorghum yields (kg/ha) in vulnerable farmers' field



Conclusions

It is possible to alleviate most of the challenges facing the vulnerable farming community in Siaya County through identifying, disseminating and supporting the appropriate technologies which will enable these farmers adapt to climate change. In the face of the climate change, special attention needs to be paid to addressing the particular needs of the vulnerable, to make them more resilience to climatic shocks. In particular, special attention should be placed in developing their human and social capital, for the longer-term, along with the selective support which will enable them adapt their farming to the immediate threats of climate change. It is possible for the vulnerable households to raise their self-esteem through building their capacity to adapt to climate change, especially in food and nutrition security. Diversification of crop production is particularly important to reduce the risks of food insecurity attributed to increasing weather variability and climate change – if one crop fails due to a drought, or flood, or disease outbreak, they will have other foods to fall back on. Diversification of the crops grown also helps the vulnerable to improve their diets, reducing malnutrition. The project beneficiaries are now also able to generate a sustained income from the sale of tissue culture banana plantlets, cooking and ripening bananas, sweet potato vines and tubers, cassava cuttings and tubers. School fees for the orphaned children may no longer a burden that requires external support. They can also afford to buy quality seed and fertilizers for planting in the subsequent season.

Conservation agriculture principles have been emphasized in all crop and land management to improve soil fertility and increase water availability to the growing crops, to address labour shortages and to rehabilitate degraded land. Most soils in Siaya are either degraded or low in fertility. Without nutrient support to these soils, improving crop production by the farmers is impossible.

Way Forward

Due to low soil fertility, there is need for adoption of techniques and practices that enhance soil fertility to increase crop productivity. Promotion of agroforestry, composting and cover crops will be required to improve soil fertility and enhance build-up of organic matter. Soil conservation needs to be enhanced, so as to check on soil degradation.

The project only supported 26 vulnerable farmers, since the vulnerable lack the capital to acquire inputs for use in their farms. Now that we are experienced in handling the vulnerable farmers in communities, there is a need to advance support to other vulnerable farmers with starter planting materials (crop seeds, vines) and farm inputs (fertilizers) if they are to be supported towards a state of food sufficiency and sustainable income generation in the face of climate change. In the face of climate change, there is need for farmers to diversify rather than relying on production of maize and beans only. More emphasis should be on inclusion of drought tolerant crops such as sweet potato, sorghum, millet and early maturing cassava which are short term crops. The yields of these crops are far greater than that of maize and beans per unit area. Banana production should also be promoted in the area as these perennials are less vulnerable to the impacts of increasing weather variability, thus contribute to long-term food security and income generation.

Since labour is a limiting factor of production in vulnerable households, there is need to promote labour saving techniques, for example conservation agriculture. Minimum tillage, with use of selected safe herbicides, will reduce the time taken in carrying-out land preparation and also save on cash compared to conventional way of land preparation and weeding. It will also check on erosion. In Siaya, the rate of evapotranspiration is high, limiting soil water available to plants. Therefore there is need to maintain soil cover in crop lands to conserve the soil-water available for plant establishment and development.

Besides focusing on increased food production, there is need to build farmers' capacity on post-harvest technology, encourage seed bulking (especially for sorghum, millet and beans), value addition and on marketing strategies.

Kenya Paper 2

Marketable banana production for enhanced incomes and food security, Siaya County, Kenya

B. Okoba, P. Mwangi and M. Waringa

Introduction

Kenya Agricultural Research Institute (KARI) was introduced to the community through the State Department of Agriculture. The latter has been supporting households in the community in a partnership to mitigate the impacts of HIV/AIDs that has impacted on food security. Furthermore, their children had challenges of accessing education and health services.

During a participatory meeting in June 2012, the farmers in the three watershed groups identified priority crops that would help them achieve both food and income security. A bottom-up approach provided an opportunity for the community to make their choice. From a possible 17 crop enterprises, banana production was the preferred enterprise by the farmers in the three watershed groups. The objective of identifying a preferred enterprise was to use it as an entry point to disseminate appropriate sustainable land and water management options. Demonstration plots were set-up as an element of farmer field schools (FFS) to promote learning the technologies involved in banana farming.

All farmers who were interested in engaging in banana production or expanding the few stools they had were identified. The minimum criteria for each farmer were:

- Sufficient land size;
- Ability to dig the banana planting pits according to recommended instructions;
- Availability of manure or compost, sufficient for all pits dug.

Groups of farmers were then trained to make compost and use manure, sharing it among themselves for planting the bananas.

Challenges

Other than the challenges facing Siaya County as a whole, the farmer groups in the three watersheds were also asked to identify the specific constraints they face to improve agricultural production and their possible solutions. The challenges included:

- Unreliable and unpredictable rainfall patterns – previously the farmers would plant by the end of February, but currently it is not certain when rains will start and the quantity to be expected, with the short rain season at times being longer and with more rainfall than the long rain season. At other times, the rains are heavier, falling over a much shorter time period, resulting in destruction of crops in the fields;
- Increased daytime temperatures, accompanied by very cold periods at night causing frost, hence negatively affecting crop production;
- Inadequate skills to implement good agricultural practices;
- Use of local varieties;
- Poor soils (low soil fertility);
- Lack of timeliness of farm operations, leading to low productivity;
- Inadequate fodder, resulting in free grazing hence increase in tick-borne diseases;
- Pests and diseases (banana Xanthomonas, avocado disease, cassava mosaic virus, blight, redwater in cattle [not previously known in Siaya] and Newcastle disease in chickens);
- In some parts of the study sites, land is steeply sloping, leading to high rates of runoff of rainwater and soil erosion from farms;
- Insufficient labour due to challenges brought about by diseases – the majority of the farmers in the targeted groups are either infected or affected in various ways by the HIV/AIDS. Where a farmer is actually infected and falls sick often, they lack sufficient labour to conduct farm activities and hence this reduces productivity and food availability on-farm.

As possible solutions to the identified challenges, the farmers in the three watersheds identified the following:

- Crop diversification to cushion against complete failure of some crops – farmers popularly selected banana production as an important perennial crop to grow alongside other food crops;

- Increase area under drought tolerant crops that also double as income sources (e.g. cassava, sweet-potato and sorghum);
- Adopting fish farming;
- Use traditional methods of preserving food in times of bounty harvest – sweet potato, cassava, vegetables, groundnuts
- Decrease herd sizes to decrease demand for land and fodder – traditionally, farmers in the county kept large numbers of cattle to cushion themselves against drought and crop failure. The current land sizes cannot however sustain such herd sizes;
- Diversify to include enterprises that require minimal labour – this will ensure that even in months where a farmer is not able to work much, they are still able to harvest and sell some of the crops. These crops ensure food security on-farm and the income can be used to hire farm labourers.

Practices Demonstrated to Improve Banana Production

With banana and fruit tree production identified by the farmers as the preferred option, it was also evident that most of the farmers in the group already had bananas, but most were diseased and had low levels of productivity on their farms. In response, the project invested in several activities to ensure the farmers understood the importance of good management practices in banana production. This in turn would ensure that the banana plantlets provided by the project would actually benefit the farmers in the medium- to long-term.

The practices demonstrated to farmers through practical training included:

- tillage practices (minimum tillage);
- cover cropping and mulching for moisture retention and weed control using locally available materials (e.g. Tithonia, maize stovers, grass etc.);
- making compost and appropriate materials to use;
- banana production – preparing the pits for planting, manure and water application, mulching and use of cover crops (e.g. Tithonia);
- run-off water harvesting for banana production;
- other in-situ water harvesting techniques.

The targeted outcome was diversified sources of income from fruit sales, improved household nutrition and reduced labour requirement once the system was established.

Outcomes (by October 2013)

At least 2,500 disease-free banana plantlets were distributed to 66 farmers in the three watersheds with at least 40 farmers in Nyusi watershed group accessing an average of 40 banana plantlets. Nyusi group had the highest number of women and vulnerable farmers. Various training sessions were conducted on management and water conservation through cover-cropping techniques.

A sample of ten of the farmers who received the banana plantlets showed that in less than two years, the ten have not only kept growing their banana stools, but also been able to sell or given away banana plantlets valued at US$ 601 at an average price of US$ 1.2 per banana plantlet. Those that have given away plantlets gave to neighboring vulnerable farmers, including 200 banana plantlets to a group of physically disabled people within the county. Nine of the sampled ten farmers have also sold 165 bunches of bananas that had matured; at a total value of US$ 971 (ranging from 9 to 44 bunches per farmer).

From the sales to-date of the sampled farmers, it is evident that once all the banana plantlets have established, the farmers will be able to increase their banana populations and hence increase the income from sales. The income generated can then be used in meeting various income needs of the farmers' families. Some of the beneficiary farmers were already growing bananas and benefited from the training on management and water conservation through mulching and cover-cropping techniques to improve the quality of their crops (Figure 1). In the words of one of the banana farmers, George Ouma, who has benefited through improved management and increase in banana population, "the banana production has huge potential in the county and beyond. One of the greatest challenges is in marketing," he adds, "is lack of sufficient volumes to interest banana traders and hence ensure better prices for the bananas produced in the county."

Figure 1: **Healthy bananas produced by project beneficiaries from plantlets**

Photo: © FAO

Case Studies

a) Mr. George Ouma – a beneficiary of training on water harvesting for banana production

Mr. George Ouma is a member of Sidindi watershed group. He was a banana farmer before the project started and had 280 stools of banana. The project trained him on improving soil fertility, rainwater harvesting and increasing the efficiency of water use in his banana farm. He also received 320 plantlets of banana from the project – half of these were F117 and half Ng'ombe varieties, which were new to him. From the Ng'ombe variety, 80% of the stools are already in production and he has sold bananas worth US$ 529 and also sold 1,500 plantlets worth US$ 1,765 from the two varieties. The F117 takes more time to start bearing the banana compared to Ng'ombe variety though F117 is more prolific in terms of plantlet production compared to Ng'ombe variety. From the 320 plantlets he received he has already established 190 more and has already prepared 120 planting pits, giving him a final total of 630 stools – he cannot expand further, as he is limited by land size. When these stools reach maximum production, each stool will at least produce three bunches of bananas per planting hole (which could have three stools) per year implying that the total production per year will be 1,890 bunches. With this production, the gross income he anticipates will be US$ 11,118 per year. He also anticipates selling at least five plantlets per stool per year i.e. 3,150 plantlets worth US$ 3,706.

From the income generated, Mr. Ouma is now able to buy food and non-food items, meet the school fees demands for his daughter in the university, his daughter in middle level college and his son who is in secondary school.

In case of an outbreak of a disease that would jeopardize his banana farming, Mr. Ouma will still be resilient since he has diversified farming as he also has sweet potato, fish farming, sorghum, local cattle and commercial local poultry production and tree nurseries. Currently he is one of the major orange flesh sweet potato vine producer in the area. He would also like to venture into production of short-term crops such as vegetables and sorghum rather than maize and beans which can perform poorly due to poor rainfall.

Since we supported this farmer through capacity building and provision of plantlets, Mr. Ouma has also supported other farmers and institutions by offering them technical backstopping on banana production and also with 270 free banana plantlets, as part of his cooperation responsibility.

Mr Ouma's major objective in providing the institutions with the banana plantlets is to develop a learning ground, especially for the pupils in these schools, so that they can take the practices back home and boost food security and also to equip them with the knowledge that will prepare them to be good banana farmers in future. In his neighborhood, he has encouraged seven farmers to take up banana production and each has at least 100 stools of banana. Mr. Ouma's future prospect is to start value addition of banana such as juice and wine making and also establish retail outlets in leading supermarkets.

b) Enhancing water harvesting within the farm to improve banana production – the case of Mr. Adonijah Owino

Mr. Owino is another beneficiary of banana plantlets from the project - he received 100. The uniqueness of his banana farm is that he has harvested all the water from within the farm and channeled it to every banana planting pit. Currently he has established 50 additional stools from the ones he received. Mr. Owino has sold bananas worth US$ 53 since establishment and many more bananas are about ready for harvesting or are just putting on fruits/fingers. He has earned US$ 588 after selling 500 plantlets to neighboring farmers. Besides selling these plantlets, he has been able to issue 20 plantlets his neighbors, free of charge. Several farmers have been frequenting his farm to enquire about banana production and he has been assisting them with the relevant information and skills.

Due to his old age (67 years), Mr. Owino considers banana as his most valuable crop, despite also growing maize and sorghum. To him it is more than the pension he receives on a monthly basis and he refers to it as his security crop.

c) Promoting crop diversification using banana farming

Another farmer, Mr.Cosmas Oduor in Ugunja District, received 5 banana plantlets through his son in school; today he has more than 200 banana stools. He attributes the successful secondary education of his first born daughter to his income from the bananas. His daughter qualified for university education in 2013. As a result of partnership with KARI, this farmer has enrolled in a group with other farmers and have benefitted from the climate change adaptation project. Besides bananas, this famer has a vegetable garden which is evergreen as he irrigates it and it is a major source of vegetables for the community throughout the year. The main challenge Mr Odour reported is that the access feeder roads are impassable during the rainy season; therefore transporting his products to the market is difficult. His customers are mainly neighbours, but his desire along with others is in his group, to widen the market beyond Ugunja District as the land under bananas is expanding.

Lessons Learned

- Mentoring farmers and using them as mentors strengthens farmer to farmer learning;
- Working with farmers in organized groups creates more impact;
- Exchange visits promote learning and adopting of new technology;
- The 'pass on' system of sharing banana plantlets promotes distribution of the new disease resistant varieties;
- The adaptive banana practices have 'quietly' broken the cultural barrier of women being prohibited from planting bananas.

Conclusions

It is evident that banana production in Siaya County is a good crop diversification to enhance food supplies and incomes. The farmers, who at the start of the project activities could not adopt most of the simple technologies demonstrated on the demonstration fields, are now able to raise and share plantlets, as well as selling plantlets and banana bunches commercially.

The Way Forward for Wider Adoption

The farmers in the groups are encouraged to demonstrate the importance of diversification through banana production to other farmers in the respective watersheds in order to increase banana production. Some farmers outside the group still have diseased banana stools on their fields and the group members in collaboration with the State Department of Agriculture are making efforts to educate these farmers on the importance of planting clean banana plantlets or plantlets from disease-free stools to increase land productivity.

As indicated by Mr. Ouma, quantities are necessary for efficient marketing of the bananas. Once the group members are able to have continuous production, they will be able to move to joint marketing of the bananas. Marketing will require capacity building and adoption of other techniques (e.g. ripening chambers, preservation boxes) to ensure the quality that meets market demands. The banana growers in Ugunja also wish to add value to their produce (e.g. products like banana chips, wine) which they wish to retail in existing supermarkets in Kisumu, Siaya and Busia to start with.

Recommendations

- Banana production is a viable diversification crop in terms of food security and income generation.
- Farmers need to be trained in value-addition and linked to external markets.
- Replication of the land and water management practices in the entire area of Siaya County (Gem, Bondo, Rarieda and Ugenya Districts) and other counties would be highly beneficial.

- Bananas should be promoted as a crop specialization.
- The adaptive capacity of farmers to climate change can be improved through promoting experience sharing, setting-up demonstration plots, and also training farmers to expand the knowledge and skills to the wider population.
- Continuous research is necessary for the development of more dynamic technology generation (e.g. ripening chambers and preservation boxes).
- Farmers can be organized in cooperatives to enhance marketing of the bananas.

Kenya Paper 3

Fish farming for food and income diversity in Siaya County, Kenya

F.W. Maina, B. Okoba, P. Mwangi and M. Waringa

Introduction

Food and nutrition security is a major problem in Siaya. This is further compounded by the fact that reportedly the county has the highest HIV/AIDS prevalence in the country, requiring higher nutrition levels to remain healthy.

As part of the implementation process, the farmers in the study area were taken on an exchange visit within the county as a way to introduce them to successful approaches in their neighbourhood. As a result of the field visit and subsequent project activities, at least 20 farmers expressed interest in engaging in fish production. Fish farming was a preferred enterprise to diversify their sources of income and improve the nutritional content of local diets. Fish is an important part of the diet of the population in Siaya County. However, the decline of the Lake Victoria fisheries, the main source of fresh fish in the region, has reduced availability in the surrounding rural towns. The fish from Lake Victoria is delivered to Ugunja District from Port Victoria through Busia (120 km away) or from Kisumu (70 km away).

Testimony: the case of Richard Ooko

Richard Ooko is a member of the Sidindi watershed group. Through the Economic Stimulus Program of the then Ministry of Livestock and Fisheries, Richard and ten other farmers in the watershed received fish and fishponds in 2009. Through sale of fish and other co mmodities on his farm, Richard has been able to increase one more fishponds next to the stream. He has since modified his house from farm income and reco mmends fish farming to the farmers within the group. Richard's testimony and his changed status encouraged the farmers who are in the same watershed and group.

The fish fetch higher prices in urban areas and the traders prefer to sell in urban rather than rural areas. Consequently, fish is quite expensive in Ugunja District.

On the other hand, several permanent rivers and streams flow in Ugunja District, but the farmers and other residents have not utilized them sufficiently for fisheries. This presents an opportunity for the farmers in the county who are able to have fishponds on their farms to improve their families food and nutrition security through production and consumption of fish, as well as providing a new income sources.

Objective

The objective of the activity was therefore to tap into the common diet of the community and introduce fish farming as a favorable enterprise that would improve local food supplies and nutrition, as well as a new source of income in the study area.

Approach

The farmers in the three study watersheds were introduced to fish farming through visits to other farmers within the watersheds who were already practicing fish farming in ponds along the streams or using harvested rainwater on farms far from natural streams/rivers. The objective of the visits was to give the farmers an opportunity to appreciate the dynamics of fish production, including the costs and benefits associated with the fish farming in the two different pond types.

The project facilitated the State Department of Fisheries to train the farmers on various aspects of fish farming, including: selection of pond sites and excavation; pond and fish management; preparation of home-made fish feed rations for various stages of growth; potential benefits.

Following the introduction, at least 30 farmers expressed the desire to engage in fish farming as their farms were next to permanent streams. However, the farmers indicated that the major constraint was lack of finances to excavate the ponds, purchase the fingerlings and the feed.

The project proposed a cost-sharing arrangement with the farmers. The farmers were to meet the cost of excavating the fishponds and preparing sufficient home-made feed rations for the targeted number of fingerlings, while the project would meet the cost of purchasing fingerlings for each fishpond approved by the State Department of Fisheries.

The farmers were free to choose the type of pond they preferred, based on their farm location. In the case of the harvested-water ponds, care had to be taken not to situate the pond on a very steep slope, which would result in rapid siltation of the pond. The farmers were required to install sufficient silt traps to reduce siltation of their ponds. To aerate the pond, a pedal pump is used to pump the water out and directly back into the pond. To reduce the water volume after rain and make way for fresh water, excess pond water is used for other activities, including irrigation of tree nurseries and vegetable gardens.

Results

The farmers excavated 12 ponds, all of which were approved by the Fisheries Department and the project supplied them each with at least 1,000 fingerlings. All the farmers/farmer groups preferred tilapia, as it is the most popular fish and easiest to both manage and sell.

Of the 12 fishponds excavated in the study area, two were constructed by subgroups and ten by individuals. The two sub-groups pooled their labour resources together and will use the returns from fish farming as a means to finance their future activities. The members will also use part of the fish from the sub-group ponds as food.

After reviewing the processes involved, the costs and benefits of fish farming were estimated. The cost of preparing homemade feed rations, made from readily available crushed maize, maize germ from posho mills, chicken droppings, dried Desmodium leaves (where available), dried bean leaves, mineral salts among others, amounted to US$1.1 for 1,000 fingerlings. Excavating a fish pond for 1,000 fish measuring 20 m long x 15m wide x 1.2 m deep requires 25 days of labour at a cost of US$3.4 per workday, a total labour cost of US$ 86. Each fingerling costs between US$ 0.08 and 0.12 giving a maximum total of US$ 115 for 1,000 fingerlings. The geo-membrane lining, which was used for rainwater harvesting runoff ponds, cost approximately US$ 862 per pond. Tilapia, the preferred fish type in the study area, costs approximately US$2.3 /fingerling at maturity (after eight months). These costs and benefits are summarized in Table 1.

Table 1: Costs and benefits of fish farming (in US $) using different types of ponds

Costs/Benefits items	Ponds along streams (US$)	Ponds using run-off (US$)
Costs:		
i) Labour costs:		
a) Excavating pond	86	86
b) Purchasing pond liner	0	862
c) Laying lining by professional	0	287
ii) Management costs:		
a) Preparation of homemade feed rations	1	1
b) Labour costs during feeding, cleaning pond	14	14
Total Costs (US$)	**101**	**1,250**
Benefits:		
i) Sale of 900 mature fish**	2,069	2,069
Total Revenue (US$)	**2,069**	**2,069**
Gross Profit (US$)	**1,968**	**819**

** It is approximated that the household consumes at least 100 fish and sells the rest

The gross margin analysis shows that even with the use of geo-membrane lining, the farmers are able to make a profit within the first season, having consumed at least 100 fish within the household.

Testimony: the case of Eliud Omondi

Eliud Omondi is member of the Nyusi watershed group. He was among the farmers who were interested in fish farming after the project introduced the community to the concept. There is a permanent stream that passes through his farm. Upon excavation of the fish pond and with certification from the Fisheries Department, the project provided Mr. Omondi with 1,000 fingerings. His fish pond measures 20 m long x 15 m wide x 1.2 m deep. He feeds them twice a day with 2 kg of feed. The fingerings are now three months old and will be harvested when they are eight months old (at maturity). The cost of feed per day is approximately US$ 1.1 and so by the time he sells them his costs will total about US$ 276. Depending on size, he anticipates he will sell each fish at a minimum of US$2.3 meaning his income will be about US$ 2,300, therefore he should be able to make a profit of between US$1,765 – 2,000 if all other factors are constant (i.e. no theft and limited mortality).

Testimony: the case of Eliud Omondi (continued)

According to Mr Omondi, with this income he will be able to pay school fees for his children, purchase certified seeds, fertilizers, fingerling stock for rearing more fish, also other food and non-food items. He foresees himself being more resilient to climatic shock than when he was relying on maize and beans production only. Consumption of fish will improve the diets, hence the health of his family.

At a time like this when the Siaya area is experiencing frequent dry spells, Mr Omondi can also irrigate his kale using the water from his fish pond and using the manual ('money maker') pump he borrows from Uyoma Farmers Group of which he is a member. Providing that he does not deplete too much water! Mr. Omondi is able to get US$ 28 per week from the sale of kales. This ensures a steady source of food and income as he awaits the anticipated income from the sale of fish (Figure 1).

Figure 1: Fish famer working in Siaya County

Photo: © FAO

Conclusions

Fish farming is one way available to some famers in Siaya to increase their sources of income and food security, diversifying their near subsistence livelihoods. Fish is a rich source of dietary protein and selling surplus provides additional income for purchasing food and non-food items.
The land area needed for fish farming is small compared to other farming enterprises. In addition, farmers who also fish farm are now utilizing the harvested water to irrigate their vegetables during the dry spell, which is ensuring a steady source of food and income. In Siaya County, with periodic rainfall, this irrigation does not reduce the water levels needed for fish farming. However, the rainfall in between the rain seasons is often not sufficient to sustain crop production. Hence harvesting the water enables the farmers to use it for both fish farming and irrigation.

Since fish pond excavation was found to be labour-intensive, in cases where ponds were not located in riverine areas, only a few farmers managed to benefit from this project support.

Some of the farmers who wanted to have fish farming as an enterprise were limited as they did not have a suitable water source on their farms. Others had permanent water source, but their soils were very porous, requiring expensive lining materials, while others had no access to reliable water source.

Way Forward and Recommendations

Fish farming can enhance incomes and food security as a way of adapting to climate change. Fish is a good source of protein and its inclusion in the diet will improve health. In the three watersheds, only 12 farmers were supported with fingerlings. In the face of climate change, as a way of enhancing food security and income among the farming community, there is a need to support more farmers in fish farming. Since not all farmers are endowed with soils that can retain water for long enough periods to sustain fish farming, there is need for farmers who are disadvantaged by this to be supported in fish farming by the provision (or perhaps a loan to buy) pond lining material. From the analysis (Table 1), the cost of the pond lining material is recoverable within the first cycle of fish farming.

There is need to build the capacity of the farmers on efficient utilization of the pond water for irrigating their vegetables, tree nurseries and other viable enterprises. This will ensure a greater diversity in food and income generation sources using pond water, as well as ensuring sufficient water for fish farming. Use of manual ('money-maker') pumps and hosepipes makes the irrigation process easier and more targeted.

Access to credit will be vital to farmers who intend to have more fish ponds to enhance their incomes and food security from a fish farming enterprise. A starter revolving loaning system could be developed through this project to increase number of farmers engaging in fish farming on their farms without taking part in Lake Victoria fishing activities. Construction of fish ponds within the farm and along the riverine regions of the landscape has been observed to reduce downstream river pollution since the structures reduce overland runoff, which would otherwise end up in the rivers/stream and other water bodies. This effort has been appreciated by water-users association given the stable ecosystem. More of fish farming activities need to be supported on already degraded landscapes on the farm that is source of surface runoff. Inlets to these fishponds would need to be constructed with silt traps/ponds to collect silt/sand in the overland flow emanating from the immediate catchment.

Kenya Paper 4

More land for food production from reclaimed gullies in Mwala, Machakos County in Eastern Kenya

B. Okoba, S. Ogeto and P. Mwangi

Introduction

The FAO-Sida project being implemented by the Kenya Agricultural and Research Institute (KARI) and The African Institute for Social and Economic Development-Kenya identified the sub-county as an area that could benefit from testing and application of sustainable land management technologies with potential to assist farmers to adapt to the impacts of climate change.

The prolonged application of poor and unsustainable land management technologies on the steep slopes in Mwala District have continually degraded the formerly arable land, removing topsoil and reducing vegetation cover, thus leaving it unprotected from the impact of high rainfall intensity (which is becoming more frequent due to climate change). This, coupled with disorderly exploitation of construction sand has contributed to the formation of gullies, which are extending across formerly arable land and contributing to a decline in food production over time. The sensitization of farming communities to protect their arable land by reclaiming gullies under the project began at the beginning of January 2012.

The project targeted over 2,400 households from Kibao, Kathama and Maweli watersheds of Mwala District. It has adopted a model of strengthening the capacity of representative watershed committee members, also referred to as the Farmer Resource Persons (FRPs), through relevant training on demonstration plots. The FRPs were responsible for passing on the expertise they had gained on best-fit practices to the other households in the watershed. The size of the watershed committee in each watershed was determined by the number of village units in the watershed - each village is represented by one farmer. The committee members were to train and ensure widespread adoption of the soil and land management practices by the rest of the village members on their farms and the village communal lands. Capacity building for watershed committee members was done by project officers and other selected extension agents.

Through relevant training on reclaiming land affected by gully erosion, including building of gabions, agroforestry and other improved farming practices, participating beneficiary farmers have been able to rehabilitate and recover eroded gullies. The reclamation efforts vary from farmer to farmer. There have been common measures that have contributed to the success, mainly the use of the yellow sisal varieties, also use of stone rows and gunny bags to stabilize the soils and check the run-off speed (Figure 1). In an effort to ensure sustainability of these reclamation practices farmers, have been using a combination of locally available materials such as tree logs, branches and stones to construct sand barriers across the gullies. The efforts have greatly rewarded the people, who are not only able to reclaim land for arable use but also hold the river-bed sand and retain water, which they use for domestic and livestock.

Figure 1: A reclaimed gully using sand gunny bags in Kibao watershed

Mr Daniel a farmer from a Kibao watershed says: "I have taken the step to use the available local resources to contain the gully that has been eating up our farming land. I am a proud farmer and I have gained the respect of my neighbours, who have been asking me for advice in containing this menace."

Challenges

The success has however not gone without its share of challenges. One of the greatest is the disorderly sand harvesting practice which is still being carried-out by a number of farmers across the watersheds. This challenge hampers the reclamation efforts of the rest of the members of the community and is a great discouragement to those community members who have worked hard to restore gullies.

In some regions of Kibao, the yellow sisal variety that the farmers have been using to recover the land has also recently suffered a severe attack from a certain, currently unidentified pest. This variety of sisal has been more effective in the reclamation practices due to its prolific and hardy nature, but the new adversary is posing a serious threat to its survival in the region.

The Way Forward/Lessons Learned

Throughout the Mwala watersheds, excess runoff continues to aggravate gully erosion, therefore continued outreach efforts on the use of very simple sand bags, check dams and stone rows as gabions will be emphasized especially because availability of sand and stones in the target areas is not limited.

Land rehabilitation using agroforestry to check further erosion and restore soil organic matter and fertility will continue to contribute to a very large extent to the efforts towards more effective soil and land management.

Taking a community-based approach as opposed to a group approach in various issues, especially sand harvesting as relates to this case study, would be helpful in better assessing problems and identifying more viable solutions.

Application of simple and affordable rehabilitation techniques is desirable. Local communities are more likely to adopt simple and cost-effective technologies; making up-scaling to other watersheds easier.

Recommendations

On the basis of the underlying causes of land degradation in Mwala and based on this experience, the project team recommends the following:

1. Integrated and holistic land management, including off-farm livelihood opportunities
2. Integrate use of scientific knowledge and with traditional knowledge for alternative ways to control the pests of the yellow sisal which has been observed to be best vegetative measure in rehabilitation of degraded lands.
3. Advocacy on awareness on the effects of sand harvesting on the environment. Sand harvesting in the region is a huge contributor to poor

soil and water management measures on the farm, especially affecting the people living downstream in the catchment areas. This also requires a community-based approach as opposed to the group approach, since it is a community resource.

4. There is need to research the valuation and socio-economic aspects of the rehabilitated areas, as this will be useful to encourage future rehabilitation efforts.

Kenya Paper 5

Coping with insufficient rainfall through drought tolerant crops in the drylands of Machakos, Kenya

S. Ogeto, B. Okoba, P. Mwangi

Introduction

There is no shortage of good ideas for conserving soil and water in Kenya. Researchers have developed many simple and useful technologies to use the scarce rainfall for crops, but farmers have tended not to adopt them on a significant scale. Similarly, production of drought tolerant crops (sorghum, green grams and cowpeas in this case) is not a new practice in Kenya and more widely in sub-Saharan African. This practice was once common, but with time it has been overtaken by the predominance of maize, along with a small number of other food crops as monocultures, especially in the arid and semi-arid areas of Kenya.

Why is the production of drought tolerant crops special and what has made it successful? Maize had become the 'darling' food crop for farmers in the semi-arid areas of Machakos (see Part 1 Figure 1). The Kenya Agricultural Research Institute's baseline survey for this project in 2012 showed that 92% of farmers in Mwala-Machakos plant maize as the main food crop, yet it has many constraints, especially with respect to the amounts of water it requires to reach maturity. Maize productivity is low and such reliance on it alone poses a serious threat to household livelihoods in these areas. Reliance on rain-fed maize production has increased the vulnerability of small-scale farmers in the target areas to be food insecure and yet there are indigenous food crops that remain unused, even though they have the capacity to tolerate the increasing dry spells and require much smaller amounts of rainfall to achieve a harvest.

Approach

In January 2012, the project began work to revive the production of more drought tolerant crops (DTCs) as an adaptive measure in the face of increasing weather variability, frequency of droughts and climate change in the target areas. The project has been working to demonstrate to farmers that growing DTCs, often alongside maize, increases crop productivity because, unlike when only growing maize, a farmer can still be hopeful that there will be something to harvest, even if only minimal rain has fallen.

The local climate in Machakos County is semi-arid. The area has a bimodal rainfall distribution pattern, with the long rains starting mid-March to May, while the short rains are from mid-October to December. The average rainfall ranges between 250 mm to 400 mm per annum. Farmers in this area understand the value of water, how its scarcity limits crop production and how essential it is for survival. They must contend with increasingly unreliable rainfall and short, unpredictable rainy seasons – it is a typical drought-prone area.

The terrain is hilly and less than 30% of the total area of the county is classified as either of high or medium potential for rainfed agriculture.

In 2012, a baseline survey was carried out in the area by the Kenya Agricultural Research Institute (KARI) (see Kenya Baseline Chapter). The study found that about 92% of farmers in the area planted maize as their main food crops, yet the crop yields were low (see Table 1). After discussions with the farmers on possible solutions to counter the low level of maize yields, the need to reintroduce the simple, replicable practice of growing drought tolerant crops (see Table 2) was brought up (among other measures).

At the beginning of the project, there were implementation problems. The farming community in the target watersheds had little or no experience with the proposed simple technology, as the traditional knowledge of how to grow these crops had been lost. The farmers wanted to continue the usual practices of growing maize monocultures, even though their harvests had been poor or had failed in the recent past.

Table 1: Drought tolerant crop productivity changes by target beneficiary farmers before and after the project interventions

Farmer and project site	Maize kg / ha		Cowpeas kg / ha		Greengrams kg / ha		Sorghum kg / ha	
KATHAMA	Before	After	Before	After	Before	After	Before	After
Benjamin Mbatha	0	0	900	1,500	360	1000	0	1,800
David Mutua	0	0	400	1,800	0	600	100	450
Beth Mwangangi	0	0	63	180	0	375	0	25
Grace Munini	0	0	0	0	0	0	300	1,000
Margret Mwania	0	0	180	650	0	1,400	0	1,000
MAWELI								
Caro Mbithi	0	0	0	3,900	510	1,260	450	1,950
Rosina Kanzalu	0	0	90	270	50	175	0	0
Rose Musau	0	0	175	325	25	90	0	0
David Mwalali	0	0	600	1,800	250	750	0	0
Josephine Mbatha	0	105	100	425	180	325	50	150
KIBAU								
Timothy Kitavi	0	0	2,550	550	0	1,260	1,200	5,700
Victoria Mutua	0	0	200	1,700	400	1,080	600	3,000
Ngila J	0	113	0	360	0	340	800	1,800

Table 2: Types of drought tolerant crops promoted

Green grams
The varieties of green grams promoted are Green: N26.These take 40-45 days to flower, 60-65 days to mature and with a seed rate of about 10-15 kg per ha. At a spacing of 45cm by 15cm by 4-cm depth a farmer can project a production rate of between 1,300-1,500 kg per ha, this is equivalent to 14-17 ninety-kilogram bags.
Cowpeas
The varieties of cowpeas promoted are Machakos 66, M66 and Katumani 80, K80.These take about 55-60 days to flowering and 80-90 days to maturity and with a seed rate of between 20-25 kg/ha and a spacing of 60cmx20cm, farmers can project a production rate of at least 800-1700 kg for every hectare planted.
Sorghum
The local sorghum takes about 45-52 days to mature. This variety has a seed rate of 7.5-10 kg/ha and a spacing of 60x60 and 20cm and the projected production rate stands at 18-20 bags of 90 kg-weight.

Production of drought tolerant crops revived

Through demonstration plots that acted as farmer learning centres, the extension workers on the project have been able to provide tools, start-up seeds and relevant crop husbandry training in pre-harvest, production and post-harvest practices.

Today, production of DTCs is slowly becoming an integral part of the local farming scene. The technique has spread to at least 150 households from the target areas. It has even produced a growing new industry of selling the surplus grain for income. DTCs are not new, but their revival has already contributed to reducing agricultural risk and improving household food security for the project beneficiary families in Mwala- Machakos.

Evidence of Results

Figures 1 - 3 and Table 1 show the yield rates of the drought tolerant crops before and after the project interventions and the harvest (yield) per crop.

Figure 1: Cowpeas yields before and after the project intervention for farmers from three watersheds in Mwala- Machakos

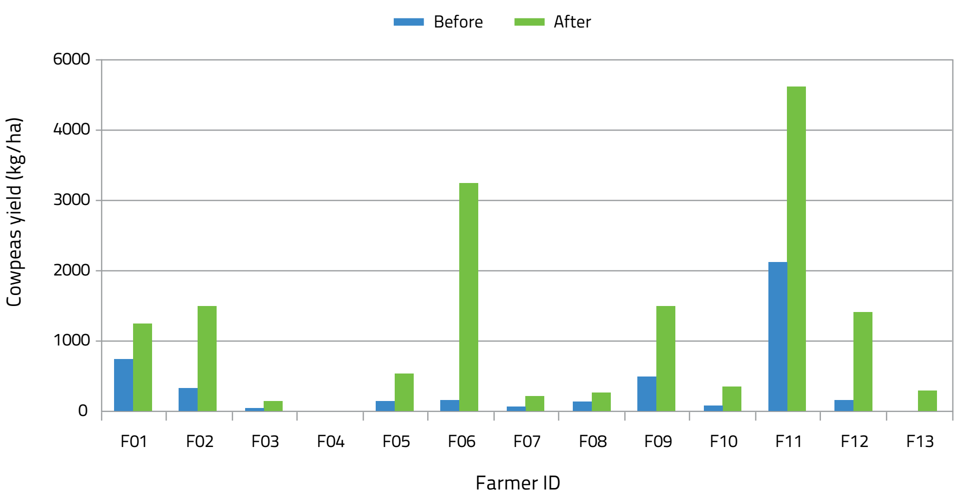


Figure 2: Greengrams yields before and after the project intervention for farmers from three watersheds in Mwala-Machakos

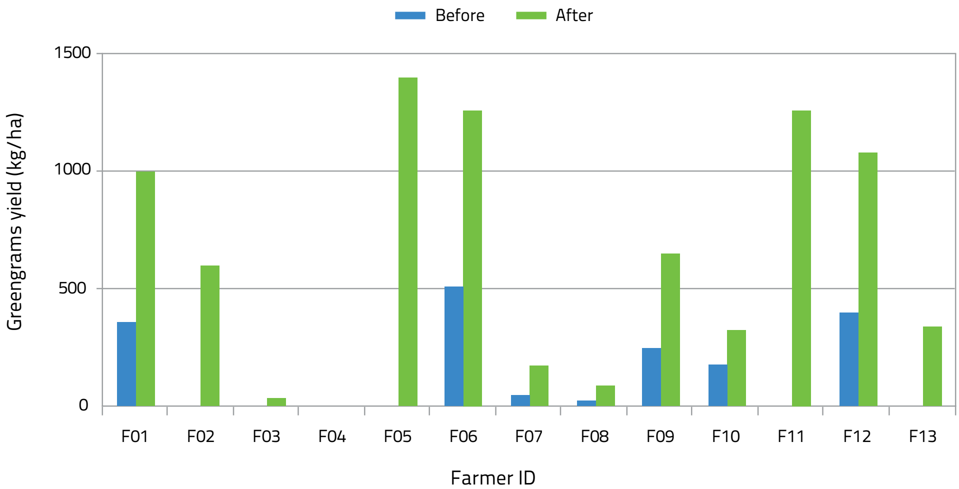
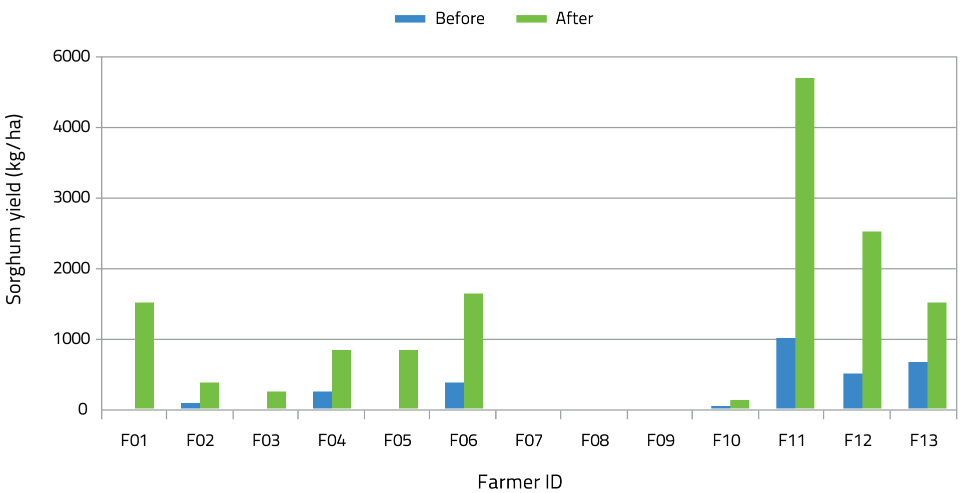


Figure 3: Sorghum yields before and after the project intervention for farmers from three watersheds in Mwala-Machakos



Why growing DTCs continues to succeed

Three key factors have contributed to the success of the project encouraging the growing of drought tolerant crops:

- An action-research approach was taken at the demonstration sites, which identified and assessed local practices, facilitated onsite training, encouraged farmers to watch what their neighbours were doing, let farmers choose without added incentives and supported them in fine- tuning their preferred DTC varieties;

- Production of DTC is an easy, cheap, traditional technology that yields a harvest despite poor rainfall and can easily be replicated by farmers;
- It is a technology that could be adapted to suit the changing local context and is highly favourable (in comparison to maize) to the unpredictable and uneven rainfall patterns in the target areas.

Lessons Learned

- The participatory baseline survey at the beginning of the project helped establish relevant stakeholders and relevant climate change concerns.
- If well conducted, demonstration plots can be one of the strongest dissemination techniques for convincing farmers that a technology works.
- Establishing and empowering community structures (committees) at different levels ensures cooperation, acceptability and sustainability of projects.
- The adoption rate of this practice and the crop varieties chosen by farmers differed from one watershed to another, being a case of different perceptions by the targeted farmers.

Way Forward

- An extension of the project is necessary to co-ordinate farmers for increased production and sensitization to other areas.
- Commercialization of the growing of more drought tolerant crops will give an opportunity to farmers to have a high impact on dietary diversity, improve nutrition and provide and alternative source of income generation. This will include exploring marketing opportunities and developing the value chain.

Tanzania

Strengthening the capacity for climate change adaptation through sustainable land and water management in Kiroka village, Morogoro, Tanzania

Henry Mahoo, Pendo-Edna Henry, Jackson Masakia, Geofrey Pyumpa, Edith Kija and Charles Pangapanga

Introduction

Over the last four decades, Tanzania has been hit by a series of severe droughts and flood events (Kandji *et al.*, 2006; Tumbo *et al.*, 2011). These are undeniably part of the impacts of increasing weather variability and climate change, which are already affecting ecosystems, biodiversity and people all over the world. The observed increase in variability in most countries and especially Tanzania has increased the uncertainty in seasonal rainfall prediction. Increasing weather variability and climate change are therefore increasing the need for actions to overcome the challenges and provide accurate and reliable weather and climate predictions that will enable the agricultural sector not only ensure food security of the majority of the population but also help them get out of poverty, which is in line with Tanzania's Vision 2025 and Kilimo Kwanza Policy (URT, 2010).

Agriculture is the leading sector in Tanzanian economy in terms of its contribution to real gross domestic product (GDP) (URT, 2001). The livelihoods of the majority of the population (about 80%) are heavily dependent on the agricultural sector (URT, 2001). Agriculture in Tanzania is mostly rainfed and thus the success of activities in the sector remains highly sensitive to weather, especially rainfall. Many places in Tanzania receive less rainfall than the crop water requirements (only about half of the country receives over 750 mm of rainfall per annum with 80% probability). Climate change adaptations in river basin systems rely to a great extent on encouraging upstream and downstream farmers to be partners in river basin management. Knowledge and practice to improve upstream and downstream management is available and needs to be implemented systematically. It is therefore important to strengthen the capacity for farmers at the catchment (upstream) and irrigation scheme (downstream) for climate change adaptation through enhancing land and water management, increasing agricultural productivity and encouraging farmers to diversify their livelihoods. It is on this basis that the project 'Strengthening the Capacity for Climate Change Adaptation through Sustainable Land and Water Management in Kiroka Village, Morogoro' (see location map, Part 1 Figure 1) was initiated.

There is a considerable potential for both rainfed and irrigated agriculture in Kiroka village and the surrounding areas. In the lowlands, the soils have good water holding capacity and remain moist for a long period during the dry season. There is also abundant water supply, good road access, markets (Morogoro and Dar es Salaam) are close and there is high market demand. Despite this, potential, land degradation (soil erosion, loss of soil fertility and bush fires) is widespread in the highlands. One of the main reasons is poor land husbandry exacerbated by increasing weather variability and climate change. Furthermore, during the dry season, there is water shortage due to poor management of water sources. However, during the rainy season, flooding is experienced in the lowlands, causing damage to property and crops.

Appropriate, effective and informed decision making are required to allow people to organize their activities (both short- and long-term) for effective climate change adaptation.

Objective

The overall objective of the project is to: 'Reduce the impact of climate change and variability on smallholder farmers through sustainable land and water management and thereby contribute to improved agricultural productivity, livelihood and ecosystem resilience in Kiroka village, Morogoro'.

In order to appreciate the level of stakeholders understanding on issues of climate change, a baseline study was carried out with the following specific objectives:

- To understand the community awareness and perception on climate change.
- To assess the climate related risks and hazards facing the communities in the study area.
- To analyse gross margins for food and livestock and the major challenges facing the production.

- To assess soil conservation measures practiced by the communities in the study area.
- To identify adaptation options practiced by farmers in the study area in response to the changes in climate.

Methodology

Study Area

The study was conducted in Kiroka village in Morogoro District in September, 2012. Specifically the survey was carried-out in six hamlets in Kiroka (Mahembe, Mwaya, Kimangakenge, Temekelo, Msamvu and Kingobwe). Kiroka village lies between 6° 25'S and 6° 30'S and 37° 30'E and 37° 35'E, at an altitude of 887 masl along the lower reaches of Mahembe Mwaya and Kiroka River valleys in Morogoro District (see Figure 1). Access to the project area is 35 km from Morogoro town, along the murram road. The area experiences a humid climate, receiving an average of 1,100 mm of rainfall per annum (May-Oct 650 mm/Feb-March 450 mm) (URT, 2001).

Data Collection and Analysis

Data collection involved structured interviews using a questionnaire, checklist, key informant interviews and focus group discussions. Data collected during the questionnaire survey was analyzed and synthesized using the SPSS, then results calculated. Information collected from the key informants and focused group discussions was grouped together and synthesized according to the checklist questions, then the information summarized for easier interpretation.

Results and Discussion

General Information

A total of 112 respondents were interviewed using a structured questionnaire. Respondents were asked whether they were indigenous in Kiroka village. Results show that majority of the respondents were from Mahembe, while only few were from Kimangakenge. The results showed that 72 (64%) of respondents were native and born in Kiroka village, while 40 (36%) had migrated to Kiroka village. Some of the reasons that led to their migration and resided in Kiroka villages included marriage (27%), accompanied parents (24%), farming (24%) and employment transfer (7%).

The interviews were conducted with 73 (65%) male respondents and 39 (35%) female. The majority of the respondents 88 (79%) had received primary education, while 15 (13%) did not attend any formal education. However, only one person had received a certificate level of education. Results show that majority of the respondents 89 (80%) were married, 14 (13 %) were widows/widowers while only 9 (8%) respondents were single. Household member adults ranging between the ages of 35-60 years were a dominant group with an average age of 42 years, thus the majority of Kiroka farmers were within the working age group.

The main source of income was generated from crop sales (107 (96%) of respondents) while 5 (5%) of respondents said they generated their incomes from off-farm activities. Some of the off-farm activities were teaching, selling timber and charcoal, petty business and retailing. Respondents were asked to list their main occupations, and results show that majority of the respondents 108 (96%) were farmers, and only 3 were businessmen while only 1 respondent was a government official.

Community Awareness and Perception on Climate Change

Generally, results indicated that the majority of the respondents (107 (95.5%)) were aware of the changes in climate. However, 2 respondents reported to be unaware while 3 claimed not to know anything about climate or any changes related to it. While 94 respondents (84%) reported to have observed the changes themselves, radio was the most used media (9%) to find weather and climate information. Other weather- and climate-related information sources widely used by farmers were village meetings (3%), newspapers (2%), and researchers (2%). The least used sources of weather and climate information were television, NGO's, Tanzania Meteorological Agency and input suppliers. There is room to improve sources such as NGOs and input suppliers in weather and climate information dissemination. The majority of respondents (82 (73%)) were fairly well informed on weather variability and climate change, while only 21 respondents (19%) claimed to be very well informed on increasing weather variability and climate change. However, 9 respondents (8%) had not received any information on increasing weather variability and climate change.

Notably, results show a remarkable observation that almost 76 respondents (68%) reported to have heard of or experienced the changes in climate only recently, compared to 36 (32%) who reported having heard or experienced the changes in weather and climate five to nine years ago. A possible reason for this observation could be that the majority of the interviewed respondents were not elderly, who particularly track the changes in their local area's climate.

In general, climate change was perceived to be a bad thing as reported by 109 respondents (97%). Reasons behind these observations could be due to the fact that they have seen climate change cause unpredictable and unreliable rainfall, resulting in droughts and sometimes floods, which in turn have led to crop failure, poor yield, loss of income, hunger, damage to property and life. Respondents also recalled and said that twenty years ago in their village, when rains were reliable, they used to grow all sorts of cultivars of fruits and crops with no crop diseases. However, 3 of the 112 respondents perceived climate change to be a good thing. For instance, farmers with access to irrigated agriculture may not feel seasonal drought to be a bad thing contrary to the experience of farmers without access to irrigation (perhaps due to location). Moreover, the perceived severity of the negative impacts caused by climate change underlies the knowledge on awareness and understanding of the term climate change and its related risks, as well as the ability of farmers to cope with the hazard(s) he/she is exposed to.

Climate Related Risks and Hazards in the Community

Occurrence and severity of climate extremes

According to respondents' opinions, the nine major weather / climate extremes / impacts presented in Table 1 are occurring more frequently over the past 6 years in the study area. Drought appears to have occurred most frequently (85%) compared to other climate extremes, followed by crop insect pests (85%). Extreme cold was the least reported to have occurred in the study area (31% of respondents).

Perceptions of climate change as risk

The majority of the respondents (102 - 88%) reported drought as a major risk. This is supported by the fact that drought has seemed to have occurred most frequently compared to the other weather extremes. Moreover, crop insects and pests have also been observed to be among the main risks in the community. This is evidently supported by 95 respondents (85%) who reported to have been highly affected (i.e. crop yields reduced due to insect and pest outbreaks). Surprisingly, high temperatures were not mentioned as a problem by many respondents (only 35 - 31%), despite the fact that drought prevails in the project area.

Severity and concern of climate extremes

The perceived severity of weather extremes and changing climate underlie the ability of a farmer to cope with a hazard he or she is exposed to. Therefore, the

Table 1: Occurrence of extreme climatic events in Kiroka village

Climate extreme	Reported Occurrence of the extremes	
	Frequency	%
Drought	99	88
Floods/excessive rain	94	84
Stormy rainfall	62	55
High temperature	45	40
Extreme cold	35	31
Crop insect pests	95	85
Livestock insect pests	66	59
Human disease epidemics	69	62
Other diseases epidemics	39	35

pattern of the perceived severity of extremes can change, with an increase in the ability of a farmer to cope with such climate hazards. Adaptation to risks is next to perception and attitude processes - after the farmer has experienced or anticipated the threshold of risk damage and become determined to react. However, due to the dynamism of risks and contexts, such adaptive strategies are not always understood, because they never remain static over time and space for the same individual or among individuals. In this study, the results show that drought and crop insects and pests were cited to be the most severe by farmers. It was also reported that the severity of the seasonal drought had an effect on food production in the area, due to the fact that drought leads to decreased yields of crops as compared to previous non-drought years.

For any farmer who is deprived of the means to manage a certain climate hazard is likely to feel concerned about the hazard. Results in Table 2 indicate that many respondents were concerned about weather and related extremes compared with those who were not. About a quarter of all respondents were extremely concerned about seasonal drought, also crop and livestock insect pests. Seasonal drought is an extreme concern for both farmers and livestock keepers, since drought decimates crop and livestock production.

Overall, 92 respondents (82%) reported being affected by the impacts of climate change. It was apparent that the most prominent negative impacts of climate change were unreliable rainfall (unclear onset and ending of rains), reduced crop yields (food shortage), reduced income, destruction of crops due to floods, pests and diseases and sometimes death.

Table 2: Concern of climate and weather extremes to farmers

Climate extreme	How concerned (%)		
	Unconcerned	Concerned	Extremely concerned
Drought	39	48	13
Floods	5	41	54
Stormy rainfall	41	54	5
High temperature	59	39	2
Extreme cold	35	65	0
Crop insect pests	7	47	46
Livestock insect pests	12	68	21
Human disease epidemics	37	61	3
Other diseases epidemics	34	66	0

Food and Livestock Gross Margins and the Challenges facing Production

Gross margins for crops and livestock production

Gross margin (GM) is a technique that is used to establish economic profitability. GM is defined as the difference between gross income accrued and variable costs incurred. The analysis is therefore a simplified tool, but in many cases it is a sufficiently powerful tool for economic analysis (Makeham *et al*., 1986). The GM enables one to directly compare the relative profitability of similar enterprises and consequently provide a starting point to decide or alter a farm's overall enterprise mix. It is important to compare GMs of different participants in the same line of investment, in order to know who are able to pursue their economic activities sustainably. Therefore, the GMs for both crop and livestock production are presented in Table 3. The results show the GMs for farmers and livestock keepers were 10,929 Tshs/kg (21%) and 37,235 Tsh/kg (27.6%) respectively. The GM for farmers was the lower (21%) compared to that of livestock keepers. This could be due to the fact that majority of farmers sold their produce at lower prices and they faced a number of environmental and production challenges, the most critical being high production costs as compared to the livestock keepers. In addition, crop production as a sector is seen to be the most vulnerable sector in the context of changing climate compared to livestock production. This shows that farmers are still not benefiting from crop production, due to the lower returns.

Table 3: Gross margins for crops and livestock production

Sector	Description	Sales/Costs (Tshs)	Percent (%)
Crop production	Average revenue (Tshs)	51,249	
	Less		
	Average costs (Tshs)	40,320	
	AGM	**10,929**	**21%**
Livestock production	Average revenue (Tshs)	134,897	
	Less		
	Average costs (Tshs)	97,662	
	AGM	**37,235**	**27.6%**

Note: AGM=Average Gross Margin and is given in Tshs/kg

Constraints to crop and livestock production

The constraints facing crop and livestock production in the target villages are shown in Table 4. Higher costs during production activities and insufficient modern agronomic practices were widely reported as constraints limiting crop production while floods, unavailability of inorganic fertilizer and improved seeds were the least reported constraints. Inadequate extension services were also mentioned as constraints to crop production, as well as prolonged drought (unreliable rainfall). Livestock activities seem to be highly constrained due to lack of availability of pasture, livestock diseases and unavailability of veterinary drugs.

Assets and Energy Security

Assets

Assets ownership is summarized in Table 5. As presented, the majority of respondents (107 - 96%) owned hand hoes. A radio was also owned by the majority (84 - 75%), an indication that it is the most used media to access all sorts of information, including on issues concerning climate change. Assets ownership could be one of the indicators of levels of vulnerabilities and adaptive capacities to the impacts of climate change. Results also indicate that 39 (35%) of the respondents had consolidated mud walls with iron sheet roofing while 73 (65%) said their houses were made up of simple mud walls with thatched roofing (Table 6).

Energy security

Tanzania has a good range of energy sources including solar, wind, biogas, coal reserves, natural gas, hydropower, biofuel, wood fuel and geothermal power.

Table 4: Constraints to crop and livestock production in a changing climate

Sector constraints	Frequency	Percentage (%)
Crop production		
Floods	4	5.2
Insufficient modern agronomic skills	64	83.1
Unavailability of inorganic fertilizer	6	7.8
Unavailability of improved seeds	6	7.8
Inadequate extension services	52	67.5
Crops pests and diseases	40	52
Prolonged drought/unreliable rainfall	29	37.6
High production costs	73	94.8
Livestock production		
Unavailability of pasture	56	72.7
Livestock diseases	51	66.2
Inadequate extension services	29	37.7
Unavailability of veterinary drugs	40	52
Wild animals and theft	6	7.8

Note: The basic question was whether a certain constraint was a serious constraint to production

Table 5: Assets Ownership

Assets	Ownership	
	Frequency	Percentage (%)
Car	1	0.9
Motorcycle	5	4.5
Bicycle	31	27.7
Television	4	3.6
Satellite dish	0	0
Radio	84	75
Mobile	84	75
Plough	4	3.6
Tractor	0	0
Hand hoe	107	95.5
Axes	92	82.1

Table 6: House structure

House structure	Frequency	Percentage (%)
Brick walls tiled with iron sheet roofing	0	0
Consolidated mud walls with iron sheet roofing	39	34.8
Simple mud walls with thatched roofing	73	65.2
Total	**112**	**100**

Respondents were asked to rank the main energy sources widely used in their villages and the results show that, of all sources, wood fuel was the most commonly exploited (91%), followed by kerosene (62%) and charcoal (58%). This could be explained by the fact that firewood is considered both cheap and accessible to the poor in the majority of both rural and urban areas. However, this practice has negative impacts on the environment, as it accelerates deforestation and drying out of streams. Due to the reported recent increase in frequency and duration of droughts, water flows in most of the rivers in the area of Kiroka such as Mahembe, Mwaya, and Ndege have progressively been declining in recent years as reported by many respondents.

Weather extremes such as drought are most frequently considered to have occurred in the study area mainly as a result of prolonged deforestation practiced by the community members for the purpose of getting firewood.

Soil Conservation Practices, Water Sources and Woodlots Ownership

Soil Conservation Practices

The survey results showed that 89% of farmers in Kiroka village reported that there was a great demand for conserving soil and water in their village, while only 11% disagreed. Farmers suggested practices such as afforestation, provision of training on environmental conservation, avoiding bush fires, avoiding farming along water courses should be done in order to conserve soils. Moreover, they said that laws ensuring environmental conservation should be strictly enforced and penalties should be given to people who break them.

A number of factors that contributed to soil degradation were mentioned by land users, including bad agronomic practices, deforestation and removal of vegetation cover. The majority (55%) of the interviewed farmers reported to have faced

Figure 1: Cultivation on steep slopes around Kiroka village without conservation measures

Photo: © Henry Mahoo

soil degradation in their villages while the remaining 50 (45%) said they did not face soil degradation. Some farmers used contour ridges as a strategy to minimize soil erosion, in order to encourage better root penetration and enhance moisture conservation. The most common factors that caused soil degradation in the study area were the removal of soil nutrients mainly through harvests and burning of crop residues (poor agronomic practices). Cultivating on very steep slopes without any conservation measure could be another factor (Figure 1).

Linked to climate change, drought might have also contributed to low soil productivity as it tends to reduce water in the soil, consequently affecting nutrient mineralization and their availability to crops. On the other hand, increasing temperature might also contribute to rapid decomposition of organic matter and thus accelerate nutrient loss through production of carbon dioxide (CO_2) (Mkeni, 1992).

In response to these situations, farmers were asked to explain the measures they were using to reduce degradation of soils in their areas. As shown in Table 7, about half of the respondents said they did not practice any measures to solve the problem. This response brings an alarming signal to the environmentalists and soil and water experts, as it indicates many of Kiroka farmers take no action to curb soil degradation. However, 65 respondents (58%) reported that all measures that are undertaken do not reduce the risks associated with soil degradation.

Water sources

Water has become increasingly scarce locally due to the demands placed upon it. The opportunity cost of Tanzania's raw water is increasing, especially in many of the areas considered to have irrigation development potential. The use of water for productive purposes which include irrigation is seen as an essential requirement for poverty alleviation and food security. According to the survey results , 95 (82%) of the respondents reported that they have water sources in their areas. Some of the main water sources found in the study area as mentioned by farmers were Mahembe River (34%), Kiroka River (15%), Temekelo River (13%), Mwaya River (12%),

Table 7: House structure

Soil conservation measures	Frequency	Percentage (%)
Afforestation	39	35
Contour farming	4	4
Conserve water sources	1	1
Mulching	2	2
Planting vegetation cover	3	3
Use of traditional terraces	4	4
Do not practice any measure	59	53
Total	**112**	**100**

Bamba River (11%), Ndege River (9%), Kimangakenge River (5%) and Kisogoso River (2%). Respondents were asked to report the benefits they have received from the mentioned water sources and majority (46 (37%)) reported using it for domestic purposes. However, 22 (18%) of respondents use the water for irrigation purposes and 17 (14%) use it for both irrigation and domestic purposes. However, 36 (31%) respondents reported not to have benefited from the use of the mentioned water sources, probably because their farms were not located near the water sources. Despite the availability of water sources, irrigation was observed not to be widely practiced, maybe due to poor water distribution and availability in some areas. The existing irrigation scheme is still under rehabilitation and unless this is completed, some areas will continue to suffer from water shortage

Woodlots ownership

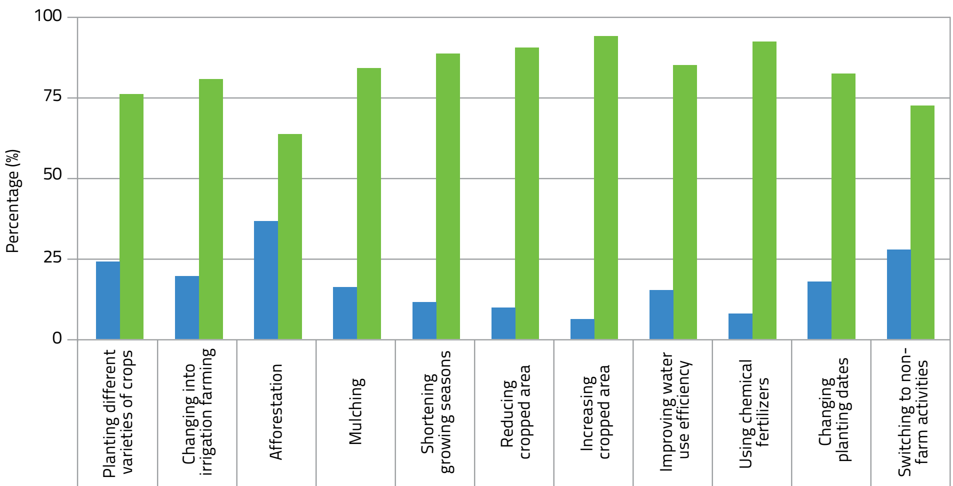
Many researchers have demonstrated that emission of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chloro-and-fluoro-carbons and a number of other gases resulting from human activities are responsible for the recent changes in the global climate system (IPCC, 2007). Therefore, there is a need to use cleaner technologies that do not emit a lot of GHGs or provide sinks for the emitted GHGs. In the forestry sector strategies include planting of trees species in woodlots, forestry plantations, on farm boundary planting and other agroforestry systems. Woodlot ownership plays a significant role in the establishment of forests. Raising the number of people who own woodlots is likely to increase the chance of reducing deforestation in a particular area. In Kiroka village, however, the results show that the majority of the respondents do not own woodlots (53%).

Climate Change and Adaptation Options

Strategies for adapting to the fluctuations in climate

The results of the baseline survey indicated that 103 (92%) of respondents reported that climate change has negative impacts in their village, while only 9 (8%) reported this was not a concern. Respondents were asked whether they have made any adjustments in response to the impacts they have faced. To avoid or at least reduce the negative effects and exploit possible positive effects, several agronomic adaptation strategies for agriculture have been suggested. However, the majority of the respondents (53%) have not made any adjustments to reduce the impacts of increasing weather variability and climate change. Results indicate that about 47% of respondents had adopted some strategies and ways to minimize the impacts from increasing weather variability and changes in climate. Saka (2008) noted that adaptation measures to climate change among communities have been considered with two broad activities in mind: i) measures that reduce vulnerability and ii) measures that increase resilience through the utilization of the available common assets. Figure 2 gives a summary of the strategies used by the respondents in response to the impacts associated with climate change and variability in the study area.

Figure 2: Strategies adopted by farmers to respond to climate change and variability



	Planting different varieties of crops	Changing into irrigation farming	Afforestation	Mulching	Shortening growing seasons	Reducing cropped area	Increasing cropped area	Improving water use efficiency	Using chemical fertilizers	Changing planting dates	Switching to non-farm activities
Yes	24.1	19.6	36.6	16.1	11.6	9.8	6.2	15.2	8.0	17.9	27.7
No	75.9	80.4	63.4	83.9	88.4	90.2	93.8	84.8	92.0	82.1	72.3

The findings are in line with a study by Mahoo *et al.*, (2007) which indicated that farmers adopted tillage methods, agronomic practices and crop diversification approaches to maximize yields from available water. However, these adaptation strategies need to be undertaken in tandem with government policies and strategies for poverty alleviation and food security.

Adjustments made by Kiroka farmers as a result of changes in rainfall

Rainfall variability due to climate change has proved to be one of the biggest challenges to many farmers in Kiroka. Changes in rainfall patterns are at times leading to increased water levels, but at others decreased levels. For farmers, this leads to increased risk of crop failure due to poor seed germination, washing away of seeds and crops, also stunted growth. Sometimes this requires re-ploughing and replanting, so increasing production costs. For livestock, this leads to decreased pasture productivity, also increased outbreaks of parasites and diseases. Surprisingly, results in Table 8 show that the majority of farmers have not yet adopted any strategy to minimize the negative impacts resulting from changes in rainfall patterns in the study area. However, about 6% of the respondents said they had shifted to production using irrigation instead of relying only on the traditional rain-fed mode of production. The prospects of adaptations due to the variability of rains in the study area are summarized in Table 8.

Adjustments made by Kiroka farmers as a result of changes in temperature

According to IPCC (2007), increasing average temperatures will adversely affect crops, especially in semi-arid regions, where already high temperatures are a limiting factor of production. Increased temperatures also increase evaporation rates from soil and water bodies, as well as evapotranspiration rate. Results in Table 9 indicate that about 90% of the respondents reported not to have adopted any strategy in response to the changes in temperatures, while others have shifted to irrigation production systems due to water scarcity exacerbated by rising temperatures. Some have planted banana trees for the purpose of providing shading in their farms, to reduce heat intensity (Table 9).

Perceived hindrances to adoption of modern techniques

Farmers were asked their perceived barriers to adoption of modern technologies for adapting to climate change. The majority of the respondents (88%) reported the most common challenge facing them was lack of capital (cash) to acquire modern technologies such as irrigation pumps (Figure 3).

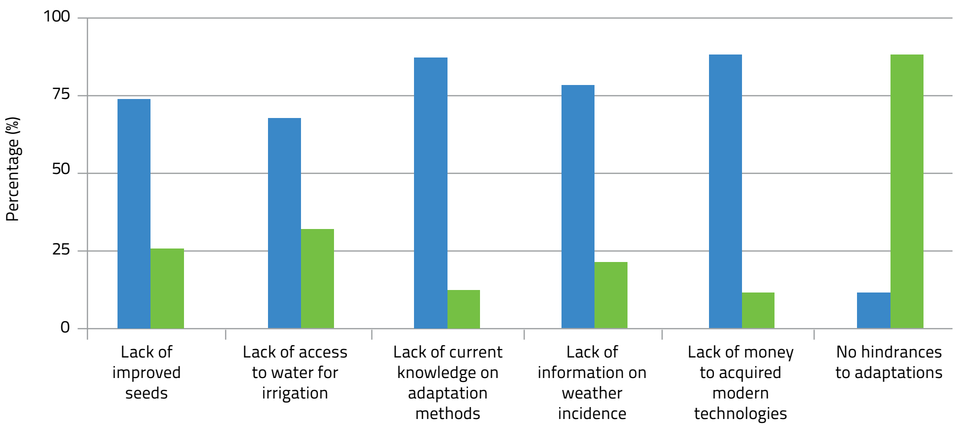
Table 8: Adjustment strategies due to changes in rains

Adjustment strategies	Frequency	Percentage (%)
Shifted to irrigation production system	7	6.3
Construction of dams	16	14.2
Use of the drought resistant banana seeds	2	1.8
Not adopted any strategy	87	77.7
Total	**112**	**100**

Table 9: Adjustment strategies due to changes in temperature

Adjustment strategies	Frequency	Percentage (%)
Shifted to irrigation production system	10	8.9
Plant banana trees on farms for shading	1	14.2
Not adopted any strategy	101	0.9
Total	**112**	**100**

Figure 3: Perceived hindrances to adoption of modern (climate resilient) techniques



	Lack of improved seeds	Lack of access to water for irrigation	Lack of current knowledge on adaptation methods	Lack of information on weather incidence	Lack of money to acquired modern technologies	No hindrances to adaptations
Yes	74.1	67.9	87.5	78.6	88.4	11.6
No	25.9	32.1	12.5	21.4	11.6	88.4

Farmers Association and Institutional Support

Some of the associations, groups and NGOs concerning with food and livestock production as well as environmental conservation in the study area included World Wildlife Fund, Wildlife Conservation Society of Tanzania, Food and Agriculture Organization, Japan International Cooperation Agency, Pennsylvania Department of Environmental Protection, New Rice for Africa, CARE International and Savings and Credit Cooperative Organizations (SACCOS). There were some other local associations and farmers groups, including: Msamvu Development for People; Umoja wa Wamwagiliaji Kiroka; Mahembe Mazingira Group; Mkombozi SACCOS; Juhudi group; Wangeuye group; and VICOBA. These groups provide services such as education on environmental conservation, training on paddy rice production and on the proper utilization of agricultural inputs such as fertilizers, also savings and loans provision. Farmers were asked if they were members in any association in the study area and the majority of respondents (54%) responded to be actively involved in those organizations.

Conclusions and Recommendations

Conclusions

Like many other parts of Tanzania, Kiroka village is seen to be vulnerable to environmental change, particularly climate change. Such vulnerability is reflected in various impacts of environmental change on, among others, food security, livestock and human health. Agricultural production, which is an essential component of food security, is largely rain-fed in Kiroka village. Droughts have become more frequent, while floods have often destroyed infrastructure, affecting food distribution and access by many communities. Other climate-related risks have also increased, for example outbreaks of pests and diseases such as diarrhea. Increased health risks due to climate change are of particular concern as they affect the population, including reducing the labor force for agricultural production, also other sectors of the economy. Sound adaptation mechanisms are needed to address the consequences of climate change on agricultural production, food insecurity and health, which cause stress factors that affect livelihoods in rural communities such as Kiroka.

Recommendations

It is significant that Kiroka's local government formulates and implements policies that will accelerate environmental conservation in Kiroka village. This also requires scaling-up of budgetary allocations to issues such as construction of improved irrigation schemes and capacity building to Kiroka farmers. Afforestation, mulching when planting different crops, as well as switching from farm to non-farm activities, should be encouraged as strategies to adapt to increasing weather variability and climate change. Constraints on the wide scale adoption of modern technology by households must be identified and dealt appropriately through further research, training and information dissemination.

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Tanzania Paper 1

The system of rice intensification to maximise paddy yields using improved water management, Kiroka village, Morogoro, Tanzania

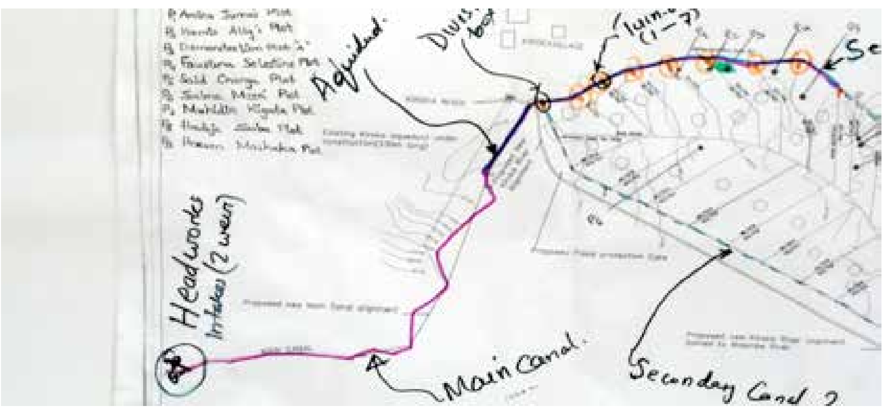
Henry Mahoo, Pendo-Edna Henry, Jackson Masakia, Geofrey Pyumpa, Edith Kija

Introduction

As described in the baseline study (Tanzania Baseline Paper), Tanzania is highly vulnerable to the impacts of climate change and various parts of the country are already experiencing increasing water scarcity, which is negatively affecting agricultural production especially by small-scale farmers. In addition, water conflicts are occurring very frequently. Examples of conflicts involve upstream versus downstream farmers; livestock keepers versus farmers; also farmers versus farmers in water distribution.

Kiroka village is among the most productive areas for cultivation of rice under irrigation practices in Morogoro Region and has 147 ha of a land which could potentially be used. Following water stress conditions attributed to climate change, the current command area under cultivation is only 80 ha (see Figure 1).

Figure 1: Sketch map of Kiroka irrigation scheme



Background of the problem

Rice is the staple food in Kiroka village and before the project's introduction of the System of Rice Intensification (SRI), yields were low (averaging between 1.35 and 2.3 t/ha). Various constraints contributed to these low rice yields, including: shortage of water: poor water distribution; poor management; and low use of improved technologies. Shortage of water was caused by environmental degradation and encroachment by farmers on water sources, leading to drying-up of rivers and streams. In addition, the irrigation infrastructure is not fully functional. For example parts of the secondary canal are broken, leading to high losses of water. In-field water management is also problematic, as there are no tertiary canals, the fields are not well leveled and some do not have strong bunds. Drainage facilities are also inadequate, leading to water-logging during excessive rains.

The techniques used by farmers included: seed broadcasting leading to high seed rate use; transplanting seedlings of 21-28 days old leading to less tillers and stunted growth; transplanting 2-3 or more seedlings per hill. These lead techniques to nutrients competition and stunted growth. Farmers also practiced continuous flooding, which suppresses tillering, leads to nutrient leaching – and gives rise to competition for water among farmers.

The SRI was introduced by the project as a means of addressing the constraints mentioned above (SRI-Online, 2013). SRI is a package of interventions for increasing rice productivity by changing the agronomy, water and nutrient management. In SRI technology the use of wider spacing between seedlings is encouraged (i.e. 25 x 25 cm or more), thus, fewer seeds are used (3 kg/ha, a single 8-15 day old seedling is transplanted per hill) and less water is applied during growing period.

The main objective was to ensure that the introduction of SRI technology contributed to household food security and improved livelihood of farming communities in Kiroka village. The specific objectives were to:

- Conduct training on SRI to equip farmers with knowledge on SRI practices to increase rice productivity;
- Establish demonstration plots to enable farmer to practice SRI by themselves and teach others who were interested to practice SRI technology to improve rice production;
- Conduct a study tour to share experiences on rice growing under SRI technology.

Methodology

Training on the System of Rice Intensification (SRI)

SRI methodology is based on four main principles that interact with each other (SRI-Online, 2013):

- Early, quick and healthy plant establishment;
- Reduced plant density;
- Improved soil conditions through enrichment with organic matter;
- Reduced and controlled water application.

Training sessions were organized for fifty beneficiaries (33 women and 17 men farmers). The farmers were trained on:

- Introduction to SRI;
- Principles of SRI technology;
- Factors to consider when practicing SRI;
- Procedures for SRI implementation;
- Preparation of plots for SRI;
- Preparation of quality seeds;
- Transplanting of seedlings;
- SRI field management;
- Harvesting and record keeping.

The training used participatory approaches, for example participants were given the chance to contribute their ideas on the conventional methods used before.

Farmer Field School (FFS)

A total of three SRI-based Farmer Field Schools (FFS) comprising of 25 farmers were organized. Each FFS was responsible for setting and managing its plots. The FFS also served to disseminate SRI technology more widely to neighbouring farmers, not only those that attended training. Figure 2 shows farmers demonstrating proper spacing of seedlings using the SRI.

Study Tour/Farmer Exchange Visits

A study tour was organized for 21 Kiroka farmers who had adopted SRI technology to visit Mkindo Irrigation Scheme in Mvomero District (a neighboring district in Morogoro Region). During the study tour, farmers met others with more than 2 years experiences on SRI technology and had an opportunity to exchange hands-on experiences and skills on rice production under SRI technology at farm level.

Figure 2: Farmers demonstrating proper spacing for rice seedlings under SRI

Farmer to Farmer Learning

Another methodology used was farmer to farmer learning, in which farmers in the FFS volunteered to train other non FFS farmers on SRI technology. At least 8 farmers out of 50 of those trained adopted SRI technology also many individual farmers have learned to use SRI using their own effort. Most of them are now practicing SRI technology in their fields.

Results and Discussion

Training

A total of 50 farmers were trained on SRI practices. Of the fifty trained farmers, 74% adopted the SRI technology. In addition, farmer to farmer learning has resulted into additional eight framers adopting the SRI technology. This is evidenced by one of the farmers Ms Faustine Selestine. She was quoted saying the following.

> ***"Nimelima Kilimo Shadidi cha Mpunga ili niweze kumshawishi mume wangu akubali teknologia hii mpya ya kuzalisha mpunga"*** *(the English translation is: "I have adopted SRI technology and I want to convince my husband so that he can also adopt this technology").*

Crop Yields

Yield data recorded in the 2012/2013 cultivation season (December-June) showed an increase in rice yield from farmers' plots from the average of 1.65 t/ha without SRI to 11.6 t/ha with SRI. Apart from grain yield, there was also increased biomass yield. The biomass yield is illustrated by improved roots development in Figure 3.

Figure 3: Rice roots under traditional management (left) and under SRI (right)

Reduced Water Conflicts

Since the adoption of SRI, many farmers have stopped continuously flooding their fields during the growing season. This has resulted in reduced competition for water and has also contributed to a reduction in water-related conflicts. The testimony by Hussein Mashaka is the evidence to this. He was quoted saying the following:

> ***"Kwa sasa ugomvi wa maji na wakulima wenzangu haupo tena kwa sababu nimegundua Kilimo Shadidi cha Mpunga hakihitaji maji mengi"*** *(the English translation is "meanwhile water crisis with other farmers has been resolved due to recognition of SRI technology, since this system requires minimum amount of water under dry and wet techniques").*

Most of the farmers appreciated the SRI technology. The following is a testimonial Ms. Habiba Msonga – a woman farmer from Kiroka village (Figure 4).

Figure 4: Ms. Habiba Msonga, a project-trained SRI Farmer

"I have my plot in the Sub-scheme A; occupying 0.5 ha and have been farming for two consecutive seasons now. Through FAO support I joined the FFS and I am getting good yields of 2.6 t/ha from my plot. The yields are enough for my household food requirements and I am selling surplus which provides me with cash that support me in training my children and other requirements. Thanks to the Project, from the sales of rice I have managed to finish my house".

Conclusions, the Way Forward and Recommendations

Conclusions

SRI technology has proved that even under moisture stress conditions, rice yields are considerably better in comparison to yields harvested through other technological packages.

Way Forward and Recommendations

For further disseminations of the SRI technology to other farmers, more efforts are required to make sure almost all rice farmers adopt the SRI technology, particularly the improved water management for rice growing to adapt to increasing weather variability and the predicted impacts of climate change. Also SRI technology should also be spread nation-wide by institutionalizing it into district- and national-level plans where irrigation is practiced.

In the future, project activities should include wider dissemination and sensitization through brochures, newspapers, farmer field days and exhibitions.

References

SRI-Online (2013) Welcome to SRI-Rice Online. Available from: http://sri.ciifad.cornell.edu/index.html (accessed September 2013)

Tanzania Paper 2

Assisting smallholder farmers to adapt to the effects of climate change through soil and water conservation, Kiroka village, Morogoro, Tanzania

Jackson Masakia, Henry Mahoo, Pendo-Edna Henry, Geofrey Pyumpa, Edith Kija and Charles Pangapanga

Introduction

Kiroka village (see Part 1 Figure 1) has six sub-villages (hamlets), including Mahembe, Mwaya and Kimangakenge which are located in the highlands, also Kingobwe, Msamvu and Temekelo which are located in the lowlands.

The major problem associated with agricultural production in the highlands is poor land husbandry. Despite steep slopes, farmers practice flat cultivation of maize, cassava, bananas and horticultural crops, without any form of soil and water conservation. This has led to severe soil erosion including loss of fertile topsoil (and landslides), resulting in low crop production leading to food insecurity at household level.

Figure 1: Bush fire on the highlands near Kiroka village

Uncontrolled bush fires in the highlands (Figure 1) are rampant, especially during dry seasons. The causes include: slash and burn during land preparation; harvesting of wild honey; charcoal making; and hunting of small game. As a consequence, the land is left bare without any vegetation cover thus exposing it to the vagaries of weather.

Deforestation (frequent cutting of trees for firewood, timber and charcoal) is another problem in the highlands. This has contributed to various problems, including: drying of water sources; destruction of the ecology; conflicts among water users; and exacerbating soil degradation and erosion. Last but not least, the majority of farmers have low agronomic skills and use poor farming tools.

Objectives

The main objective of this part of the project was to assist smallholder farmers in Kiroka village to cope with the effects of climate change through use of soil and water conservation measures. Specifically, this was achieved through the following interventions:

- Provision of training on establishment of tree nurseries, tree planting as well as construction of Fanya Chini terraces;
- Establishment of tree nurseries;
- Planting of timber and fruit trees;
- Construction of Fanya Chini terraces and pineapple plantlets planting.

Methodology

Training of farmers

A total of 148 farmers were trained in soil water conservation (SWC), tree planting and nursery establishment. In addition, the staff of three institutions (Diovuva, Bondwa and Kiroka Primary Schools) were also trained and supported.

The training aimed to create awareness and the importance of best practices of soil and water conservation, tree planting and nursery establishment. This was achieved through theory, field practical, study tours and field demonstrations using the farmer field school approach.

After the training, farmers were able to fabricate local tools such as line boards and spirit levels (used in contour layout and demarcation, determining slope percentage and vertical interval).

A number of farmers were further trained to be Trainers of Trainers (ToT) and a total 5 groups each comprising of 5-10 members were formed. These groups were tasked to demarcate and lay down contour bunds and terraces on their fields and other villagers' farms.

Farmer field schools

Farmer field schools (FFS) were introduced in Mahembe and Kenge sub-villages, both in the highlands.

Figure 2: Farmers from Kiroka village listening to a village extension officer in Lushoto during a study tour

The Mahembe FFS has 12 farmers while Kenge and Changamoto FFS have 8 and 7 farmers respectively. Mahembe and Changamoto FFS groups are the most active.

Study tours

Study tours were conducted as part of the training and farmers visited Lushoto District (Figure 2) to learn about SWC technologies, which included bench terraces, stone bunds, mixed cropping and energy saving stoves.

Results and Discussion

Farmers' training

A total of 148 farmers were trained on SWC measures over a period of two weeks. In addition, 5 groups comprising of 5-10 farmers were trained so that they could train others. Training included:

- Types of soil conservation measures (biological and physical measures);
- The use of soil conservation equipment (line board, A- frame and water ring);
- How to determine the slope percentage, vertical interval and contour line.

The SWC training enabled farmers to learn how to demarcate and excavate contours bunds. For instance in the highlands, a total of 45 contours with total length of 2,670 m were demarcated and excavated, as summarized in Table 1.

During the rainy season of (March-May 2013), farmers appreciated the role of the contour bunds and the excavated trenches in controlling soil and water erosion. The storms were very intense but no crop damage was experienced. These observations assisted in strengthening and mobilizing interest amongst farmers to appreciate the role of the contours bunds in controlling soil and water erosion.

Table 1: Number of *Fanya Chini* terraces constructed in highlands

Name of farmer /institution	No of terraces constructed	Total length in metres
FFS Mahembe	5	340
Diovuva primary school	15	1,050
Rajabu Juma	9	386
Fadhili Rajabu	9	374
Muhidini Kigadu	7	520
Total	**45**	**2,670**

This observation was echoed by Mwinyimvua Nassoro, a farmer at the FFS Mahembe. He was quoted saying the following:

> *"**Tumeona chemchem ya maji wakati tumefukua udongo kwenye mitaro. Hii inaonyesha makinga maji ni kweli yanahifadhi maji shambani.**" (The English interpretation is as follows: "During scooping out of the soil that was intercepted by the trenches, I observed a lot of water retained in the trenches which looked like water coming out from a spring".)*

In order to stabilize the bunds and increase the economic value/benefits, pineapples were planted on the bunds. A total of 8,091 pineapple plantlets were planted in the highlands on individual farms, Diovuva Primary School and Mahembe FFS. Some of the planted pineapples have started bearing fruits and therefore encouraged many farmers, who will be able to earn more by selling them, thus supplement their incomes.

Muhidini Kigadu is a farmer in Kiroka village among those whose pineapples have started bearing fruits (Figure 3). Quoting his words he spoke the following:

> ***"Nina furaha kubwa minanasi yangu niliyoipanda kwenye makingamaji imeanza kuzaa mananasi, hii itanisaidia sana kwani nitauza matunda na miche na kuongeza kuongeza***

Figure 3: Pineapple on Muhidini Kigadu's terraces

Figure 4: A *Fanya Chini* terrace FFS field integrated with banana/maize cropping

kipato na maisha ya familia yangu yatakuwa mazuri zaidi". *In English he meant the following; "I am so overwhelmed because my pineapple plants have started bearing fruits. I am thinking of selling the fruits and I know by doing so it will enable me supplement my income and improve my family's living standard".*

Between the bunds, bananas were mixed cropped with maize and other crops in order to increase the economic value of the land (Figure 4). In the highlands, a total of 257 improved banana plantlets were planted. The performance of banana and maize were very good due to moisture retained by terraces.

Establishment of tree nurseries

Training on establishment of tree nurseries and tree planting as means of conserving water sources and woodlots in highlands was held in September 2012 and particularly included:

- The importance of trees and nurseries;
- Reasons for encouraging woodlots;
- How woodlots helps in soil and water conservation;
- Meaning of a tree nursery;
- Steps of preparing tree nurseries;
- Steps of transplanting trees in the fields and near water sources;
- How to do grafting;
- How to do budding.

One of the key outcomes of this training has been the formation of farmers groups who are engaged in trees/fruit trees nursery establishment. In the highlands two groups have been formed while in the lowlands there is one group. Two tree nurseries were established by the Mahembe Changamoto FFS, raising a total of 5,672 seedlings, as highlighted in Tables 2 and 3 respectively.

Table 2: Seedlings raised in the Mahembe FFS nursery

Type of Seedlings	Total raised
Khaya anthontheca	1,600
Grevillea robusta	2,200
Afzelia quanzensis	330
Total	**4,130**

Table 3: Seedlings raised by the Changamoto FFS nursery

Type of Seedlings	Total raised
Albizia gummifera	200
Khaya antholtheca	1,012
Grevillea robusta	100
Ficus comorus	4
Carica papaya	4
Other local trees species (i.e. *mikanyi*)	30
Cloves	192
Total	**1,542**

The advantages of the different trees species in Tables 2 and 3 will be realized after a period of 5 to 10 years. Trees serve both short and long term purposes. In this particular case, advantages will be in the form of water sources conservation, soil erosion control, improved soil fertility and increased income from forest products.

Construction of *Fanya Chini* terraces

A total of 45 terraces were constructed with total length of 2,670m on individual farms and institutions. All embankments were planted with pineapples in order to stabilize them (Figure 5).

Figure 5: Terraces constructed in Mahembe FFS at Kiroka village

Farmers were also encouraged to plant other crops in the fields in order to maximize economies of scale. Different crops such as maize and vegetables were mixed cropped in the fields. As results of water retention in the contour ridges, farmers have harvested much more from their fields compared to when they were not practicing contour farming.

Quoting Mwinyimvua Nassoro, he said the following:

> ***"Kutokana na shamba langu kuwa na makinga maji imenisaidia kuvuna mahindi kilo 48 kwenye kipande kidogo chenye mita 10×10 bila kutumia hata mbolea. Hili ni jambo la ajabu kwangu, kweli nimeona manufaa ya kilimo cha makingamaji kwenye kubakisha unyevu shambani".*** *Translating into English he meant the following; "I am so amazed on how fanya chini contour farming has helped retained water moisture in my field. This has helped me harvested a total of 48 kg (4.8t/ha) in just a small plot of 10x10 m even without applying fertilizer".*

Similar opinions were also expressed by a young boy who said he has seen how fanya chini contours have helped to retain water in his father's field and how they have helped his family harvested more maize and vegetables. Therefore he is planning to practice this type of farming in the future when he grows up. Quoting his words in Swahili he said:

> ***"Nilimuona baba akichimba makinga maji shambani nilipenda kuwa nikiwa mkubwa na mimi shamba langu nitafanya hivyo kutunza udongo. Vilevile nimeona jinsi tulivyoweza kuvuna mahindi na mbogagamboga sana ukilinganisha na zamani".*** *The English translation is as follows: "After seeing my father digging contour bunds, I promised that when I grow up, I will do the same in order to conserve soil and water. I also witnessed that we harvested more maize and vegetables this season compared to the previous seasons".*

Conclusions and Recommendations

Conclusions

Farmers have learned a great deal about the importance of managing and conserving soils and water in their village. During the project inception, farmers had a lot of enthusiasm. However, during the period of implementation, there is still a lot to be done to encourage more people to participate in sustainable soil and water conservation activities in the highland areas. The results far so are encouraging and will serve as a learning platform for other farmers.

Recommendations

The work that started needs to be consolidated and more farmers need to become involved. SWC is a process and needs time and money for implementation. Also there is a need to change mind set of farmers by sending them to study tours to see how other farmers do conservation on their farms.

Tanzania Paper 3

Cost saving ($410/household/year) and reducing deforestation through energy saving stoves, Kiroka village, Morogoro, Tanzania

Jackson N. Masakia

Problem Statement and Justification

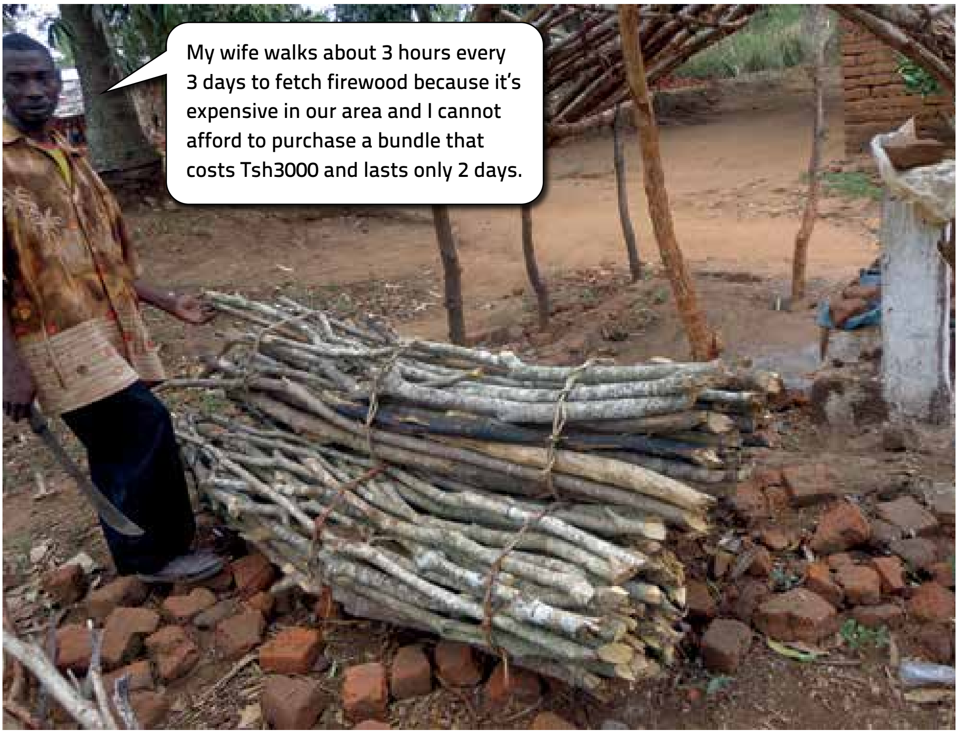
About 99% households (HHs) in Kiroka village depend for cooking on firewood, which is now becoming a scarce and expensive resource due to population growth, which has led to agricultural land expansion involving deforestation - and an increased need for firewood. These households still cook using the traditional three-stone open fire hearths, which require huge loads of firewood to function and are very inefficient – reportedly with a heat loss of more than 80%. Dependence on firewood marginalizes local women and girls in the community, as they are burdened with collecting or paying for expensive firewood and cooking over inefficient and smoky traditional stoves (Figure 1). By introducing energy saving stoves that efficiently burn wood, reduce heat wastage and amounts of smoke, the project is improving forest conservation, soil and water protection, women's health and saving to families money they had needed to buy wood (Figure 2).

Figure 1: Smoke pollution when using a traditional three stones stove.

Objectives

Energy saving stoves were introduced by the project to reduce deforestation, improving the resilience of the landscape to climate change, also contributing to mitigation and bringing health and financial benefits.

Figure 2: A farmer explaining how firewood is expensive to his household in Kiroka



Methodology

The methodology used to teach about energy saving stoves included mobilization of resources, training, also the demonstration and local construction of stoves.

Mobilization of Resources

Training materials were prepared through reviewing different manuals and books on the subject of energy saving stoves. The project team then prepared a project-specific training manual, which covered all aspects in a simple and self-explanatory way to convey the knowledge to farmers during the planned training. The manual included both for classroom training and practical demonstrations, including details of the equipment necessary for stove construction [tape measure, knife, brick forma (0.8 cm x 1.6 cm x 3.2 cm), chimney brick forma (frame of 3.2 cm x 3.2 cm x 1.6 cm diameter hole in middle, height of 0.8 cm) wire or thread and iron rod] (Figure 3).

Figure 3: Preparing the basement for the improved store

After all the material for the training was in place, the project staff wrote a letter to invite 50 farmers through the village council to attend two days of training.

Training

A total of 50 farmers in Kiroka village (from both the highlands and lowlands) were selected to represent their hamlet and participate in the training. Forty-five farmers attended the training out of 50 farmers invited. A flip chart presentation and partcipatory approch were used to pass on the infomation to participants, including:

- Introduction on improved cooking stove;
- Importance of improved cooking stove to enviroment and health;
- Efficiency of improved stove;
- Site selection and material needed;
- Types of improved cooking stove (Morogoro type,oneport,two port stove);
- Steps on making improved energy saving stove.

Demonstration

Three demonstration stoves were constructed (i.e. Morogoro type (molded), one port cooking stove and two port cooking stove). After construction of the three types of stove as a model, farmers were required to test them and to choose the effective stove according to the size of their household and their fuel consumption level. Twenty-five farmers selected a two port energy saving stove, five farmers selected the Morogoro type and 15 selected a single port energy saving stove.

Stove Construction

Figure 4: **Farmers participate in construction of energy saving stoves**

After training and demonstration, farmers were required to start preparing materials for construction of their stoves. Construction of each improved cooking stove was done by the project facilitator in collaboration with individual farmers. The project provided an iron rod, brick forma (0.8 cm x 1.6 cm x 3.2 cm), chimney brick forma and technical advice during construction of stoves. Thus farmers were responsible for making the bricks by preparing a mixture of sand and clay. Figure 4 shows the construction procedures for the energy saving stoves.

Results and Discussion

Fuel Consumption

Through introduction of energy efficient stoves (Table 1), households have reduced the amount of wood needed to cook their food. This lifts the burden from women and girls to collect or pay for expensive firewood in Kiroka (Figure 5) and proves that the energy saving stove is economical viable, conserve environment and time efficient by efficiently burning wood and reducing heat wastage.

Stoves Improve Kitchen Environment and Women's Health

The kitchen environments of Kiroka have been improved because the energy saving stoves reduces the smoke and fumes in the household, protecting women and girls from respiratory problems. Provision of long chimneys prevents smoke circulating around the kitchen and this keeps the kitchen free from smoke. Women reported that:

> *"Our kitchens are now very clean and we do not get fumes from our stove. Also our eyes are not suffering from fumes now days we are very happy for this technology".*

Figure 5: Woman in Kiroka expressing her savings after using the improved stove

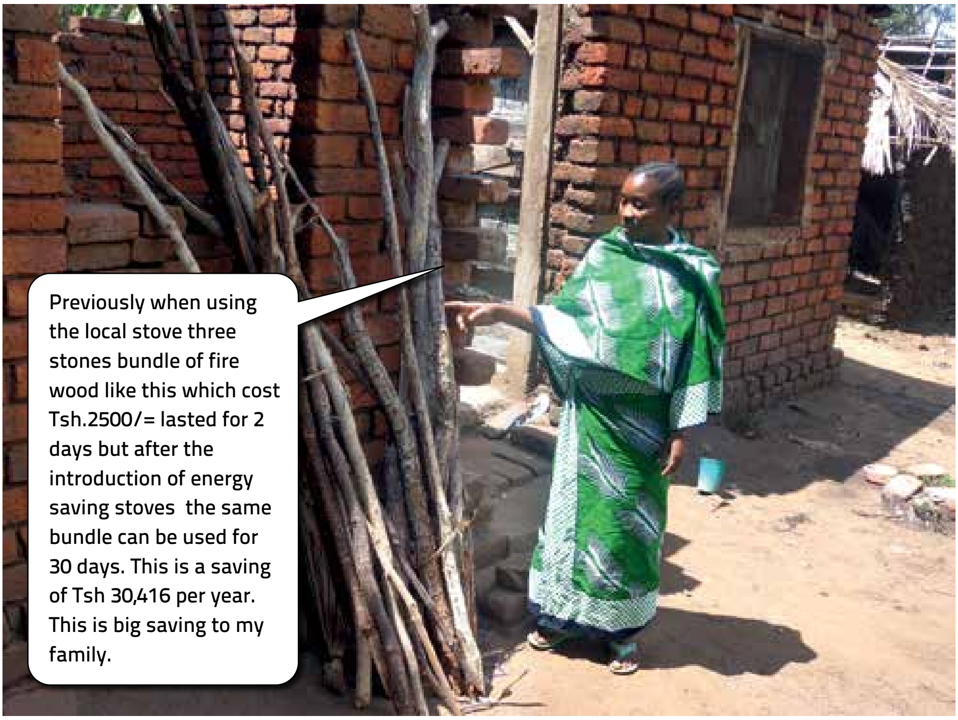


Table 1: Statistics on the population of Kiroka village, numbers trained and implementation of energy saving stoves

Sub-Village	No. of HHs	Numbers of HHs trained	Number of stoves present in sub-village	HHs in each sub village as % of Kiroka village	% of HHs trained in each sub village	% of stoves present in each sub village
Tmemkelo	668	70	15	35%	10%	21%
Kingobwe	797	80	35	40%	10%	44%
Msamvu	189	49	15	10%	26%	31%
Mahembe	110	50	16	6%	45%	32%
Kenge	100	10	0	5%	10%	0%
Mwaya	69	7	0	4%	10%	0%
TOTAL	**1933**	**266**				

Relevance for Climate Change

Cutting trees for fuel in Kiroka was resulting in alarming amounts of deforestation, causing extensive land degradation. By substituting the traditional inefficient cook stoves with clean burning and energy efficient stoves, the project will mitigate climate change by reducing GHG emissions. In addition, the reduced consumption of firewood and charcoal will reduce pressure and thus conserve the natural forests.

Figure 6: Woman using energy saving stove

Time Savings

Using improved energy saving stoves reduces the time required for collecting wood and cooking (Figure 6). The women will consequently also have increased opportunities for income generation. Mama Salama reported that:

> *"We have now reduce time to cook food and our husband are happy because food has been prepared timely due to this technology it helps in reduces domestic violence to our families".*

Adoption

The project received a large number of requests from farmers in need of the three types of improved cooking stoves after the initial training. The two port energy saving stove proved to be high performance and efficient in wood consumption and thus preferred by most women. From 2nd April 2013 after training to 30th August 2013, the project managed to construct two-port energy saving stove for 81 household and 10 Morogoro stoves for HHs in Kiroka village. The project has had more than 30 further requests from households for two port cooking stove. Project together with seven key adopters are working hard to fulfill the request in time and efficiently.

Conclusions, Recommendations and the Way Forward

Conclusions

The problems of firewood have led this technology to be accepted (Table 1) and appreciated by the people of Kiroka. The technology is easily adopted because it is simple to practice and all the materials for construction are both cheap and locally available. The project has been able to help householders make their own energy saving stoves, giving them training on construction, operation and maintenance to ensure proper and extended use. Farmers are now able to make and repair all types of energy saving stove on their own. It is concluded that simple, affordable and locally produced energy saving stoves ensure speedy adaptation of this technology in Kiroka village and neighboring villages. This component of the project is also improving local conservation by reducing the amount of wood harvested for fuel. In addition it is reducing indoor air pollution and improving the health condition for women and children.

Recommendations

This experience shows that it is relatively easy and low cost to help farmers to construct and use energy saving stoves that efficiently burn wood, reduce heat wastage, save money and reduce land degradation. The Government and other stakeholders should intervene to promote this technology more widely for its multiple benefits – and to contribute to climate change resilience. More funds are required to train more farmers on this environmental friendly technology.

The Way Forward

The energy saving stove technology should be disseminated to all the households in Kiroka and neighboring villages, to make sure that energy saving stoves replace the traditional open stove. Energy saving stoves should also be introduced to the different institution (hospital, school, churches and other institution), as these are significant consumers of firewood. This will greatly help in saving the environment and financial status to households in Kiroka and more widely.

Tanzania Paper 4

Beekeeping as an incentive for participatory forestry, land and water management in the highland areas of Kiroka village, Morogoro, Tanzania

H. Mahoo, G. Pyumpa, J.N., Masakia, P.-E.Mahoo, E. Kija and C.P. Pangapanga

Introduction

Beekeeping in Tanzania plays a major role in socio-economic development and environmental conservation. It is a source of food (e.g. honey, pollen and honey-comb with young lava), raw materials for industries (e.g. bee wax for candles and lubricants), medicine and source of income for beekeepers. At present, Tanzania produces about 4,860 tons of honey worth more than 4.9 billion shillings and about 324 tons of wax worth more than 648 million shillings every year. The beekeeping sector employs about 2 million rural people. It is estimated that the production potential for bee products in Tanzania is about 138,000 tons of honey and 9,200 tons of bee wax annually from an estimated 9.2 million honey bee colonies which is only 3.5% of the productive potentials.

Among the areas with high potential for production and therefore for investment in beekeeping is Kiroka village in Morogoro Region (Part 1 Figure 1).

Beekeeping as an environmental friendly and income generating activity was introduced as a part of project implementation as an intervention is to assist the farmers in practicing beekeeping as an incentive to encourage participative forestry, land and water management within the highland areas.

Background to the Problem

Fifty years ago the Kiroka highlands were covered mainly with forests; today this has been reduced to around by 50%. (There is no available statistical data; this is according to elders views on Kiroka village.) A number of pressures continue to reduce forest cover and are adversely affecting biodiversity within the high-lands. The most important threats include forest degradation, over exploitation of species, bush fires and loss of habitat. As a result, cases of unpredictable rainfall, prolonged droughts, floods, soil erosion, and shortage of water supply within the watersheds have been experienced. All these have a negative impact towards production and productivity, resulting in the poor livelihood and food insecurity of the Kiroka community.

Objectives

The objective of this component of the project is to provide additional incentives for participatory forest, land and water management through the introduction of beekeeping in natural forests, and further encourage nursery establishment and tree planting in bare areas, alongside rivers and water catchments.

Methodology

The methodology used included:

- Training on the principles of beekeeping;
- Demonstration on how to construct beehives.

Training on the Principles of Beekeeping

Figure 1: Beneficiaries training on beekeeping

A two-days training session on the principles of beekeeping was organized for a group of seven farmers (six men and one woman). The training used a visualized participatory approach - where experiences of farmers were used to capture the traditional modalities of beekeeping techniques (Figure 1). The training covered the following topics:

- Importance of beekeeping on environmental conservation, food security and income generating;
- How to attract bees into beehives to establish their colony;
- How to construct beehives;
- Economic benefits of bee keeping.

Beneficiary Training on Construction and Positioning of Beehives

The seven farmers received training on how to construct beehives by using materials that are locally available. As part of the training, each farmer was assisted to assemble his/her own beehive (Figure 2). Farmers were then trained on positioning of the beehives (Figure 3), which include hanging and on stand.

Figure 2: Beneficiary training on construction of beehive

Results and Discussion

- As part of a learning platform to scale-up beekeeping in the area, the seven farmers (Changamoto Group) have established a farmers' field school (FFS) on beekeeping. Presently the farm has 16 beehives, of which 14 are placed on stands and other two were hung on trees.
- On an individual basis, each farmer is now planning to establish a beekeeping

Figure 3: Positioning of beehives in the forests of Kiroka highlands

farm with a target for each farmer to start with a minimum of ten beehives. Furthermore, the farmers have established a nursery comprising of 3,846 tree seedlings - of which 72% are indigenous species. These seedlings will be distributed amongst the group members for planting in their individual farms.

Conclusions, Recommendations and the Way Forward

Conclusions and Recommendations

Inter-community exchanges and mutual learning among communities are important tools to be applied in capacity strengthening. The experience gained by the farmers following a study tour to Lushoto District in Tanga Region is a good example.

Empowerment at grass roots level goes hand-in-hand with participation and sharing of skills. A case of 'learning by doing' practiced on making beehives has been a success, such that the Kiroka farmers have become trainers and suppliers of beehives to other community members.

Beekeeping activities has the potential to increase resilience of the farming communities as a means of livelihood diversification. Beekeeping is particularly attractive to these farmers as it has low investment costs but promises high returns in the immediate and longer term. Thus promoting beekeeping will lead towards sustainable livelihood options, household food security and improved incomes of the Kiroka communities.

The Way Forward

The progress attained within a six months period (March to September 2013) has shown positive impacts in the realization of the project objectives. Positive 'lessons learned' and the 'good agricultural practices' that have been observed in the course of this implementation will be applied in up-scaling of the project interventions within and beyond the borders of Kiroka village. Where ever applicable, use of cheap and available local resources should be emphasized.

Tanzania Paper 5

Changing the mind-set of Kiroka farmers towards adoption of climate smart agricultural innovations through capacity building – a Summary

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Introduction

Agricultural production in Tanzania, on which over 80% of the population depends for its livelihood, is primarily smallholder. To a large degree it is rain-fed, which makes it principally sensitive to increasing weather variability and climate change which have been experienced in many areas in recent years and are predicted to continue to change.

Gaps in capacity, knowledge and experience are common in Africa, especially the dissemination of concepts and experiences on effective adaptive strategies is concerned (FAO, 2009). Measures to help assist farmers to adopt new or existing under-used agricultural innovations that sustainably increase productivity acts to increase resilience to the effects of climate change (adaptation) and may also reduce or remove greenhouse gases from the atmosphere (mitigation). These are components of climate-smart agriculture. However, changing the mindsets of farmers to adopt a certain innovation is the most crucial facet that assists the transformation journey.

Results of the baseline survey (Tanzania Baseline paper) conducted before project intervention indicated that majority of Kiroka farmers lack knowledge on the innovations that are used as measures for reducing the impacts of climate change. It was therefore crucial to change the mind set of Kiroka farmers towards adaptation of climate smart agriculture innovations through capacity building.

Training and field visit have proved to be the most successful methodologies that are helping changing the mindsets of Kiroka farmers to adopt the introduced agricultural innovations. Farmer to farmer learning through study visits enabled Kiroka farmers to teach as well as learn from each other, therefore increased their capacity to innovate through enhanced skills and knowledge and improve extension services within the village

Training for Farmers

Two approaches were used; training courses and study visits. Six training courses were conducted, including:

- System of rice intensification (SRI) (Tanzania Paper 1);
- Soil and water conservation measures in highlands and lowlands (Tanzania Paper 2);
- Tree nursery and tree planting as means of conserving water sources and woodlots in highlands;
- Banana farming in both Kiroka highlands and lowlands;
- Energy efficient stoves in highlands and lowlands (Tanzania Paper 3);
- Bee keeping in the highlands (Tanzania Paper 4).

Study Visits

Capacity building was also enhanced through study visits. These visits were done purposely to facilitate farmers' learning process. Through the visits farmers were able to observe and learn from other farmers. Farmer to farmer learning was a key factor of learning as it enabled them to understand application of certain innovations though other farmers' testimonials and experiences.

Mkindo study tour

Kiroka farmers particularly SRI farmers visited SRI farmers of Mkindo Irrigation scheme so that Kiroka farmers would be able to learn SRI practices and then implement the techniques demonstrated by Mkindo farmers once back to their field. The tour consisted of 21 farmers from Kiroka village, two village leaders and five members of the project team.

Lushoto study tour

The study tour was carried out from 11st - 13rd July, 2013. A total of 20 farmers and seven team members visited Lushoto District where soil and water conservation is widely practiced (Figure 1). The purpose of the tour was to let Kiroka farmers learn SLM practices from Lushoto farmers.

Muhidini Kigadu is among the farmers who visited Lushoto. The visit has changed his mind-set and he has started constructing the bench terraces on his farm. Quoting Muhidini Kigadu exact words in Swahili he said the following:

> ***"nimekwenda ziara ya mafunzo Lushoto niliona jinsi uchimbaji wa bench terrace ulivyo na faida kubwa kwenye kuhifadhi maji na udongo, nimeanza kuchimba terracess kupanda viazi kwenye materasi ili niongeze kipato na chakula kwenye familia yangu".*** *(Translating these words in English, he said the following: "Lushoto study tour has really helped me to see the importance of using bench terraces as means of soil and water conservation. I can also produce Irish potatoes and therefore supplement my income as well as securing food for my household".)*

It is anticipated that mobilization of resources and collaboration of different partners in adoption of the innovations systems will enhance successful adaptation to the changing climate.

Conclusions, Recommendations and the Way Forward

Conclusions

Review of the experiences demonstrates that as in any other developed-based project, the success and sustainability of its achievements and services depends on capacity building. Capacity building uses a country's human, scientific, technological, organizational, institutional and resource capabilities. The goal of capacity building is to tackle problems related to policy and methods of development, while considering the potential, limits and needs of the people of the country concerned. Therefore, the trainings, study visits and the participatory approaches used by the project during implementation were able to build the capacities of Kiroka farmers to adopt a range of technologies as means of reducing the impacts of climate change in the area.

Recommendations

As capacity and education on the use of agricultural innovations has been already provided as means to adapt to effects of climate change, laws and regulations should also be formulated and enforced for sustainable use of land and water in the village. Kiroka local government in partnership with non-governmental institutions and farmers themselves should work together to enhance effective capacity to adapt to the impacts of increasing weather variability and climate change through promoting existing and other possible adaptation strategies.

Dissemination of more trainings and awareness creation is still required. However, the current funding of the project is scheduled to end in December 2013. It is the opinion of many stakeholders that it will be unfortunate to stop the project at this stage. Stakeholders therefore have requested that FAO/Sida should extend and fund the implementation of this project for another one year because many farmers have realized the benefits of the technologies the project is promoting.

The Way Forward

The project team plans to ensure formed groups are well organized and continue to receive support to sustainably carry-out the innovations as means of adaptation to climate change in Kiroka village. Moreover, the team will put more emphasis on farmer-to-farmer training because through this some farmers can train others in various technologies such as SRI, soil and water conservation, improved energy saving stoves and beekeeping, even when the project has closed.

References

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Glossary

Adaptation (to climate change): Adjustments to current or expected climate [weather] variability or changing climate conditions, which moderates harm or exploits beneficial opportunities. Adaptation is a manifestation of adaptive capacity.

Adaptation benefits: Avoided damage costs or accrued benefits following the adoption and implementation of adaptation measures.

Adaptive capacity: as defined by the Intergovernmental Panel on Climate Change (IPCC), it is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC).

Adaptive strategy: A strategy that allows people to respond to a set of evolving conditions (biophysical, social and economic) that they have not previously experienced. The extent to which communities are able to respond successfully to a new set of circumstances depends upon their adaptive capacity.

Agroforestry: Land use systems or practices in which trees are deliberately integrated with crops and/or animals on the same land management unit.

Capacity development: The process through which organizations create, adapt, strengthen and maintain capacity to set and achieve their own development objectives over time.

Catchment/watershed planning: Planning that aims to enhance synergies and inter-relations between the various land use and soil and water conservation measures and to optimize positive impacts on the range of ecosystem services (production, hydrology, soil health, biodiversity and livelihoods).

Climate change: A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (IPCC, 2007, p.871).

Climate: The statistical description in terms of means and variability of key weather parameters for a given area over a period of time (usually 30 years). Climate variability: Variations around the mean of key weather parameters on temporal scales beyond that of individual weather events.

Climate-proofing: Ensuring that climate risks are reduced to acceptable levels through long-lasting and environmentally sound, economically viable and socially acceptable changes implemented at one or more of the stages in the project cycle.

Climate-smart agriculture (CSA): Agriculture that sustainably increases productivity and resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals (FAO, 2013a).

Conservation agriculture (CA): Conservation Agriculture is an approach to managing agro-ecosystems for improved and sustained productivity, characterized by three linked principles: continuous minimum mechanical soil disturbance; permanent organic soil cover; and diversification of crop species grown in sequences and/or associations.

Coping capacity: The ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters.

Crop diversification: The re-allocation of some of a farm's land into new cropping activities through varied crop associations and/or rotations. Factors leading to decisions to diversify are many, but they often include a reduction of risks related to climate variability or to market uncertainties.

Drought resistant crop: Typically refers to crops that have been subjected to plant breeding to improve their ability to survive in periods of extended water shortage.

Drought: The phenomenon that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems.

Dry spell: Short period of water stress during critical crop growth stages and which can occur with high frequency but with minor impacts compared with droughts.

Erosion: The process of removal and transport of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, winds and underground water.

Exposure (to climate variations): The nature and degree to which a system is exposed to significant climatic variations.

Farmer field school (FFS): A group-based learning process during which farmers carry out experiential learning activities that help them understand a given issue and test possible solutions. These activities involve simple experiments, regular field observations and group analysis.

Food and nutrition security: A situation which exists when all people at all times have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO).

Hazard: A dangerous phenomenon, substance, human activity or condition that causes loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Landscape approach: The management of production systems and natural resources in an area large enough to produce vital ecosystem services and small enough to be managed by the people using the land and producing those services.

Livelihood: The sum of means by which people get by over time. Livelihoods are based on households' availability of and access to assets (human, natural, physical, financial and social) as well as the enabling environment of policies, institutions and public/private goods and services.

National Adaptation Programmes of Action (NAPAs): Documents prepared by least developed countries (LDCs) that identify the activities to address urgent and immediate needs for adapting to climate change.

Rainfed agriculture: Agricultural practice relying exclusively on rainfall as its source of water.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner.

Risk: The combination of the probability of an event and its negative consequences.

Sensitivity (to climate variability or change): The degree to which a system is affected by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Supplementary irrigation: The process of providing additional water to stabilise or increase yields under conditions where a crop can normally be grown under direct rainfall, the additional water being insufficient to produce a crop. The concept consists in making up rainfall deficits during critical stages of the crops in order to increase yields.

Sustainable land management: the adoption of land use systems that, through appropriate management 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 (definition used by Terrafrica).

Vulnerability (to climate change): The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the system's adaptive capacity, sensitivity, and exposure to changing climatic patterns.

Water shortage: The point at which the aggregate impact of all water users impinges on the availability of water to the extent that the demand by all users, including the environment, cannot be fully satisfied.

Watershed management: An organized set of actions aimed at ensuring a sustainable use of watershed resources. Participatory watershed management puts communities living in the watershed at the centre of the watershed planning, development and management process.

Adapting to climate change through land and water management in Eastern Africa

Results of pilot projects in Ethiopia, Kenya and Tanzania

This publication presents the results and lessons learned from the FAO-Sida supported pilot project 'Strengthening capacity for climate change adaptation in land and water management" in Ethiopia, Kenya and Tanzania.

The project proposed an integrated package of approaches that addressed the drivers of vulnerability and targeted climate change impacts. It focused on technologies that improve soil health and facilitate water conservation, the diversification of the sources of livelihood and income, and the strengthening of local institutions.

The publication describes a series of pilot activities that successfully contributed to enhanced resilience of farming communities and offer substantial opportunities for up scaling. This experience shows that a boost in investment is needed to ensure a more sustainable and resilient management of an already declining resource base, and that adapting to climate change in the region will require renewed efforts in improving land and water management through supportive policies, capacity development and targeted investments.

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