Food and Agriculture Organization
of the United Nations

Sustainable Land Management (SLM) in practice in the Kagera Basin

Lessons learned for scaling up at landscape level

Results of the Kagera Transboundary Agro-ecosystem Management Project (Kagera TAMP)

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Foreword

Land degradation, biodiversity loss and climate change and variability, which all contribute to food insecurity, are major challenges that smallholder farmers face across sub-Saharan Africa. This publication presents the findings of one of the 36 projects under the TerrAfrica Strategic Investment Programme – SIP – that was funded by the Global Environment Facility (GEF) with co-financing by Governments and project partners, that aimed at developing capacities at all levels for a transition towards sustainable land resources management (SLM). Through the Transboundary Agro-ecosystem Management project in the Kagera River Basin (Kagera TAMP) that is shared by Burundi, Rwanda, Tanzania and Uganda, the Food and Agriculture Organization of the United Nations (FAO) has been assisting the smallholder farmers and service providers on the ground in 21 districts in testing and adapting sustainable land management practices (crop, livestock, soil, water) and integrated production systems that sustain biodiversity and enhance the delivery of ecosystem services and contribute to both environmental and development goals.

Smallholder farmers in the basin depend on the natural resources for their livelihoods, besides growing crops they are usually also livestock keepers and, where they are close to Lake Victoria or other surface water resources, they may also supplement their diet through fishing and gathering wild products. The "best" existing SLM practices for the range of agro-ecosystems were identified and documented by local actors as a basis for farmer field school learning by doing and adaptive management and for subsequent SLM scaling up in target catchments and agro-ecosystems. Communities were supported to develop catchment or micro-watershed management plans and to identify and address conflicts over natural resources through stakeholder dialogue and problem solving. The improved practices at farm and catchment scale demonstrated multiple win-win benefits: enhanced soil health and soil organic matter, effective use of rainwater and restored water flow in streams, increased, diversified and more reliable yields as well as more resilient ecosystems and livelihoods.

The status and trends of land resources were assessed and mapped across the basin, as a basis for planning SLM interventions with district authorities and technical teams. Constraints and barriers to SLM adoption were brought to the attention of policy makers from local to district and national levels through stakeholder dialogues, technical studies and project steering committees and solutions were explored through training, knowledge sharing and the identification of potential payments for ecosystem services for subsequent scaling up through district plans and budgets and follow up investment programmes that support watershed management, such as the Lake Victoria Environmental Management Programme (LVEMP-2) and Nile Basin Initiative. The project highlights the importance of strong local institutions and community-based organizations in land resources and landscape management that are backed up by an enabling policy environment, for building enhanced resilience to climate change and food and nutritional security.

We trust that the lessons learned from the diverse practices and interventions that are presented in this book, as captured so vividly by the many practitioners and authors in the four countries and by the project management team, will provide insight for prioritizing interventions for scaling out and mainstreaming SLM across target agro-ecosystems in the beneficiary countries and across sub-Saharan Africa through the TerrAfrica partnership and related processes.

Eduardo MANSUR

Director Land and Water Division

Mr. Mohamed HAMA GARBA

Representative of the FAO in Burundi

Mr. Attaher MAIGA

Representative of the FAO in Rwanda

Mr. Fred Kafeero

Representative of the FAO in the United Republic of Tanzania

Mr. Alhaji JALLOW

Representative of the FAO in Uganda

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Activities on the ground were co-ordinated by Joseph Anania, the Regional Project Coordinator and work in the basin countries was led by the FAO recruited National Project Managers, namely: Salvator Ndabirorere (Burundi); Emmanuel Muligirwa (who took over from Theobald Mashinga) (Rwanda); Fidelis Kaihura (Tanzania) and Wilson Bamwerinde (Uganda). At FAO Headquarters in Rome, Italy, the project was implemented by a multidisciplinary team in the Land and Water Division (AGL) led technically by Sally Bunning with operational and budget support of Stefan Schlingloff and specific support by Bernardete Neves (PES/IES), Monica Petri (GIS/LADA), Janie Rioux (M&E/climate) and Iwona Piechowiak (WOCAT) under guidance of the FAO country representatives in the four countries (Burundi, Rwanda, Tanzania and Uganda). Ad hoc support was provided by other technical officers through a project task force (e.g. Peter van Lierop on fire management, Philippe Ankers on livestock management, *et al.*).

This book - Sustainable Land Management (SLM) in Practice in the Kagera basin - is the final product of a process that started with a writeshop exercise held in Musanze, Rwanda in November 2014, at which some of the very many experts, technicians and field operators who worked in each country presented key lessons from their work. The intention was that these experiences should be published and widely disseminated to guide further scaling-up of the sustainable land resources and landscape management (SLM) practices and the successful approaches that were implemented by the Kagera project. Sally Bunning, FAO Senior land resources officer, was the overall lead of the publication, fostering team commitment, exploring options for continuous book concept improvement and inspiring the team for highlighting innovative strategy and perspectives presented in the book. Anne Woodfine, FAO Consultant, acted as overall technical editor for the preparation of this publication, including coordinating the authors' inputs prior to and following the writeshop and receiving contributions to prepare the Introduction and Conclusion of the section themes. Monica Petri was technical editor for a peer review and finalisation of the book by re-contacting all authors for revisions or authorizations, harmonizing contents and preparing or completing the Introduction and Conclusion chapters of the book and the section themes 2, 3, 4 and 5. Julianus Thomas, Regional Farmer field school adviser and master trainer wrote the Introduction and Conclusion chapters of section theme 1. Desktop publishing and graphic design were under the responsibility of Gherardo Vittoria and, last but not least, James Morgan and Isabelle Verbeke, Divisional communications experts, supported the book publishing process.

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Acronyms and abbreviations

ACE	area cooperative enterprises
AESA	agro- ecosystem analysis
AEZ	agro-ecological zone
APFS	agro-pastoral field schools
AVRDC-ARP	World Vegetable Center (previously Asian Vegetable Research and Development Centre) - Africa Regional Program
BXW	banana *Xanthomonas* wilt
CBA	cost-benefit analysis
CBO	community based organization
CC	carrying capacity
CCRO	Customary Certificates Right of Occupancy
C/N	carbon/nitrogen ratio
CMD	Cassava Mosaic Disease
CNDD	Conseil National pour la Défense de la Démocratie, Burundi
CO_2e	carbon dioxide equivalent
CSDGIS	Centre for Sustainable Development and Geo-Information Studies, Rwanda
CSDH	Cadre stratégique pour le Développement de l'Horticulture, Burundi
CSLP	Strategic Framework for the Fight against Poverty, Burundi
CTA	Technical Centre for Agricultural and Rural Cooperation, Netherlands
DC	district commissioners
DDA	documentation, dissemination and advocacy
DM	dry matter
DPAE	Provincial Directorate of Agriculture and Livestock, Burundi
DPSIR	Driving forces, Pressures, State, Impacts and Responses
DRC	Democratic Republic of the Congo
DMRT	Duncan's Multiple Range Test
EAC	East Africa Community
EX-ACT	Ex-Ante carbon-balance tool
FAO	Food and Agriculture Organisation of the United Nations
FBu	Burundian Franc
FDD	Force de Défense de la Démocratie, Burundi
FEC	Farmer Extension Centre, Tanzania
FFS	farmer field school
FYM	farmyard manure (animal dung)

GEF	Global Environment Facility
GDP	gross domestic product
GHG	greenhouse gas
GIS	geographical information systems
GPS	global positioning system
GTZ	German Agency for Technical Cooperation
ha	hectare
HDDS	household dietary diversity score
hh	household
HIMO	high labour-intensive (usually public works)
IAP	Integrated Approach Pilot (GEF 6)
ICM	integrated crop management
ICS	improved cooking stove
IGA	income generating activity
IDP	internally displaced person
IFAD	International Fund for Agricultural Development
ILM	integrated landscape management
IPCC	Intergovernmental Panel on Climate Change
IPM	integrated pest management
ISABU	Institute of Agronomic Sciences of Burundi
ISFM	integrated soil fertility management
IWM	integrated watershed management
IYS	International Year of Soils (2015)
Kagera TAMP	Kagera Transboundary Agro-ecosystem Management Project
KI	key informant
kWh	kilowatt hour
LADA	LAnd Degradation Assessment (in drylands)
LFFS	livestock farmer field school
LUS	land use system
LUP	land use planning
LVEMP II	Lake Victoria Environmental Management Program
MKURABITA	Property and Business Formalization Program, Tanzania
MINAGRIE	Ministry of Agriculture and Livestock, Burundi
MTEF	Medium Term Expenditure Framework, Tanzania
NAR	national agricultural research
NBI	Nile Basin Initiative
NFE	non-formal adult education
NEPAD	New Partnership for Africa's Development

NH_4	ammonium
NPK	nitrogen, phosphorus and potassium
NO_3	nitrate
OC	organic carbon
OPA	Direction d'Appui aux Organisations Professionnels Agricoles, Burundi
PES/IES	payments/incentives for ecosystem services
PFG	participatory farmer groups
PLUM	participatory land use management
PLUP	participatory land use planning
PNSA	Programme National de Sécurité Alimentaire (Burundi)
PNTD	Participatory and Negotiated Territorial Development
PRA	participatory rural appraisal
PRODEMA	Projet de Productivité et de Développement des Marchés Agricoles, Burundi
PUF	proper use factor
PVLUP	participatory village land use plans
QA	questionnaire for SLM approach assessment (WOCAT, 2008a)
QM	questionnaire for mapping land degradation and sustainable land management (also LADA-WOCAT QM)
QT	questionnaire for SLM technology assessment (WOCAT, 2008b)
R_2	coefficient of determination
REDESO	Relief for Development Society (Ngara, Tanzania)
RPO	rural producer organizations
RWF	Rwandan franc
SDGs	Sustainable Development Goals
SED	standard error of a difference
SIP	Strategic Investment Program (TerrAfrica)
SLaM	sustainable land and agro-ecosystem management
SLM	sustainable land management
SOESA	soil ecosystem analysis
SCC	Swedish Cooperative Centre
SWC	soil and water conservation
tCO_2e	tonnes of carbon dioxide equivalent
TIC	Tanzania Investment Centre
TLU	tropical livestock unit
ToT	training of trainers
TZS	Tanzanian shilling
UCA	Uganda Cooperative Alliance
UGX	Ugandan shilling

VLUM	village land use management
VLUP	village land use plan
VPLUP	village participatory land use planning
WARC	Ward Agricultural Resource Centre, Tanzania
WOCAT	World Overview on Conservation Approaches and Technologies
$	US Dollar

Introduction

Land comprises a complex set of resources primarily soil, water and biological resources, their diversity, as well as interactions with the atmosphere and the underlying geology. The product of their interactions, a range of interlinked ecosystem goods and services, is the foundation for sustainable livelihoods, social cohesion and economic growth.

Land degradation refers to the "reduction in the capacity of the land to provide ecosystem goods and services and assure its functions over a period of time for the beneficiaries of these" (FAO, 2011a).

Land degradation is caused by increased pressures on limited resources and "extractive" rather than "restorative" management practices. It is also both a cause and a consequence of climate change. Most troubling, land degradation and climate change can form a 'negative feedback loop' whereby increased food production increases emissions while the loss and degradation of soil and vegetation significantly reduce potential carbon sinks. Charcoal exploitation and resulting deforestation by the rural population and from expanding urban areas due to the lack of alternative fuels is a massive challenge in the Kagera Basin as throughout sub-Saharan Africa.

Land degradation not only endangers the livelihoods of families and communities but the resulting risk and poverty is a cause of migration and a threat to wider peace and stability. Population growth and dependence on natural resources for rural livelihoods also leads to increasing land fragmentation, overexploitation and conflict over resources. This can take the form of conflict between pastoralists and subsistence farmers over land resources, exclusion of pastoralists from more productive grazing land due to expansion of cropping or tree planting and irrigation in valley bottoms and increasing demand over increasingly scarce water and fuel resources. When land becomes unproductive, people - especially youth - are often pushed into internal or cross-border migration; leaving a very high dependency ratio in rural areas.

The United Nations Convention to Combat Desertification (UNCCD) was established in 1994 as an international commitment to halt land degradation worldwide but with a focus on desertification and drought in drylands. Despite the twenty-year long endeavours worldwide and national development plans and multiple projects on sustainable land management, the situation continues to worsen as pressures on resources increase. UNCCD is the sole legally binding international agreement linking environment and development through sustainable land management.

UNCCD (2013) highlights that the current cost of land degradation reaches about $ 490 billion per year (Berry *et al*., 2013), much higher than the cost of action to prevent it. Land degradation is a generalized risk as there are many degradation processes caused or exacerbated by human activity: erosion, compaction, nutrient mining, loss of organic matter and soil biodiversity, acidification, salinization, contamination and sealing. Yet roughly 40 percent of the world's degraded land occurs in areas with the highest incidence of poverty. Land degradation directly affects the health and livelihoods of an estimated 1.5 billion people.

Fortunately, there are clear economically viable and environmentally sound actions that can prevent and/or reverse land degradation. For example, it is estimated that the adoption of sustainable land management practices could deliver up to $ 1.4 trillion in increased crop production worldwide (ELD Initiative, 2013).

Sustainable land management (SLM) practices are adapted practices for the range of land use systems- and rainfed and irrigated cropping, grazing and forest, as well as protected areas. Sustainable management implies, as appropriate, the integrated management of crops (including trees and forage species), livestock grazing/browsing, soil, water, nutrients, biodiversity, diseases and pests to optimize and sustain the delivery of a range of ecosystem services (provisioning, regulating, cultural and supporting). SLM is an essential prerequisite to sustainable development; and requires attention at all levels (from local to national, transboundary and global) so as to optimise resource use and minimise conflicts over resources and demonstrate benefits in terms of the interlinked development concerns of food security, poverty alleviation, livelihood improvement, energy supply (biomass), and land and water governance.

The FAO Director-General, José Graziano da Silva said on the eve of World Soil Day in 2014 (5 December) that healthy soils are critical for global food production, but we are not paying enough attention to this important 'silent ally'. Graziano da Silva highlighted that: "*It can take up to 1 000 years to form one centimetre of soil, and with 33 percent of all global soil resources degraded and human pressures increasing, critical limits are being reached that make stewardship an urgent matter*". Calling soils a "*nearly forgotten resource*," he called for more investment in sustainable soil management, which will be cheaper than restoration and "*is needed for the achievement of food security and nutrition, climate change adaptation and mitigation and overall sustainable development*." The International Year of Soils in 2015 brought renewed attention to these issues. Also, soils are explicitly mentioned for the first time in the recently adopted Sustainable Development Goals (SDGs) (September 2015), so strong foundations are now in place for much more concerted action for sustainable soil management and restoration.

This book documents the lessons learned from a Global Environment Facility (GEF) funded transboundary project which was designed to demonstrate how "bottom-up" approaches with farming communities could restore degraded land and provide a basis for sustainable management across the diverse agro-ecosystems in the basin of the Kagera River. The process started by involving communities in conducting a diagnostic of their land resources, management practices and livelihoods and finding-out and developing with them a vision for their land and livelihoods and for restoring productive systems and food security during the project and in the longer term (20-30 years). The communities were then helped to develop and implement concrete action plans for selected micro-catchments, farmer field schools were established for learning, sharing and adapting SLM practices at farm and hillside level and catchment committees were established for identifying problems and conflicts and developing and promoting by-laws for improving natural resources management and gradually scaling out SLM across the landscape.

This book is a compilation of case studies on various aspects of SLM and associated activities from a range of local actors and authors who wrote up their own learning experiences that were supported through the Kagera TAMP project. It provides guidance on what works, is already being replicated and what needs to be more widely scaled-up for greater and sustained impact.

The case studies demonstrate the win-win-win (local, national and global; economic, social and environmental) benefits of working at the landscape level with concerned technical sectors and stakeholders, from land users to service providers to local policy makers to address upstream-downstream interactions and on- and off-site impacts of land resources management – soil, water and biodiversity. It also demonstrates where cross-border co-operation is encouraging alignment of policies and laws between the countries sharing the river basin. Lessons-learned for scaling-up are provided including the need for incentive measures to encourage wider SLM adoption, as well as the need to assess and monitor impacts of land degradation and local SLM practices at household level, as well as at wider community territory / watershed level, upstream-downstream and other landscape effects. This can include biophysical impacts such as water retention, erosion, sedimentation, water flow and quality, recharge of groundwater resources as well as socioeconomic and livelihood impacts in terms of productivity, income, risk, security of tenure and so forth.

The Project Area

The basin of the Kagera River is shared by Burundi, Rwanda, the United Republic of Tanzania and Uganda. Maintenance of the flow regime of the Kagera is vital for preserving water levels of Lake Victoria and the outflow to the Nile, while the riverine wetland areas are vital for deposition of eroded sediments and nutrients and hence maintaining water and pasture quality and associated livelihoods.

The basin lies in the sub-humid agro-ecological zone with a bimodal rainfall, the long rains from late February to May/June and short rains from late September to early December, providing a growing period of 90 to 200 days. Climate change however is disrupting the rainfall pattern which is becoming more unreliable and erratic with intense rain and drought periods as well as more extreme temperatures, as shown by the few scientific records backed up by farmer knowledge. The soil parent materials range from extensive schist, sandstone, quartzite or granite and gneissic formations; intrusive basic rocks and volcanic materials in the highlands; to alluvial and colluvial materials in the valley bottoms, marshes and wetlands. As in much of Africa, the soils have been leached and weathered over generations, so they tend to be acidic, with low organic matter content and cation exchange capacity, hence with low productivity. Except for the clay-rich soils which retain nutrients and alluvial soils in valley bottoms which benefit from continuous deposition of silt and nutrients from the eroded hillsides.

The basin vegetation includes a complex of forest and woodland, savannah shrub and grasslands and wetlands, with the majority of the land used for agriculture by farmers and herders. The diverse ecosystems and convergence of lowland (mainly western Guinea-Congolian) and highland (eastern afro-montane) species provide an array of habitats for multiple species of high global significance. The transboundary area of the Kagera Basin is among the most important areas in Africa in terms of agro-biodiversity and food production.

The range of farming systems and social organization has built on local knowledge generated over its long history of domestication and resource utilisation, evolving from the prehistoric hunters and fisher folk, to sedentary agriculture based on sorghum and finger millet and, subsequently, more intensive systems to meet increasing demands of the growing human populations and their livestock. Nonetheless, the farming system remains essentially subsistence agriculture, with low or negligible purchased inputs, high labour input and limited sale of surplus food and cash crops (banana, maize, coffee, etc.), and livestock products (meat, milk, hides, breeding stock). Limited areas are under commercial farms (sugar cane, horticulture, coffee, tea). Some of the drier areas in eastern Rwanda and the drier belt of the Tanzanian-Ugandan border were, until recently, still used for seminomadic pastoralism – but most pastoralists have now settled to adopt other livelihoods. More widely across the basin there is a breakdown in traditional land protocols that regulate grazing.

The farming landscapes and the socio-economic and cultural context vary widely within and among districts and countries. The agricultural systems are characteristic of east and central Africa, however, the varying ecologies and socioeconomic contexts provide for a range of locally-adapted cropping, livestock and fishing activities and livelihood systems that are strongly influenced by land and water availability and quality.

The land is used intensively and inter-linkages between the highland and lowland ecosystems are important in terms of water regulation, also for the transfer of nutrients and sediments. These ecological processes are directly affected by human intervention which determines net losses upstream – runoff, erosion, fertility decline – and net gains downstream; where there is a fine balance between benefits in terms of productivity of aquatic and terrestrial systems and risks of sediment/nutrient loading and flooding.

There is some transhumant movement of Ankole and zebu cattle in the cattle belt but paddocking and ranching has increased, and in areas with more dense human population, cattle are now stall fed and small ruminants tethered. Mixed systems include agro-forestry and aquaculture combined with pig or chicken production for nutrients. Perennial banana and coffee based systems include also tea, cassava, fruit trees- apples, mangoes and avocadoes according to the altitude. Annual cropping systems are cereal based but integrate to various extents, legumes, tubers and agroforestry species (e.g. *Grevillea*, *Cedrella*, *Calliandra*).

The natural resources of the Kagera River Basin supported the livelihoods of some 16.5 million people in 2006 when the project was being designed and based on average population growth rates for the period 1999-2015 (three percent per year) had risen to 20.9 million by the end of 2014 (expected to grow to 32.8 million by 2030). The majority of the basin's population live in the rural areas, depending directly on farming, herding and fishing activities. However, the resource base and the ecosystems have been facing increasing pressures as a result of rapid population growth, agricultural and livestock intensification characterised by progressive reduction in farm sizes and unsustainable land use and management practices. The basin's land and freshwater resource base, associated biodiversity and populations whose livelihoods and food security depend on those resources, are under threat due to land degradation, declining productive capacity of croplands and rangelands, deforestation and encroachment of agriculture into wetlands and climate change.

The Project

The **Kagera Transboundary Agro-ecosystem Management Project** (Kagera TAMP) is part of the **TerrAfrica Strategic Investment Program (SIP) for sustainable land management (SLM) in sub-Saharan Africa (SSA)**. The SIP was the response from the Global Environment Fund (GEF) to support SSA countries under GEF 4 to tackle land degradation. The SIP provided a challenging framework bringing together the World Bank, UNDP, UNEP, IFAD, AfDB and FAO as implementing agencies in close coordination with New Partnership for Africa's Development (NEPAD), regional economic communities and countries, aiming to strengthen coordination between GEF and other funding mechanisms. The SIP provided $ 150 million of GEF's land degradation funding to 36 projects in 26 countries in sub-Saharan Africa between 2007 and 2010, and attracted co-financing of about $ 800 million.

The overall goal of Kagera TAMP was to support the adoption of an integrated ecosystems or landscape approach for the sustainable management of land resources in the Kagera Basin to generate local, national and global benefits including: restoration of degraded lands; carbon sequestration and adaptation to climate change; agro-biodiversity conservation and sustainable use; and increased agricultural production, thereby contributing to food security, sustainable rural livelihoods and protection of the international waters of the wider basin. The adoption of improved land use systems and resource management practices by the range of land users was to be supported by stakeholders at all levels by participatory and inter-sectoral approaches. To achieve these objectives, the Kagera Transboundary Agro-Ecosystem Management Project (TAMP) included four components:

1. Enhanced regional collaboration, information sharing and monitoring;
2. enabling policy, planning and legislative conditions;
3. increased stakeholder capacity and knowledge at all levels for promoting integrated agro-ecosystems management; and
4. adoption of improved land use systems and management practices generating improved livelihoods and environmental services.

Increased regional cooperation was designed to provide an enabling environment across the transboundary river basin to build local capacities and knowledge, also mobilising stakeholders to bring about a transformation towards more productive and sustainable agricultural ecosystems (range, agro-pastoral and cropping).

Sustainable management of the shared resources of the Kagera Basin and revitalised farm-livelihood systems were envisaged to generate significant environmental benefits through restoration of well-functioning ecosystems and their environmental services, such as water regulation, nutrient cycling, carbon storage and provision of habitats for biodiversity.

The Kagera project focused especially on the identification, piloting, demonstrations and dissemination of best practices and technologies adapted to the various agro-ecological and socio-economic contexts. The focus was placed on three main farming systems:

i. The **extensive agro-pastoral systems** on drier lowlands and floodplains (with erratic rainfall between 600 and 1 000 mm per year) in the cattle belt in the Kagera Region of Tanzania (Karagwe, Ngara and Missenyi Districts), and parts of Uganda (Mbarara, Rakai and Isingoro Districts), as well as in Rwanda (Nyagatare, Kayonza and Kirehe Districts) where cattle grazing is now largely restricted (but many herds are kept over the border) and farmers rely on one or two stall fed cows to provide manure for the farmstead;

ii. the **intensive mixed banana and annual cropping systems** (maize, beans and vegetables) in the wetter more productive areas along Lake Victoria (around Bukoba town reaching a high of 2 000 mm mean annual rainfall) and in the hills and valley bottoms in Uganda (Kabale, Ntungamo), Rwanda (Rulindo, Kamonyi and Bugasera) and Burundi (Kirundo) with an average rainfall between 800 and 1 200 mm, and

iii. the **mid altitude plateau** (1 500 to 1 900 meters, and reliable rainfall 1 000 to 1 400 mm), with coffee mixed with banana, fruit trees and annual crops, including Irish potatoes, and with natural and planted forests in the upper catchments in Burundi (parts of Muramvya, Mwaro and Gitega), and Uganda (parts of Kabale and Ntungamo).

Figure 1: Landscape rehabilitation activities in Burundi

This Book

This publication records some of the many lessons learned by the project over the period 2010 and 2014. These include implementation of many win-win-win solutions drawn from the broader range of sustainable land and water management technologies. It also presents the key approaches that were used to promote the planning and adoption of improved practices. The project has tapped into traditional as well as innovative management practices, focusing those that are technically, ecologically, economically and socially sound.

This gathering and analysis of the results of the pilot projects seeks to identify those technologies that enhance productivity and decrease crop and livestock production risks in particular regions and agro-ecological zones and thereby contribute also to climate adaptation.

The results clearly demonstrate that restoration of the degraded lands of the Kagera Basin and increasing the resilience of livelihoods can only happen if and when land users have the knowledge and capacity to both organise themselves in response to changing social economic and environmental trends including pressures on land resources and resulting land degradation. In particular land users need to understand the impacts of land fragmentation and over-exploitation as well as of increasing weather variability and climate change which threaten the livelihoods of their households on family farms. Educating the land users about the crucial role that soil restoration and water conservation play in food security, climate change adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development is shown to be vitally important.

The chapters of this book are organised into five themes, namely:

- **Theme 1**: Farmer field schools approach for successful learning and uptake of adapted SLM technologies at farm and ecosystem level;
- **Theme 2**: Catchment planning and local governance for integrated land resources management;
- **Theme 3**: Agro-ecosystem management for multiple benefits (production, SLM, climate and biodiversity and ecosystem services);
- **Theme 4**: Natural resources and livelihoods diagnostics and Impact assessment for SLM planning and monitoring;

- **Theme 5**: Inter-sectoral cooperation, planning and policy for addressing transboundary land resources management.

The fist theme of the book describes the **Kagera TAMP capacity developed based on the farmer field school (FFS) approach** focusing on adapted and sustainable land and agro-ecosystem management (SLaM) technologies. FFS have been used throughout the project. However, in the book's first theme, case studies are presented using FFS for land rehabilitation, soil fertility enhancement, crop-livestock integration, horticultural production, and climate change adaptation at farm and ecosystem levels. In FFS farmers are using their skills to undertake adaptive research (validation trials) and at the same time learn the *what*, *why* and *how* of the new skills and become active rather than passive receivers of extension/new messages.

The second theme targets **catchment planning and the importance of local level governance for integrated land resources management**. While the specific Kagera TAMP interventions and processes in each country were defined based on their local context, the general assumptions included the importance of informed planning and of collection of data to increase knowledge in order to prioritize interventions. Also, the participatory planning process based on and focusing at an enhanced community awareness. In addition, the project supported the diversification of practices in order to multiply benefits and include multiple stakeholder's preferences and technical focuses. Finally, planning and governance was grounded in capacity development both at the farmers and at institutional level.

The third theme of the book analyses **agro-ecosystem management interventions and their multiple benefits**. The agro-ecosystem approach aims to overcome the multifaceted constraints facing agricultural systems through a broad-based integrated process. Although all the project activities are agro-ecosystem based, the theme describes some activities such as agroforestry management for sustainable land management, improved agro-biodiversity to boost sustainable environmental uses, improved cooking stoves to reduce deforestation and support livelihood and crop-livestock systems to control soil erosion, increase fodder production, and boost soil fertility management.

The Kagera TAMP used **diagnostics and impact assessment** – taking into consideration both indigenous and scientific knowledge – as the basis to guide appropriate locally based intervention. The forth theme of the book describes how the project applied a number of proven methodological frameworks and tools at farm-household, catchment and ecosystem scales. Such methods were used to assess and quantify the nature, extent, severity and impacts of land degradation and sustainable land management. The theme also illustrates how such assessments were used to derive appropriate conclusions that guided interventions on the ground in an adaptive manner.

Finally, the fifth theme addresses **transboundary land resources management** issues and analyses how inter-sectoral cooperation, planning and policy can improve livestock management, reduce grassland degradation, and reduce natural resources related conflicts. The studies included in the fifth theme provide expanded knowledge on the root causes of conflicts in the basin, and provide recommendations for policy harmonization within and between countries. Also, the analysis suggest that strengthening negotiation between actors through increased capacity development would reinforce conflict solution even if the increase of investments for grassland rehabilitation and livestock sector is deemed necessary.

It is anticipated that these results will provide models for scaling-up improvements in the targeting of sustainable land and water management techniques as part of efforts to promote farm-level and wider catchment or landscape level adaptation to climate change. The findings provide much needed on-the-ground experience to assist other project and programme designers to plan initiatives which better support the "silent ally" and restore healthy soils and agroecosytems.

Sustainable land and agro-ecosystem management

Sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously:

- maintain or enhance production/services (Productivity)
- reduce the level of production risk (Resilience/Security)
- protect the potential of natural resources and prevent degradation of soil and water quality (Protection)
- be economically viable (Viability)
- and socially acceptable (Acceptability).

These five objectives of productivity; security; protection; viability and acceptability are seen to be the basic 'pillars' on which the SLM edifice must be constructed and against which its findings must be tested and monitored.

In addition to the SLM principles, the agro-ecosystem management avoids simple prescriptions for the application of ecological principles to agriculture, emphasizes the continued centrality of the ecosystem perspective, and the need to integrate ecological, economic, and social considerations in agroecosystem science and management. Such a concept implies that purely technological approaches are insufficient for solving the food systems problems of the future. It explores practical innovative strategies, policies, and research needs necessary to develop management approaches that emphasize whole system productivity, diversify agricultural operations, and sustain multiple functions, including ecological integrity.

Source: FAO Terminology database www.fao.org/faoterm/en/ and Bohlen and House, 2009.

Preface

The Transboundary Agro-ecosystem Management Project for the Kagera River Basin (Kagera TAMP) was approved by the Global Environment Facility (GEF) in June 2009. The project goal was to adopt an integrated ecosystems approach for the management of land resources generating local, national and global benefits. The project has promoted sustainable land management (SLM) for the restoration of degraded lands, climate change adaptation and mitigation, protection of international waters, agro-biodiversity conservation and sustainable use and improved agricultural production. Project activities lead to increased food security and improved rural livelihoods. The situation and achievements at the end of the Kagera project as per the final regional project steering committee meeting held in Tanzania in 2015 are listed below including main challenges, strategy and approaches and outcomes and opportunities.

Five main challenges for promoting and scaling up SLM were highlighted during the Kagera project:

1. Limited availability, knowledge and capacity of service providers (extension staff) in soil, water, agro-biodiversity and integrated ecosystem management and in understanding interrelations between SLM and development;

2. Inadequate data and knowledge on the short, medium and long term benefits of SLM practices adopted at farm and wider catchment/watershed level [production-food security and income, environmental services (control land degradation, water supply, flow and quality, biodiversity conservation and livelihoods and culture)];

3. Inadequate attention to SLM in plans and budgets and inadequate investment in SLM by central and district governments, also other development partners despite the multiple benefits that can be generated;

4. Sectoral fragmentation of activities and inadequate mechanism(s) for providing multi-sector advice and technical support to ensure sound design and quality control for SLM interventions;

5. Inadequate attention and mechanisms to address conflicts over natural resources, access and user rights (gender, youth) and security of tenure through individual and common property rights as an integral part of SLM and as a basis for sustainable investments.

An eight point SLM strategy and approaches was developed by Kagera TAMP to tackle the interlinked issues of human pressures on natural resources, poor management practices and limited capacities and the implications in terms of widespread and escalating land degradation, biodiversity loss, vulnerability to climate change and food insecurity. The SLM strategy for integrated ecosystem management and enhanced food security and livelihoods that was validated by the project over the five years lifespan highlighted the importance of **eight main actions**:

1. **The farmer field school approach** on sustainable land management (FFS-SLM approach) for building farmers capacity in integrated natural resources management for the maintenance of ecosystem services and food and enhanced livelihood security;

2. **Participatory catchment process from diagnostic** (using LADA Local tools) for informing community action planning and management – and local mechanisms such as catchment/watershed committees, stakeholder dialogue and negotiation for conflict resolution and FFS – catchment linkages for scaling up proven practices;

3. **Demonstrating how SLM brings win-wins**, contributing to climate change adaptation/building resilience and mitigation (carbon sequestration and reduced GHG emissions), reducing land degradation (vegetation cover, erosion control, nutrient cycling, restoring soil organic matter), enhancing agro-biodiversity (genetic resources, species, habitat), as well as socio-economic benefits/ livelihoods (yield, income, nutrition and food security, resilience and reduced risk);

4. **Partnership and capacity development** for improved support to farming and pastoral communities:

   a. Service providers including community based organizations (CBOs) and farmer facilitators for effective continued support to farmers and livestock keepers (e.g. through FFS);

   b. Multi-sector SLM teams at local Government level, and linkages with agricultural research for technical support and quality control.

5. **Leveraging of resources** (micro-credit, income generating activities, small grants) and incentive mechanisms [payment for ecosystem services (PES), markets, sustainable harvesting, etc.] for sustained actions and scaling-up;

6. **Documenting, assessing and sharing knowledge on SLM practices** (tools and methods) including packages of SLM practices for specific land uses/agro-ecosystems in the basin [soil and water conservation on steep lands; crop-livestock-tree integration for food, energy and resilience (agrosilvopastoral systems); regenerating healthy rangelands systems through grazing and livestock management, protecting river and lake margins];

7. **Cross border diagnostics and collaboration** for conflict resolution and management of transboundary issues (erosion-sedimentation, livestock movements, pest and diseases, refugees outbreaks, etc.);

8. **Integration of SLaM into policies, planning and legislation** at local, district/province and national levels through creation of multi-sector national SLM teams, synergy and partnerships with other projects and programmes (LVEMP, NBI, TerrAfrica, etc.) mainstreaming SLM into plans and budgets and implementing food and agricultural strategies, Rio conventions, etc.

Finally, six main outcomes and opportunities for scaling-up and next steps were identified for the various partners (central and local government, service providers and other actors), specifically:

1. Multi-sector teams at district/provincial levels with enhanced capacity to guide and coordinate a SLM strategy and actions;

2. Farmers, herders and local actors convinced of the multiple benefits generated by the SLM practices;

3. SLM FFS validated as a proven approach for promoting participatory learning and empowerment for sustainable land resources management and enhanced production;

4. Capacity of local actors built and demonstrations in place (FFS study plots and catchment management plans) as a basis for scaling up SLM;

5. Increasing recognition of the need for governance mechanisms for SLM at local level (committees, by-laws, etc.) and for multi-sector policy, planning and integrated catchment/watershed approaches (landscape);

6. Follow-up projects are in formulation at country level by line ministries with support of FAO in line with FAO-government agreements (country programme frameworks) in at least three of the four countries (with GEF, LVEMP-II and other donor support) and interest confirmed by other regional programmes/partners (such as Nile Basin Initiative Integrated Kagera River Basin Management Project and Vi-Agroforestry) for scaling-up Kagera TAMP achievements. In particular further GEF support has been provided post Kagera TAMP for developing two innovative projects under the Integrated approaches pilot for food security (GEF-6) in the Burundi highlands and northern Uganda (Karamoja subregion) for better integrating SLM and value chains, linking science and policy platforms and monitoring and assessing impacts. While in Rwanda, FAO is providing support for an agro-environmental process by enhancing the integration of sustainable food and agriculture systems (SFA) with the forest and landscape restoration process (FLR) to meet the Government commitment towards the Bonn Challenge and scale up through innovative financing with support of the GM, WRI *et al*.

Farmer field school approach for successful learning and uptake of adapted sustainable land and agro-ecosystem management technologies at farm and ecosystem levels

1

Introduction

One of the major objectives of the Kagera transboundary agro-ecosystem management project (Kagera TAMP) is *"increasing stakeholders' capacity and knowledge at all levels for promoting integrated agro-ecosystem management"*. The chapters under this theme therefore provide examples of the Kagera TAMP experiences on how the objective of increasing the capacity of stakeholders was achieved. The theme specifies the learning and uptake of adapted sustainable land and agro-ecosystem management (SLaM) technologies at farm and catchment levels through the farmer field school (FFS) approach. The theme explores on how various SLaM technologies were developed through the FFS learning cycles, validated, adopted and disseminated.

The theme also provides evidence and experiences on how these specific technologies performed in achieving or contributing to sustainable and profitable use of land resources, through (but not limited to) soil erosion control, improved vegetation cover and productivity in crop and rangeland management, and improved livelihoods.

The final chapter provides an example of how under the project in Uganda, FFSs are being directly guided by the district commercial officer to form rural producer organizations (RPOs) which then form area cooperative enterprises (ACEs). This process is enabling the farmer groups to exploit their higher productive and marketing potentials to improve their incomes and livelihoods. To achieve this, they are addressing the key constraints of low group numbers per location and improving enterprise selection to increase their income generating potential – providing a model for other FFSs to follow.

The FFS concept

The FFS approach is an extension methodology which uses farmer groups to delivery advisory services in a more interactive, participatory and democratic manner than previous often top-down extension systems. Through the FFS methodology, the agriculture extension officer or FFS facilitator interacts with farmers in more of an interactive learning environment. Furthermore, the FFS extension approach follows the principles of adult learning (i.e. non-formal adult education (NFE) in delivering the extension messages, knowledge and skills. Together with other merits of NFE, farmers' already acquired experiences and indigenous knowledge provide the starting point and basis of learning in FFS, hence it is an experiential learning approach.

In its grassroots operational sense, FFS involves a group of farmers coming together to learn something related to agriculture and/or life skills. These groups of farmers, usually numbering 25 – 30 individuals, normally share a common interest (e.g. how to increase the crop yields on their degraded plots) and meet regularly in their learning field. Most of learning activities of FFS take place in the field, thus the field is their prime learning environment and material, hence they are commonly known as "*a school without walls*". The FFS field can be either an agriculture enterprise or any other related enterprise such as rangeland for livestock keeping, an animal stall, beehives, fish ponds, a tree nursery or a woodlot, etc. In all circumstances, the field is a place where members are exposed to the real situation of their production challenges and where they learn to tackle them by practically improving the way they do things and receive practical learning and make informed decisions.

The FFS field or study plot is also used by members to test and validate various new knowledge and skills before adopting them in their own fields. Instead of being mere recipients of extension messages and technologies, farmers by using their FFS plot undertake adaptive research (validation trials) and at the same time learn the "*what, why and how*" of the new skills, thus the FFS plot becomes a study plot rather than demonstration plot and thus farmers become active rather than passive receivers of extension/knowledge. In the same vein, all learning process of FFS is participatory and bottom-up rather than top-down.

The SLaM concept

Sustainable land and agro-ecosystem management (SLaM) is the adoption of management practices / technologies that enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the wider functioning of the agricultural system (living and nonliving components as well as their interactions and ecological processes).

Farmer field schools (FFS) have therefore been an instrument to generate and carry the SLaM education (knowledge and skills/practices) to Kagera TAMP catchment communities.

The FFS methodology has been well adopted and replicated across various levels of project stakeholders (notably agriculture extension officers/service providers, FFS facilitators and farmers in the communities), contributing to achieving the SLaM capacity building objective of the Kagera TAMP.

Development of the FFS component within the Kagera TAMP

The FFS component of the Kagera TAMP followed four major phases in its development (see Figure 1), these were:

1. needs assessment;
2. development;
3. implementation;
4. monitoring and evaluation.

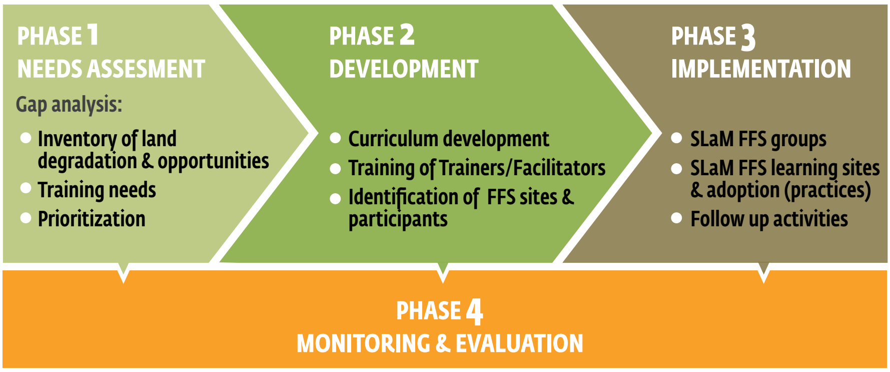

Figure 1: SLaM FFS development process.

Needs assessment phase embraced the baseline and gap analysis activities of the project. During this phase, the causes of land degradation and other production constraints were identified and documented (using WOCAT and LADA[1] tools). The aim of this phase was to both identify existing gaps to be included in the FFS SLaM learning curriculum and to identify opportunities and good practices that could be utilised by SLaM and FFS community members

1 WOCAT - World Overview on Conservation Approaches and Technologies – see www.wocat.net
LADA - Manual for Local Level Assessment of Land Degradation and Sustainable Land Management – see www.fao.org/nr/lada/.

Development phase covered various project activities such as the selection of FFS sites in micro catchments, selection of potential FFS facilitators, training of trainers and FFS facilitators (ToTs and ToFs), also development of FFS curriculum and action plans, including the FFS SLaM participatory monitoring and evaluation framework. In its core content, the development phase was essentially the capacity building phase of the FFS facilitators and coordinators (i.e. extension officers and local service providers) on SLaM practices and the FFS methodology as the avenue for learning and dissemination of SLaM.

Implementation phase was the actual period during which there was mass capacity building of community members (i.e. FFS members) through the growing season and year-long FFS learning groups, facilitated and backstopped by SLaM FFS facilitators and extension officers/service providers respectively.

Monitoring and evaluation (M&E) phase entails follow-up activities, monitoring and fostering of adoption SLaM, documentation of FFS activities at all levels and report production. The M&E phase has been continuous and recurrent during all phases of the project.

Table 1 shows the numbers of people directly involved in the FFS activities during the Kagera TAMP in each of the four participating countries.

		Gender	Burundi	Rwanda	Tanzania	Uganda	TOTAL
Training of trainers/ Facilitators	No. of session held		4	3	2	10	19
	Total No. of parcepants	*men*	22	96	35	279	432
		women	2	9	11	153	175
Farmer field schools	No. established		40	24	24	45	133
	No. active at end Dec 2014		40	24	24	41	129
	No. of FFS members	*men*	486	181	249	502	1 418
		women	729	370	261	583	1 943

Table 1: Numbers of training sessions and number of men and women trained in FFS methodologies and benefiting from SLaM through the Kagera TAMP.

In the final action stage, the SLaM FFS development process follows a series of activities for its growth and scaling-up. FFS scaling-up then follows the sequence of activities as presented in Figure 2.

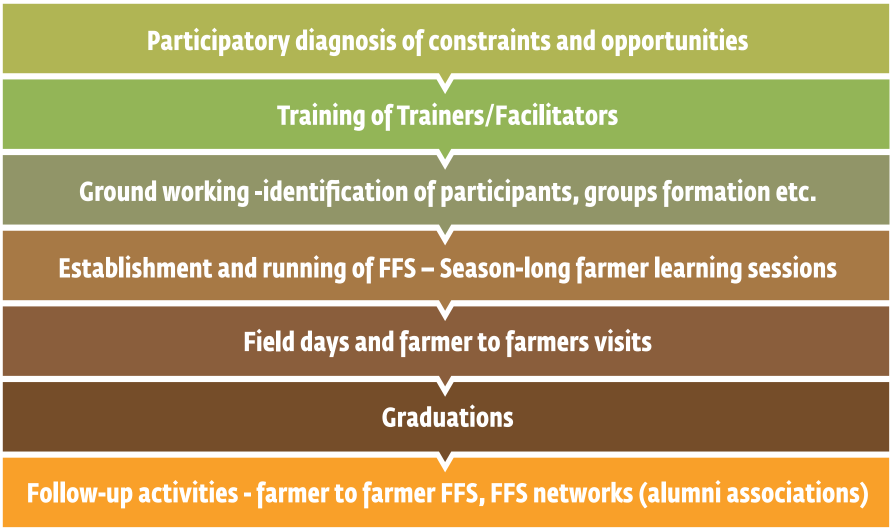

Figure 2: FFS generic sequence of activities.

Key highlights of the project's FFSs

Various SLaM technologies have been introduced, learned and practiced through the SLaM Farmer and Agropastoral Field Schools.

Chapter 1.1, based on experience from Rwanda, describes the participatory technology identification realised by community members in a micro-catchment. The process enabled farmers to address site-specific needs based on specific interests. Capacity building resulted in a variety of SLM practices taking into consideration the existing knowledge and building on it to develop the learning process, including exploration and observation on the selected technologies, and meeting the community demands in each location.

Chapter 1.2, based on Kagera TAMP experiences from Burundi micro-catchments, looks at how soil improvement has been enhanced through the use of quality compost. Giving the details of methods for making quality compost, the chapter explains further the environmental benefits of using compost and its cost effectiveness, as well as how farmers are now benefiting from what was considered as unwanted/useless plant/crop residuals to be burned.

Chapter 1.3 presents the Kagera TAMP SLaM FFS experiences on crop-livestock integration technological innovations, using the Tanzania case study. Crop-livestock integration involves the purposeful combination of crop and livestock production activities in order to benefit from their synergistic relationship in maximizing food production, increasing income and improving livelihoods and wellbeing of the communities. Specifically, animals kept on-farm enable farmers to accomplish the triple-win situation of: a) providing manure, which is a basic resource vital for increased crop productivity; b) playing a significant role in increasing farmer income and livelihood diversification; and c) enhancing ecosystem function by restoring soil fertility, increasing soil structure and moisture retention, and hence adaptating to climate change. In addition, animals kept on-farm also benefit from domestic and farm residues and animal products enhance households' diets. Soil fertility degradation is largely a result of continuous nutrient uptake by plants and removal of materials at harvest, without replenishment of important nutrients and organic matter, and is a main cause of low crop productivity, hence crop-livestock integration for soil nutrient replenishment was an important SLaM FFS learning activity.

In Burundi, FFS have also been effective to introduce drought tolerant vegetable species in order to address the challenges caused by increasing weather variability and climate change. **Chapter 1.4** analyses both the FFS household level lessons learnt and the large-scale community production and marketing. Also, to address the challenges of lack of good quality horticultural seed, FFS members were trained on local level vegetable seed production focusing on farmers' preferred indigenous vegetables. Results included increased yields and improved nutritional diversity.

The FFS has also been an effective means for enhancing attitudinal change of its members. **Chapter 1.5** presents the Burundi experiences of the impact of SLaM FFS in changing attitudes of the community members towards a common vision for the management of their landscapes. Through FFS, mass awareness creation has been made possible. Critical analysis of the state of their lands was shown to be key to prompt smallholder farmers into awareness and a decision to act to reverse the trends that are negatively affecting their environment (soil condition, vegetation cover, erosion, water scarcity, etc.).

The SLM FFS groups have realised social and economic benefits during the project which can be expected to grow in the coming years as the concept is scaled-up.

Chapter 1.6 explores the opportunities and challenges for transformation of FFS groups into larger farmer organisations or cooperatives within specified geographical boundaries. Based on Kagera TAMP experiences in Uganda, this chapter elaborates the multiple benefits of transformation of SLaM FFS groups into cooperatives: a) market bargaining power, b) collective marketing to reach buyers quantity demands, c) ability to reach distant markets, d) quality control, e) cohesion, f) sharing of experiences, etc. As experienced in the case of Uganda, taking into account the mean land size per farm or household, increasing production of certain crops through applying SLM at catchment levels provides the potential for more market-oriented production, which is being made possible by FFS organisations/cooperatives. The chapter goes further to propose desired and effective models for the formation of FFS networks or cooperatives.

Enhancing farmers' capacities through participatory learning for sustainable land and agro-ecosystem management

1.1

the impact of farmer field school approach in adoption of watershed management practices

Author: Daniel T.N. Rukazambuga

Affiliation: College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda

> *"The soil losses in sub Saharan Africa are an environmental, social and political time bomb. Unless the trend is reversed, the future viability of food security system will indeed be imperilled"*
>
> Dr Norman Borlaug, 14 March 2003, Muscle Shoals, Alabama, USA

Summary

The sound management of land based natural resources is prerequisite to sustainable resource based production system and development, in particular for Sub Saharan Africa where livelihood depends on equitable use of land resources. The degradation of natural resources is therefore considered to be the greatest constraints to sustainable agricultural and economic development in most developing countries. The top-down one-sided approach cannot address sustainable land and agro-ecosystem management related issues which are site specific. The use of participatory approaches addresses individual site specific problems, and minimize blank recommendation. The sustainable land and agro-ecosystem management FFS Kagera TAMP approach was a new concept to the

target communities. In different microcatchments, however, farmers, facilitators and service providers were motivated to make the learning activities a success and were willing to contribute both their time, inputs and other resources. Their enthusiasm and motivation was an indication of disposition to the adoption of SLaM skills and acceptable mechanism to influence sustainability of practices in the community for long term impact. There is no doubt that FFS-SLaM is the best approach in order for the farmers to be empowered to make informed decision on land resource and watershed management.

Key words: FFS, training of trainers, participatory approach, SLaM, watershed approach.

Introduction

Sustainable natural resource management

The globally concerning lack of sustainable natural resource management is especially worrying in sub-Saharan Africa where livelihood depends on equitable land resources use. Sound management of natural resources is prerequisite to sustainable resource based production system and development. The degradation of natural resources is considered to be the greatest constraint to sustainable agricultural and economic development in most developing countries (Achouri, 2005). Therefore, the sustainable use and management of land resources will only be achieved through improved management of land, water and vegetation. The involvement of all stakeholders in SLaM is essential. The top down unilateral approach cannot address SLaM related issues which are site specific, hence the use of participatory approach is critical. The Rwandan land resources are increasingly under pressure due to high rate of population increase (leading to encroachment of settlements, reduction of vegetation cover due to expansion of cropping areas, etc.). The high dependence on land resources for economic development and livelihood of the majority of the population is leading to land degradation, soil erosion, deforestation and pollution.

Watershed management

The watershed management is considered to be an appropriate approach ensuring the preservation, conservation and sustainability of all land-based resources and improving the living conditions of people in the uplands and

IWM - Integrated watershed management

The process of formulating a planned course of action with all sectors and actors concerned across a specific hydrological unit of land - the catchment or watershed - to address the biophysical, social, and economic issues affecting land and water resources and their use and the provisioning of ecosystem services. A participatory watershed management approach puts communities living in the watershed at the centre of the watershed planning, development and management process.

The aims are multiple:

- To protect, conserve and improve the land, water and biodiversity resources and ecosystem services of the watershed for more efficient and sustained production and enhanced and more resilient livelihoods.
- To restore or rehabilitate degraded vegetation and soil resources.
- To check soil erosion and reduce the sediment load in waterways and wetlands to sustain water quality and buffering capacity.
- To increase rainwater infiltration and regulate the flow regime so as to moderate flow peaks and frequency and severity of flooding downstream and resultant damage.
- To enhance afforestation in upper catchments to protect surface and groundwater water supply and recharge and improve the production of timber, non-wood food products and wildlife resources.
- To establish competent local organizations capable of planning, managing and monitoring and evaluating actions and investments and resolving conflicts over land use/natural resources across the watershed for the multiple social, economic and environmental benefits of land users and other stakeholders.
- To put in place appropriate governance regimes at all levels for improving access to and rights over resources especially for marginalised actors in the watershed (women, youth, ethnic minorities).
- To contribute to enhanced food security, poverty reduction and climate adaptation and mitigation.

Source: Bunning, 2016.

lowlands (Tennyson, 2005). The integrated watershed management through people participation has become widely accepted as the approach that ensures sound sustainable natural resource management and better economy for upland inhabitants, as well as people living downstream areas (FAO, 2005).

The watershed approach integrates various aspects of forestry, agriculture, hydrology, ecology, soils, physical climatology, and other sciences to provide different management options within specific social and economic contexts, with the aim of improving living conditions of the upland inhabitants. The empowerment of the main stakeholders in watershed management to plan and implement appropriate activities is essential for sustainability of programmes. The degree of success of watershed management interventions depends primarily on the will of the people to apply the technologies. In some cases, low-tech and low-cost uplands interventions were more sustainable than high-tech, high-cost technologies (Tennyson, 2005). The highlands of Burundi and Rwanda is the main divide between the two largest rivers in Africa: the Nile (via the Kagera TAMP) and the Congo Rivers for the 80 and 20 percent of its territory respectively. Sustainable management of the watersheds is critical for the wellbeing of the populations and requires measures that are adapted to upper, mid and downstream contexts.

Land degradation (LD) and integrated soil fertility management (ISFM)

Accelerated soil erosion is the major land degradation process in Rwanda, resulting in decreased yields among many small-scale farmers due low soil fertility in the Kagera Basin, and country at large. ISFM is the application of various complementing soil fertility management practices. ISFM increases the knowledge to adapt to specific conditions maximizing fertilizer and organic resources use efficiency and crop productivity, and potentially increasing yield. The Kagera TAMP has adopted FFS approach to disseminate ISFM technologies in the watershed of Nile Basin.

Farmer field schools (FFS) as a participatory approach

The FFS approach is widely acknowledged to have profound impact in empowering farmers with knowledge and technology, and play key role in accelerating the good practices generation and adoption among farming communities. The involvement of farmers in the selection of appropriate technology puts the farmers at the centre of FFS, and hence determines the success of technology dissemination. The FFS process involves farmers in the identification of constraints and gaps through discussion and brainstorming, and in the selection of available technologies which in turn leads to development of curriculum for learning and technology development.

The FFS process starts by developing the capacity of the trainers that will train FFS facilitators (often referred as training of trainers or ToT). The ToT study programme (curriculum) is developed by participatory identification of constraints, gaps, and training needs of the to be facilitators. Also, the trainers select farmers and identifies community-felt production constraints, technologies availability and gaps, and continue to further develop the curriculum during a season long training program that involve FFS groups of usually around 30 people. It is a dynamic approach which is able to empower farmers including built-in mechanisms for participatory monitoring, evaluation and improvement. The Kagera TAMP has adopted the FFS approach as dissemination tool of SLaM technologies.

Methodology - The Kagera TAMP FFS-SLaM approach

The farmer field school approach and site selection

Widespread adoption of SLM to address the extensive land resources degradation is one of the greatest challenges in Rwanda. The majority of farmlands are characterized by modest to severe erosion due to continuous cropping and nutrient depletion exacerbated by the steep slopes of the hilly landscape and leading to land resources exhaustion. The Kagera TAMP has adopted FFS-SLaM approach to address key challenges in catchments and watershed in general. The project adopted the farmer field school (FFS) participatory approach as a tool to disseminate SLaM in the selected ten microcatchments sites from eight sectors in the seven districts of Rwanda (Table 1) in the Nile/Kagera Basin. FFS is accepted at national level as a technology dissemination tool and also builds cohesion among group member leading to long term association as SLaM sustainability mechanism.

	FFS group visited	Micro catchment	Sector	District	Province
1	Inziraitera Mbere	Gatebe II	Rwimiyaga	Nyagatare	Eastern
2	Dufatanye	Cyabajwa	Kabarondo	Kayonza	Eastern
3	Ejo Heza Kiyanza	Nyamirama	Nyamirama	Kayonza	Eastern
4	Abishyize Hamwe	Nyagasozi	Nasho	Kirehe	Eastern
5	Tuzamurane	Muganza	Kigina	Kirehe	Eastern
6	Duteraninkunga	Nyirarubomboza	Rweru	Bugesera	Eastern
7	Dufatanye Gakindo	Gakindo	Rweru	Bugesera	Eastern
8	Abakoranamurava	Gasharu	Kayumbu	Kamonyi	Southern
9	Twizamure	Nyarurembo	Kayumbu	Kamonyi	Southern
10	Umurava	Karambo	Murambi	Rulindo	Northern

Table 1: Ten FFS groups and microcatchments selected from eight sectors in seven districts of Rwanda.

The training of trainers (ToT) and the role of facilitators

The component of SLaM FFS in Kagera TAMP began with training of FFS facilitators and a coordinator, including competent farmers, extension staff (sector and district agronomists) and service providers. These three categories of field practitioners were trained through a series of repetitive intensive and residential classes. Facilitators were selected from each of the FFS groups. Sector and district extension staff and service providers were trained to backstop the facilitators. Facilitators play an important role at all levels of the learning process. Through their knowledge of land resource management community-felt needs and potential solutions (what works and what doesn't work), they help increasing farmers' problem-solving and decision making therefore impacting on the whole watershed management. The facilitator also attends season long training and he/she should be committed to solve the community-felt problem(s) and share knowledge with others without personal benefits. The facilitator/ trainer of farmers plays a complex role during the process, as coordinator, trainer, organizer, motivator, etc. The selection of the right facilitator predetermines the success of the learning process.

FFS groups and the implementation of farmer' trainings in the communities

Constituting FFS groups and their training in SLaM technologies was one of the main activities of Kagera TAMP to enhance capacity building of the communities. Selection of committed and enthusiastic participants (in terms of learning and adopting) in the SLaM FFS learning process is a key aspect which needs to be properly undertaken for the success of learning and adopting process. These groups, guided by well trained and competent FFS facilitators, meet frequently on common grounds (i.e. SLaM FFS study fields) to discuss, test and validate various SLaM practices. By using these study fields, the FFS members set SLaM of their own choice depending on their own land degradation critical issues and needs for further innovations. These field study sites are set in various forms such as comparison studies, trials and experiments. They include technologies such as various soil cover studies/options, water infiltration and retention soil cover strategies (i.e. reduction in water run-off), fertilization trials, adaptability of leguminous plants, varietal comparisons and assessments, etc. The SLaM study fields are used for technology generation and for dissemination and adoption of proven good practices to FFS and non-FFS members.

Unlike the classical integrated pest management (IPM) FFS, the SLaM FFS follows a micro-catchment approach whereby various complementary FFS technical options are integrated in the FFS learning curriculum and diffused within and across different land use types. The SLaM-FFS are a school of thought focusing on the ecological interface of soils, plants, livestock, vegetation in the context of production, sustainable use of natural resources and mitigation of climate change.

Besides the SLaM technical learning activities, the FFS groups are also social dynamic groups addressing other daily life concerns. Groups initiated income generation activities (IGA) in line with SLaM and increasing incomes. Such IGA include goat keeping, bee keeping, commercial tree nursery establishment, etc. By keeping goats for instance, members get farmyard manure for fertilizing their soils which in turn creates revenue.

The qualities of a good FFS group are diverse including: presence of SLaM learning site, regular meetings, strong group cohesion, good attendance and participation, group dynamics, group leadership and self management, record keeping, presence of action plans (short and long term), adoption (and evidence of adoption) by members, gender mainstreaming, common interest and even the presence of group income generation activities.

Participatory technology identification in microcatchments

The FFS participatory approach involved farmers (members of FFS groups) in the baseline assessment of constraint identification, knowledge gap and learning needs assessment, and hence development of the SLaM FFS learning curriculum. FFS members were also involved in the development of the participatory monitoring and evaluation framework. Participatory monitoring and evaluation is a crucial component in FFS learning process as it provides suggestions for further improvement.

The selection of technologies by community members themselves enabled farmers to address site-specific needs and varied based on farmers' interests contrary to top-down approaches which promote similar technologies in all sites without allowing farmers choices. As a consequence, the selected technologies were not uniform across the sites and included all components of watershed management. The farmers in each FFS groups identified the SLaM practices they are interested in learning. The results of participatory selection are presented in Table 2.

	Name of FFS group	FFS group by gender			Name of micro-catchment	Selected SLaM - FFS technologies
		M	F	T		
1	Duteraninkunga	14	16	30	Nyirarubomboza	**Soil erosion control** (terraces planting Napier grass as edge rows on terraces); **ISFM** (fertilizer options = FYM, inorganic fertilizers and mix of the two); **Livestock** (keeping goats) and **ICM** (improved husbandry of maize)
2	Dufatanye Gakindo	13	17	30	Gakindo	**ISFM** (fertilizer alone and mixtures, crop rotation with legumes – beans); **Livestock** (keeping pigs); **IPM/ICM** (improved husbandry of maize) and erosion control (terraces and trenches with grass bands)
3	Abishyize Hamwe	14	17	31	Nyagasozi	**ICM** Beans production
4	Tuzamurane	20	10	30	Muganza	**ICM** (improved husbandry of banana) and erosion control (trenches with grass bands)
5	Dufatanye	18	12	30	Cyabajwa	**ICM** (maize, fertilization trials) and **Soil erosion control** (ditches, terraces with edge rows of barrier plants such as calliandra)
6	Ejo Heza Kiyanza	10	20	30	Nyamirama	**ICM** (improved husbandry of maize) and soil erosion control (terraces with edge rows of Calliandra and Napier grass)
7	Inziraitera Mbere	18	12	30	Gatebe II	**ICM** for maize and **ISFM** (manure alone, inorganic fertilizer alone, mixture of manure and inorganic fertilizers and without any fertilizer)
8	Abakoranamurava	9	21	30	Gasharu	**ICM** for banana, **Soil erosion control** (ridges, *fanya chini*); integrated soil fertility management; agroforestry trees nursery (avocado) and livestock (pig keeping)
9	Twizamure	11	19	30	Nyarurembo	**ICM** for banana; soil erosion control (ridges, fanya chini); **ISFM** (proper fertilizer use) and livestock (pig keeping)
10	Umurava	11	19	30	Karambo	**Erosion control** (tied ridges, stone lines, mounds; and radical terraces); **ISFM** (compost, FYM, inorganic fertilizer, trash lines) and **ICM** for control of CMD.

Table 2: Microcatchments, FFS groups, gender and SLaM practices in different Kagera TAMP sites of Rwanda.

Results and discussion

Capacity building of stakeholders in sustainable land and agro-ecosystem management (SLaM) practices

The SLaM technologies farmers' trainings included: soil erosion control measures (radical terraces, trenches, ridges, and rainwater harvesting), integrated soil fertility management (ISFM including crop rotation, leguminous crops green manure, composting preparation and distribution, proper mineral fertilizers application, and FYM); introduction and appropriate use of agricultural inputs and agroforestry species; organic manure; improved crop production practices; livestock keeping (pigs and goats) and farm record keeping. Most of these technologies go beyond the training period, and have long-term impact(s) in the wider area.

The FFS participatory approach took into consideration the existing knowledge and built on it to develop the learning process, including exploration and observation on the selected technologies, which meet the community demands in each microcatchment.

	Selected SLM Practice	No of farmers willing to adopt the SLM practices			
		Tuzamurane in Muganza/ Kirehe	Abishyize Hamwe/ Kirehe	Dufatanye (Cybajwa)/ Kayonza	Total
1	**Integrated crop management** (space row and planting, banana rehabilitation)	21	25	8	54 (60%)
2	**Integrated soil fertility management** (compost, crop rotation, use of mineral fertilizers, mixing organic and mineral fertilizers)	2	12	13	27 (30%)
3	**Erosion control** specific practices (mulching, trenches, terraces and rain water retention pits)	28	28	1	57 (63.3%)
4	**Agro-forestry:** Tree planting and fruit tree planting	16	8	0	24 (25%)
5	Soil moisture conservation	9	17		26 (30%)

Table 3: The preferred SLM practices for adoption as reported by three FFS groups in eastern Province, down stream sites of Kagera TAMP in Rwanda.

Erosion control technologies disseminated and adoption

Erosion control technologies were taught in 70 percent of FFS reaching 346 farmers, their households and community members. The technologies included: radical terraces; trenches; ridges; *fanya juu*; *fanya chini*; ditches to capture rainwater along slopes; bunds stabilization through planting of Napier grass on top of bunds of trenches (*fanya juu* and *fanya chini*); agroforestry trees (including fruits such as avocado, mangoes, citrus, passion fruits, and japanese plums); terrace stabilization through fodder (*Calleandra* and *Leucaena*) and *Grevillea* trees. Mulching was also widely adopted due to its multipurpose nature of reducing runoff, increasing water infiltration, conserving moisture and controlling weeds. Mulching materials included banana leaves, stems of maize, sorghum or rice, and grasses. The latest were rarely used as they are scarce in certain parts of Rwanda.

ISFM and ICM for crop productivity improvement

Integrated crop management (ICM) and ISFM targeted soil productivity improvement including fertilizer type and application rate, pests and diseases management, and improved plant management practices such as space and line planting. Organic manure alone was compared with manure combined with inorganic fertilizer in observation plots for season long learning. The main learning crops included, banana, maize, beans, cassava and tomatoes. The livestock rearing mainly constituted a source of manure for the plots, but also produced income and enhanced families' nutrition contributing to food security.

ICM practices included: good husbandry; crop protection against pests and diseases; plant spacing; proper manure application and rehabilitation of over-exploited fields by building erosion control structures in banana fields, de-suckering, manuring and mulching. Maize ICM included proper spacing, fertilizer application alone and in combination with FYM.

Agroforestry

The agroforestry for SLaM included the establishment of nursery for fodder species such as *Calliandra* spp., *Leucaena* spp. and leguminous trees (*Grevillea*). Figure 1 shows the tree nursery of one FFS groups at Kiyanja with 5 380 seedlings.

Gender composition

The gender representation in each FFS group is reported in Table 2. Women made up 59 percent of the participants. There was not a gender bias towards

Figure 1: The FFS-Group agroforestry nursery in Karambo micro catchment, with 20 000 seedlings of papaya, lemon, orange, *Calliandra* spp, *Grevillea*, and tree tomato (Tamarillo) (source: Kagera TAMP National office, Rwanda).

men, but indeed the opposite; women farmers were much more enthusiastic to be involved. By involving a significant number of women, the training will have impact on families and on food security, besides the improved land management at microcatchment level contributing to a healthier watershed.

Livestock keeping

The FFS groups preferred to keep either goats or pigs for FYM and income. The livestock was either given for free by the project or purchased using members' own contributions (100 RWF per person per meeting). The animals were either kept at a central shed or managed on schedule, and their produce (calves) distributed to other FFS members. When an animal produced its first calf, the farmer had to return it to the group for distribution to another member. The FFS group in upper stream of the basin (Kamonyi and Rulindo Districts) preferred pigs, and they distributed piglets to the members, while downstream groups (Bugesera, Kirehe, Kayonza and Nyagatare Districts) preferred mainly goats. Both pigs and goats contributed to resolving four major locally important issues: ownership of livestock; availability of manure; income and increased crop productivity (In December 2014 exchange rate 690 RWF to 1$).

Saving and credit system and social fund development and management

The FFS groups developed two sources of funds: (a) a saving and credit scheme for internal lending with interest in which every member contributed about 500 RWF per meeting; (b) a social fund, where every member contributed 100 RWF per meeting to be used for inputs purchasing or to help members in emergencies. Only one FFS group used a part of the second fund to purchase goats and distribute them to members. Every FFS group opened account at the local Saving and Credit Cooperative.

Impacts and adoption of SLaM FFS in microcatchment and watershed management

Success and impact

The farmers in FFS-SLaM groups have increased their knowledge and skills in the concepts and practices of SLaM, including their ability to analyse the causatives factors and mitigation measures to combat land degradation. This success forms the foundation of other measurable indicators and can be scaled-up with time. For example, the testing and learning of erosion control technologies and ISFM as SLaM tools is critical in scaling-up for long-term impact. Some of these technologies might have been previously promoted under a top-down process without giving community opportunity to practice, make observation, and discuss among themselves. On the contrary, the FFS approach likely allow benefits to continue beyond the project life-span.

The understanding of the technology mechanism plays a central role in the adoption process. The farmers in FFS-SLaM groups were motivated to learn more reflectively through attendance at training sessions and hence were more willing to contribute their resources to carry on the activities even despite delays in project funding. The motivation was also demonstrated by facilitators/ trainers who were willing to continue facilitation in the regrettable absence of facilitation support promised by project. Likewise, 30 percent of service providers were also motivated in supporting the FFS-SLaM groups learning process field activities. The dual success in motivating both facilitators and farmers is likely to have a long-term impact which should ensure the sustainability of activities. It is concluded that the criteria used to select facilitators, farmers and competent service providers are critical in determining the sustainability of the SLaM activities and long-term impacts in the community.

Social impacts

The FFSs enabled the individual farmers to come together and form groups with organized leadership. The FFS groups are effective associations, which give members opportunities to exchange developmental ideas, access funds, pay medical insurance, buy household assets, build or repair houses and develop their skills in land management, erosion control and improved crop husbandry. This raised the social status and outlook of members in their communities. The leaders of FFS groups are now being consulted by local leaders and invited to different gatherings; also, visitors are being brought to them for experience sharing.

Economic impacts

Besides increasing production and therefore revenues, the FFSs enabled implementation of two fund types: saving and credit funds, and social funds. The saving and credit funds grant access to associations and groups. The loan enabled the groups to: purchase livestock (cows, goats, and pigs) and increase crop productivity for food security and incomes and improve housing (purchase iron sheets, cement etc). Some members of FFS groups used their loans to purchase additional animals in addition to the ones received from the group distribution.

Sustainability options

The FFS groups have been transformed into associations. Three of the FFS groups (Rweru Sector, Bugesera Districts) applied for registration as cooperatives. This is due to organized leadership of the FFS groups. The saving and credit scheme is also a mechanism which will assure over time sustainability. The farmers will continue to access financial services and this will enable them to continue to share and exchange between themselves at community and watershed level about land resource and watershed management. Improved management of livestock, crop husbandry, soil fertility and erosion control technologies and skills are well known among FFS members and are already being disseminated to the wider community at watershed level.

Lessons learnt, challenges and way forward

Lessons learnt

As stated above, the livelihoods of rural communities strongly depend on the sound management of land resources; hence its sustainability is an important activity for most of them. The FFS-SLaM participatory approach has empowered the farmers to make informed decision on SLaM practices and skills as demonstrated by their motivation and willingness to contribute their own resources to ensure that learning activities are not interrupted.

The motivation of farmers is also shared by the facilitators and service providers who were similarly supportive and made sure that learning activities continued throughout the seasons. Therefore, the selection of service providers, facilitators and farmers is a critical activity which should be done carefully, using participatory approaches and involving the beneficiary community.

The training offered to the trainers (ToT) is critical in determining success, as it should develop confidence to deliver SLaM concepts and practices. The training should give them confidence to be able to follow-up and resolve farmers questions.

Contrary to a blanket approach, there is no single technology that can address all farmers diverse SLaM problems and needs. There was variation between microcatchments as farmers' expressed needs were different. Hence, FFS participatory empowerment is critical in the process of selection and adoption of SLaM technologies.

Challenges

The FFS approach requires full commitment and timely planning and execution to ensure that the season-long training starts at the right time. The delivery of learning materials and inputs should take into consideration the expected start of planting season. The timely involvement and facilitation of extension staff taking into consideration their multiple responsibilities is also vitally important to ensure they successful backstop the facilitators in FFS groups training during the season learning activities.

Recommendations and way forward

- The training of facilitators should be well planned and refresher courses organized on demand, driven by critical issues.
- Follow-up and supervision of FFS – SLaM activities and support to facilitators is critical during the season-long learning activities.
- Timely delivery of learning materials and inputs is a key determinant of the success of this approach to learning.
- The data collection and reporting for monitoring and evaluation is an essential step to enable further improvements based on actual situation on ground.
- The division of responsibilities should be discussed and clarified during TOT training and a plan of action developed for every stakeholder/actor invited for training.
- Funding delays reduce trust and impacts and requires capacity development of service providers to ensure capacity to report on progress, on time and on financial and technical delivery, to allow replenishment of funds according to an agreed workplan.

Improvement of soil fertility through compost techniques

1.2

The contribution of quality compost to improved soil fertility

Author: Gloriose Habonayo

Affiliation: Soil Fertility Programme, Institute of Agronomic Sciences of Burundi (ISABU), Burundi

Summary

Trials were conducted of composting in manure pits or in piles on the farms of farmer field schools (FFSs) under the Kagera TAMP on-field and on-station at the livestock experimental station of Mahwa. Three decomposition activators, namely urea, cow dung and well-rotted manure were used to promote composting. The composted materials consisted of undecomposed manure and various decomposed materials. Samples of composted manure and mature compost were taken before and after composting and analysed by the Institute of Agronomic Sciences of Burundi (ISABU) Agricultural Chemistry Laboratory to determine the presence of: organic carbon (OC), N, P, K, Ca and Mg. The compost produced was used in horticultural and food crop production. The results showed the soil fertility value of improving the quality of manure through composting. Nutrients such as N, K, Ca and Mg increased and the carbon/nitrogen (C/N) ratio declined, regardless of the composting technique used. The cow dung and well-rotted manure were as effective as the urea in activating decomposition and mineralization. Since chemical fertilizers are expensive and often inaccessible to small-scale farmers, composting technologies are options for increasing the quantity and quality of organic fertilizer, leading to enhanced soil productivity and crop yields and to increased moisture retention and resilience to drought.

Key words: FFS, soil fertility, composting, recycling.

Introduction

Poor soil fertility in Burundi is a major constraint that limits crop production. This is mainly linked to over-exploitation of land and repetitive tillage without replacing nutrients (insufficient and inadequate use of organic and / or mineral fertilizers). Poor soil fertility leads to lack of resilience in crops which become more vulnerable to diseases and parasites, with lower yields as a result (Van, 1998; Inckel *et al*., 2005). The uses of mineral and organic fertilizers, which are sources of crop nutrients, were therefore potential alternative solutions. However, given their extremely high cost, mineral fertilizers are not affordable for the low-income farmers in the project area. Furthermore, insufficient supplies of farmyard manure or well-rotted compost forces farmers to use poor quality organic fertilizer, that is to say fertilizer material which has not decomposed and consequently which cannot release the nutrients needed to feed crops in a timely manner. Their incomplete and uneven decomposition brings with it the risk of contamination of plots during fertilizer application (sources of disease and weed seeds) (Inckel *et al*., 2005). The practice of improved composting, in pits or piles, offers an alternative solution, producing good quality organic fertilizer that increases the productivity of land planted with crops.

High quality organic fertilizer decomposes rapidly, releasing nutrients when plants most need them (Palm *et al*., 1997). The C/N ratio is a highly important factor, since it indicates the degree of compost decomposition. The speed of mineralization and decomposition of organic matter is highest when the C/N ratio is lower than 20. In the opposite case (C/N > 20), there is a risk that N will be immobilized by micro-organisms and its incorporation into the soil will cause a deficiency of nitrogen, leading to a decline in crop yields (Palm *et al*., 1997; Kalumuna, 2005; Joubert and Wouda, 2007). According to Breyne and Nelissen (1993), good compost has a C/N ratio of between 10 and 15. Good compost also has beneficial effects on soils' physical properties, such as reduced subjectivity to soil erosion, increased water and nutrient retention capacities of plants, as well as reduced soil acidity.

Composting is a process of biochemical conversion, through aerobic biodegradation of carbon and nitrogen-rich organic material to make a product which is rich in humic substances. It is produced following the activity of micro and larger organisms and is a way of adding value to organic materials. The process works best when different materials with varying speeds of decomposition are placed together, reduced and mixed well (ADEME, 2012; Inckel *et al*. 2005). According to Breyne and Nelissen (1993), the addition of well-rotted manure in a pit or pile, and of the droppings of certain domestic animals (chickens, rabbits, guinea pigs and small ruminants), even in small quantities, has a beneficial effect on the quality and speed of composting. Alternating organic matter with fine layers of earth, well-rotted manure, ash and bone meal, and perhaps some chemical fertilizer, can also help to accelerate composting.

The aim of this study was to assess the contribution of quality compost to improving soil fertility and also to make these low-cost technologies available to the Kagera watershed communities and more widely, to enable them to make quality organic fertilizer as quickly as possible, so as to stabilize soil and restore fertility, and to increase crop production as a result.

Methodology

Description of trials

As part of efforts to consolidate managed microcatchments in the Kagera River Basin, a participatory research and development initiative was carried-out by the Institute of Agronomic Sciences (ISABU), together with farmer members of farmer field schools (FFS) within the Kagera TAMP. The objective was to restore soil fertility and productivity by producing improved compost. Following training in the production and importance of organic fertilizer for maintaining and restoring soil fertility, the community itself took part in compost making. Composting in piles or in pits was conducted using urea (1.5 kg/m^3) as an accelerator for decomposition. Other alternative accelerators, such as droppings of small livestock (chickens, guinea pigs, rabbits etc.) were also mentioned during the training. The materials to be composted, which varied from one region to another, mainly comprised undecomposed farmyard manure, different types of dead grass and leaves, banana tree stems and other crop residues. The size of the compost piles were: 1.5 meters long, 1.5 meters wide and 1 meter high, while the compost pits measured: 3 meters long, 2 meters wide and 0.80 meters high. This activity of making organic fertilizer as a demonstration was done together with FFS group members.

Samples of farmyard manure and compost were taken from four FFS in the same region. These were analysed by the ISABU Agricultural Chemistry Laboratory to determine the presence of: organic carbon (OC), N, P, K, Ca and Mg. The results were compared together with those obtained by composting farm organic matter in piles at the ISABU research station, where three decomposition accelerators were used: urea, well-rotted manure and fresh farmyard manure (cow dung). The quantities used for each layer were the following: 12 kg of earth rich in humus; 6 kg of ash; 12 kg of well-rotted farm manure; 15 kg of cow dung; one kg of urea and the contents of ten watering cans, each with a capacity of ten litres. A comparison of the compost's quality was also made, taking into account the material composted. The compost produced was used in horticultural and food crop production.

Training communities in composting procedure in pits and in piles

First, a pit was dug measuring three meters in length by two meters in width and 80 cm in depth (for pit composting). For composting in piles, the base was

Figure 1: Community group preparing a composting pile.

Figure 2: Community group assembling materials in layers to fill a composting pit.

marked-out measuring 1.5 by 1.5 meters, using wooden posts of approximately 1.20 meters in height (Figure 1).

At the bottom of the first compost pit or pile, large-sized, mainly hard pieces of vegetable matter were placed (e.g. banana tree stems – layer 1), followed by a layer of about 25 cm of finer vegetable residue (chopped maize stalks etc. – layer 2) (Figure 2) to be composted.

Decomposition accelerators were spread over layer 2, followed by a five cm layer of earth rich in humus and ash. This layer was sprinkled with plenty of water and the whole operation described above was repeated until the pit was full, or the pile of compost reached a height of one meter.

The compost pit or pile was then covered with a 10 cm layer of earth, as well as grass or banana leaves, and finally, shade was erected over the whole.

During the composting process, regular and plentiful watering (two or three times a week) was carried-out. The composted mass was turned after three weeks in the case of the farm manure, and after six weeks in the case of the other composted plant materials. A stick was placed in the middle and inside of the pit / pile to regularly check temperature.

Results and lessons learned

The chemical properties of organic fertilizer

Table 1 shows the effect of composting. These results reveal that there is a clear improvement in the quality of compost fertilizer following the composting trial for the three types of organic materials.

Type	OC (%)	N (%)	C/N (%)	P (%)	K (%)	Mg (%)
Uncomposted manure	25.56	1.24	21.36	0.18	0.65	0.18
Composted manure	24.22	1.28	18.87	0.25	0.89	0.30
Composted grass	8.75	0.62	14.22		0.5	0.22

Table 1: Comparison of three types of organic fertilizer.

The C/N ratio, the key indicator of compost quality, has declined and is lower than 20 for two types of compost. High quality organic matter decomposes rapidly and releases nutrients when plants need them. According to many authors (including Palm *et al*, 1997, Kalumuna, 2005 and Joubert and Wouda, 2007), the speed of mineralization and decomposition of organic matter is extremely high when the C/N ratio is lower than 20. In the opposite case, there is a risk that N will be immobilized by micro-organisms and its incorporation into the soil will cause a deficiency of nitrogen where the C/N ratio exceeds 20, leading to a decline in crop yields. However, a C/N ratio that is too low can also cause a loss of nitrogen in the form of ammonia; the best ratio is between 10 and 15 (Breyne and Nelissen, 1993). It has been observed that the quality of compost depends on the material composted (Table 1). Composted farm manure showed an improvement in nutrients essential for plant growth. Nutrients such as N, P, K and Mg increased respectively from 1.24%, 0.18%, 0.65% and 0.18% in the case of uncomposted manure to 1.28%, 0.25%, 0.89% and 0.30% in the case of composted manure. However, the levels of OC, N and K of compost made from grass remained low, compared with those resulting from the composting of farm manure.

The results presented in Table 2 show the comparative influence of cow dung, well-rotted manure and urea in improving compost quality. Before composting, manure had the following properties: 51.04 percent of OC, 1.77 percent of N, and a C/N ratio of 28.84. The C/N ratio declined in all three cases, from 28.84 before composting to 16.13, 16.21 and 15.05 respectively in the case of well-rotted manure, cow dung and urea. Nutrients such as N, K, Ca and Mg all saw significant increases. The well-rotted manure, cow dung and urea improved the composition of the final compost, as already found by other authors including Breyne and Nelissen (1993).

Treatments	M.S (%)	OC (%)	N (%)	P (%)	Ca (%)	Mg (%)	C/N
Well-rotted manure	32.45 a	25.02 a	1.58 a	0.14 a	0.67 a	0.46 a	16.13
Cow dung	31.55 a	29.53	1.85 a	0.15 a	0.65 a	0.48 a	16.21
Urea	31.90 a	27.31 a	1.99 a	0.16 a	0.62 a	0.50 a	15.05
Average	**31.97**	**27.29**	**1.80**	**0.15**	**0.62**	**0.50**	**15.90**

The averages followed by the same letter in the same column do not differ significantly from $P < 0.05$, according to DMRT

Table 2: Effect of decomposition accelerators on the chemical composition of compost.

Figure 3: Farmers being trained in the skills of composting.

Impacts of composting techniques on improving farmer livelihoods

Six hundred and ninety-eight (698) farmers, grouped into 22 FFSs in the Provinces of Gitega, Karusi, Mwaro, Kirundo and Muramvya, have been trained in composting techniques by the project, using pits and piles.

Quality compost was produced using both composting techniques at the different FFSs, enabling members to increase crop yields. A pit with a capacity of 4.8 m^3 produced about 20 tonnes of improved compost over a period of 3.5 months, while a pile of compost with a capacity of 2.25 m^3 produced about 10 tonnes of in 3.5 months – in both cases the raw materials used for the composting was a mixture of different plant waste materials. A similar yield was obtained in two months when undecomposed farmyard manure was composted, showing that if available, this is a more rapid and productive process. A total of 20 tonnes of improved compost was produced by the Twunguranubumenyi FFS in Gishubi during the training, which enabled members to fertilize a one hectare banana field.

Members of Ngeregere FFS told us that learning composting techniques has enabled them to reduce their expenses. Previously, they spent a great deal of money buying organic fertilizer, but now they make their own. The money once used to buy organic fertilizer has been set aside for other purposes (e.g. purchasing selected seed, paying for children's education, healthcare, etc.). Fields that were once left untreated, due to insufficient fertilizer, are now enriched with compost, resulting in an improvement in agricultural production.

Constraints

A constraint is competition observed for potential composting materials for other uses, such as crop residues for livestock feed. A major issue is that farmers find making compost tiresome, as it requires moving large quantities of raw materials into the piles or pits, regular turning to increase the speed of composting – and heavy work moving the final compost from the pile or pit to the fields for application.

Conclusions and Recommendations

Some weeds, crop residues and household waste which were once burned (because were not primarily used as animal feeds) have now all become sources of nutrients to restore soil fertility in the plots of FFS members. They are currently being given value by being recycled through composting. The droppings of domestic animals and well-rotted manure, all of which are available locally, can serve as decomposition accelerators, producing quality organic fertilizer.

Small-scale farmers, who previously used only limited amounts of mineral and organic fertilizer, have seen their agricultural production increase. This is increasing food security at the household level and in some cases enabling farmers to sell excess production to fund other household expenses – and contributing to wider (e.g. community) food security.

It is recommended that farm manure be composted before use, so as to improve its quality. Household waste, plant residue and some weeds can also be used to make compost, instead of being burned.

Transport for composting should be envisaged to reduce labour such as bicycle trailers, donkeys with baskets or ox drawn carts in valley bottoms. Or green manure or mulch considered for restoring soil fertility in fields far from households or water supplies.

Crop-livestock integration to improving farms and livelihoods

1.3

A case of discovery-based SLM FFS methodology in Missenyi and Bukoba Districts, Kagera, Tanzania

Author: Fidelis B. Kaihura, Allan I. Bubelwa, Jasson L. Rwazo, Godfrey W. Baraba

Affiliation: Kagera TAMP project staff

Abstract

Crop-livestock integration exploits synergistic plant and animal relationship in an attempt to maximize production and wellbeing concurrently ensuring the long-term preservation of land resources and environmental functions. This article describes the use of the Farmer Field School approach in the Tanzania Kagera TAMP project to train farmers in recycling and reuse of crop and farm byproducts for livestock production. Furthermore, use of livestock bedding material as manure and mulching ensures soil fertility rehabilitation, increases crop production and promotes acceptability, respect and social recognition of the marginalized farmers that are empowered through livestock distribution.

Key words: crop-livestock, FFS, manure, composting, ecosystem functions, soil fertility.

Introduction

Crop-livestock integration is the purposeful combination of crops and livestock to exploit their synergistic relationship in an attempt to maximize food production to meet the expanding and changing human basic food requirements, livelihoods and wellbeing, while concurrently ensuring the long-term productive potential of land resources and the maintenance of their environmental functions. To achieve maximum results in the adult learning FFS process, crop-livestock integration should be foreseen and planned in advance. Crop-livestock integration ranges from the on-farm combination of identified priority crops with easily manageable small/medium sized stock (like chickens, goats and pigs) to more demanding large stock (like cattle). Animals kept on-farm enable farmers to accomplish the triple-win solutions of: a) providing manure, which is a basic SLM resource vital for increased crop productivity; b) playing a significant role in increasing farmer income and livelihood diversification and c) as an element of an agro-ecosystem approach combating soil fertility depletion, increasing soil moisture retention and reinforcing adaptation to climate change.

Animals kept on-farm also benefit from domestic and farm residuals. Crop-livestock integration therefore capitalizes on the crop-livestock symbiotic relationship where livestock compliment crops with manure and crops provide feed to livestock.

It is well-known that the discovery-based adult learning FFS methodology developed for integrated pest management has since been widely used to enhance crop production, also increasingly to sustainable land management. But, it is also understandable that for best results to be realized in crop production and wider sustainable land management there must be sufficient available manure from livestock to restore and maintain the frequently degraded soils (Liniger *et al*., 2011). Consequently, to maximize both production and environmental benefits, crops and livestock need a well-planned, synergistic association.

Methodology and approach

Under SLM FFSs, crop-livestock integration has two main components, namely: a) a capacity-building component, partly dominated by agro-ecosystem analysis (AESA) which is discovery-based learning–by-doing; and b) an income generation component, characterized by purposeful engagement of farmers in quick-win land conserving and income generating activities.

In crop-livestock integration, the income generation component involves deliberate supply of livestock to farmers for: 1) motivating farmers' participation in long-term rewarding SLM technologies by engaging them to quick-win income generation opportunities; 2) generating incomes which have a significant role in terms of increasing farmers' capacity to invest in promotion and scaling-up of the

SLM technologies; 3) providing inputs to restore degraded soils, notably manure, which is a basic requirement for carrying-out SLM technologies.

Crop-livestock integration in SLM FFSs can thus be viewed as a three venture undertaking, leading to increased food productivity, income and livelihood diversification and deliberate conservation of landscapes and agro-ecosystems.

An SLM FFS should be discovery-based and is intentionally planned in advance to accommodate for integration of crops and livestock. Agro-ecosystem analysis (AESA) is a core of farmer experimental learning and adaptation, where farmers are empowered to make reasoned and informed decisions in their own fields and farms taking into account ecosystem interactions and the whole process leads to participatory technology development, catalyzing sustainable land management.

The principle underlying the integration of crops with small stock at farm level is that small stock are usually of short-term gestation and therefore give "quick–win" results. Additionally, livestock products are assured of a market and usually win favorable prices compared to crop products.

Soil fertility degradation is largely a result of continuous nutrient uptake by plants and removal of all materials at harvest, without replenishment of important nutrients and organic matter and is a main cause of low crop productivity (see Table 1). For assured crop performance, availability of manure and mulch, which supplies nutrients and organic matter, is thus one the fundamental requirements for farmers.

Crop	Yield (kg/ha)	Nutrient removal		
		N	P_2O_5 (P)	K_2O (K)
Maize	3 000	72	36 (16)	54 (45)
	6 000	120	50 (22)	120 (100)
Sweet potato	15 000	70	20 (9)	100 (91)
	40 000	150	75 (33)	390 (324)
Cassava	25 000	161	39 (17)	136 (113)
	40 000	120	70 (31)	350 (291)
Beans	2 400	155	50 (22)	120 (100)

Table 1: Common Crop nutrient removal rates at pre-determined yield levels (Source: FAO, 1983).

Figure 1: Aspects of crop-livestock integration: domestic remains (e.g. banana peels) are fed to the goats.

Figure 2: Aspects of crop-livestock integration: bedding materials replaced during cleaning of the goat shed are a reliable source of manure and mulching materials.

In animal production, manure is a supplementary product. In small stock production as farmers achieve a gradual increase in the number of their animals at the same time they benefit from the resulting gradual increase in manure production. In the short-term, provision (in this case by the Kagera TAMP) of a few "kick–start" animals can enable farmers to begin restoring their cropland with patchy or peripheral application of manure. Further to that, due to the rapid reproduction of small stock and resulting gradual increase in the number of animals, manure supplies increase exponentially and application can be extended to a broader area and in the long run there can be uniform application across the farm. Farmers also realize the multiple benefits of manure application, droppings and urine from animals kept on-farm that complement other existing fertilization techniques used by the farmer (e.g. use of farm remains like banana thatches, domestic food "residuals", etc.) (Figure 1).

The TAMP activities in crop-livestock integration particularly targeted the marginalized groups (widows, women-headed households etc.).

Generally in the locally dominant *Kibanja* farming system, the most acceptable, manageable and compatible mix of crops and livestock were found to be banana with goats or chickens.

Objectives of the FFSs focused on crop-livestock integration

The FFS approach was used to apply the crop-livestock system to allow merging experiential learning and social dynamics with an appropriate technology training and community based enterprise development. The main objectives were:

- To improve productivity of crops while maintaining the ecosystem services of the land resources.
- To improve farmers' livelihoods, through improved income and food security.
- To promote acceptability, respect and social recognition of the marginalized (the forgotten and neglected people in the community). The marginalized people, especially women who were unnoticed before, are empowered, develop confidence and become people of a substance in the community.

The role and importance of different animal species in crop-livestock integration

Type of animal	Average nutrient content in air dry samples of manure (%)		
	Nitrogen	Phosphorus	Potassium
Cow	0.5	0.2	0.5
Goat	0.4	0.2	0.7
Sheep	1.3	0.4	1.0
Chicken	1.3	0.8	0.3
Pig	0.4	0.8	0.3

Table 2: Average nutrient content of manure from different types of livestock (Source: Minnich and Hunt, 1979).

Manure from different animals replenishes different quantities of minerals (plant nutrients) and organic matter to the soil (Table 2) while animals also play various other roles:

Goats

Improved breed goats are preferred. The animals mature early and thus there is increased production per unit, even where small numbers of animals are kept. Overall farmers realize a significant shift in terms of improved product quality and productivity. Goats feed on domestic residuals, have a short gestation period and therefore multiply progressively in a short time period, so a small number of animals provided by a project or programme can easily be shared and the benefits replicated to more farmers.

Chickens

Compared to other animals (e.g. goats, cattle and pigs) men's dominance and interference in poultry production is usually minimal, as tending poultry is usually visualized by able-bodied men as a shameful act. The birds therefore provide an entry-point to income generating activities focusing the benefit on women. Promotion of improved poultry production is therefore a good strategy towards improving incomes and the livelihoods of the rural women, which also directly benefits children. As chicken's dropping is a mix of faeces and urine, manure contains a high mineral composition that is highly beneficial for soils.

The demand for white meat has been rapidly increasing over the last few years in the Kagera TAMP (and other) countries, following increasing fears of human diseases linked to the consumption of red meat. Consumers therefore are increasingly willing to offer favorable prices for chicken meat, providing a ready market to FFS farmers who wish to sell surplus production.

Pigs

Pigs are omnivorous and eat a range of food from forage to animal products. They can rely on scraps and garbage and therefore there is a tendency for owners to neglect them (i.e. pigs are left to look for food on their own) and this prolongs the period required for animals to attain slaughter weight.

Pork, like chicken meat, is assured of a market due to increased demand for white meat and consumers are also willing to offer a favorable price to small-scale producers such as FFS members.

Outcomes

In most of the rural areas, farmers prefer indigenous banana varieties which they have been used to over the decades and majority of farmer assert that local varieties have good taste and texture. But farmers fail to increase production of indigenous varieties due to low capacity to invest in manure which is one of the most important inputs in banana production.

The banana farmers working with the Kagera TAMP, who were introduced to keeping goats and applying goat manure in their banana fields, realize improved crop performance in terms of yield, increased plant vigour and improved tolerance to diseases within a few seasons. Their banana plants are now usually dark green and have a good and healthy appearance.

Availability of manure from animals (goat, chicken and pigs) has also contributed significantly in the expansion of banana farms.

Keeping of animals under zero-grazing, as promoted by the Kagera TAMP, involves frequent placing and replacement of bedding materials, which is a time-consuming activity. However, it has many benefits. Zero-grazed animals kept on the banana farms generate an assured, year-round supply of mulching and composting materials, as well as manure. Compared to other mulching materials, bedding materials are usually mixed with animal droppings and urine and thus have more value in terms of nutrient composition and speed of decomposition. This enables the nutrients to be rapidly taken-up by crop plants (Figure 2).

With the FFS promoting crop-livestock integration on-farms, the availability of animals manure has increased gradually and progressively. In the short-term, farmers start with peripheral application, but even within the period of TAMP intervention (four years) many have already been able to extend application to their whole farms, leading to stable and uniform restoration and replenishment of all the soils on their farms.

Introduction of the animals on-farm has opened opportunities for farmers to learn skills in manure and compost making and management. Furthermore, the presence of the animals has highlighted the importance of farmers being regularly visited by livestock experts and has strengthened their relationship, which had been weak leading to improved livestock health and productivity.

Farm and domestic leftovers are now used to feed the animals (i.e. crop residues), so are converted into useful products (Figure 1) rather than being left as waste highlighting the concept of recycling.

The presence of more animals has significantly drawn attention of development advisers to planning and designing training of farmers in domestic and farm residue management skills (manure management and compost making).

On the farms where manure is applied to croplands, farmers have realized how the increased soil organic matter content improves the soil structure and functioning, increasing the capacity of soils to absorb and hold moisture (also boosting soil biological activity). Farmers are already appreciating the benefits of the extended period in which the soil preserves moisture, which is increasing resilience to weather variability and is reducing the impacts of climatic change, notably during drought periods and also in high intensity rainfall period when soils would have been lost due to rapid run-off from degraded soils.

Crop-livestock integration through FFSs is also bringing social benefits. As a result of being supported with the animals, women who before were marginalized are increasingly making achievement in terms of increased incomes and improved livelihood diversification. They are now becoming more respected and socially recognized by the community.

The culture of drinking goat's milk has been built in the community. Furthermore, compared to cows' milk goats' milk is more nutritious and is therefore winning a favorable high price at market. Availability of goats' milk has contributed in improving the food security and nutritional standards of the rural poor. Similarly, poultry production has resulted to improved production and consumption of eggs, also increasing incomes accrued from the sale of eggs and live chickens.

Farmers supplied with the animals by the Kagera TAMP (Table 3 below) have further benefited in terms of using the money generated from the sales of livestock products in acquisition of the daily basic domestic needs like salt, sugar etc.

Animal Type	Missenyi District (Minziro and Kigazi villages)		Bukoba District (Karonge and Buturage villages)	
	Number of animals	Number of farmers	Number of animals	Number of farmers
Improved dairy goats	48	24	48	24
Improved cocks	10	10	8	8
Improved boars	4	4	4	4

Table 3: FFS members supplied with animals by Kagera TAMP.

Lessons learnt

- Crop and livestock integration has synergistic effects, which is crucial for participatory SLM technology development and should be given weight in initial planning and designing of SLM farmer field schools.
- Chickens, which are regarded as being women's property, can be used as an entry point and a strategy towards improving incomes and livelihoods of the rural women.
- Small stock are easy to manage compared to large stock and have a short gestation period, therefore in a short period they can easily be shared and their benefits replicated to more farmers.
- Compared to crops, livestock products win markets and good prices, but farmers should be left to select the type of animals which they are in favor of keeping. Research is needed for farmers to be certain and make informed decisions on the compatibility of recommended crop-livestock combinations in different geographical areas (e.g. due to access to markets etc.).

Challenges

- Fodder inadequacy: animals kept under zero-grazing largely rely on cut-and-carry products and therefore there needs to be a reliable and adequate source of animal feeds (pasture and fodder). Planting fodder plants and fodder agroforestry trees may be one of the best options to ensure year-round supplies.
- Inadequate training on good animal husbandry practice: it was assumed that farmers supplied with the animals would be able to manage and nurture the animals on their own, but it was found that farmers did not have the requisite skills so could lead to loss of stock. The successful promotion of crop-livestock integration needs thorough training of farmers on recommended animal husbandry practices before they are supplied with the "kick-start" animals.
- There is a shortage of veterinary medics and limited availability of medicines that can usually only be accessed at high price. A reliable veterinary service and assured availability of medicines is needed for maximum results.
- Low knowledge on improved farm residual management is common. Upscaling knowledge on improved farm residual management might sustain the integrated crop-livestock approach over time.
- To avoid outbreaks of Newcastle disease in chickens farmers should be sensitized on timely vaccination of the fowls.

Recommendations

- Bedding materials should be sliced into pieces to improve handling, assure faster decomposition in zero-grazing method, and increase surface area and high nutrient absorption.
- Crop-livestock integration requires a reliable veterinary service and assured availability of the veterinary medicines.
- Farmers should be encouraged to use semi-intensive chicken rearing system.

- Most farmers prefer improved animal breeds, but in the long run farmers should be encouraged to opt for cross breeds, which are more easily managed and less susceptible to diseases.

Conclusion

Planned crop-livestock integration exploits the synergistic relationship between crops and livestock. Thus, it contributes meaningfully to efforts of increasing on-farm production to meet the expanding and changing human food requirements. By increasing productivity, integration also improves the food security, livelihoods and well-being of local people. Last but not least, it plays a part in restoring and supporting the long-term productive potential of land resources and maintaining of their ecosystem services. Finally, crop-livestock integration should be given weight and credible consideration during initial planning of SLM farmer field schools. Experience shows that SLM FFSs implemented involving crop-livestock integration has achieved maximum results in terms of achieving both environmental and production objectives (*Text Box 1*).

Swahili: *"Mbolea kutokana na mbuzi tuliopewa na mradi wa TAMP imenisaidia kuongeza uzalishaji wa ndizi. Migomba niliyo iwekea samadi inatoa mkungu wa kilo mpaka 40 tofauti na kilo 18-20 za zamani. Vilevile mbolea imesaidia katika kurutubisha ardhi na kuifanya kuwa na unyevunyevu kwa muda mrefu."*

English: *"Manure from goat supplied by Kagera TAMP has assisted in improving banana productivity. In banana plants where I applied manure, bunch weight has increased from an average of 18 to 40 kg. Soil in the area where the manure was applied is also more fertile and retains water for a much longer time."*

Text Box 1: Testimony given by a widow Paulina Jasson who was supported with the goats by Kagera TAMP.

Impact of horticultural production on the food security of farmers in watershed communities

1.4

Author: Cyrille Mbonihankuye

Affiliation: Fruit and Vegetable Programme, Institute of Agronomic Sciences of Burundi (ISABU), Burundi

Summary

Horticulture is a key activity for promoting food security in conditions where land is scarce and is one of a number of initiatives being implemented by the Kagera TAMP. The horticulture option was chosen due to the fact that vegetables require little space, their growth cycle is relatively short and there is a readily available local market. In a climate marked by substantial seasonal variations (drought and excessive rainfall), this highly water dependent activity is mainly carried-out by small-scale producers on very small plots, often using rudimentary resources. The search for a solution to these challenges resulted in a multi-pronged and biologically diverse horticulture system, introduced by the Kagera TAMP to members of project' farmer field school (FFS). As part of the scheme, 1 205 vegetable farmers belonging to 36 FFSs were trained in good vegetable production practices, so as to maximize diversity and yields and make their produce available to markets. A total area of more than 50 hectares was planted with many species and varieties of vegetables. In order to address the challenges caused by increasing weather variability and climate change, drought tolerant species were introduced which proved popular with FFS members and buyers.

Key words: FFS, agro-ecosystems, watershed, horticulture.

Introduction

The problem of food insecurity is particularly acute in Burundi, mainly due to population growth, inadequate quantities of arable land and the absence of improved agricultural techniques (CTA, 1994). The economy of Burundi is characterized by a series of unfavourable factors, of which the most significant are the annual decline of GDP by 6.3 percent between 1993 and 2007, increased poverty, with 84 percent of the poor living in rural areas and 67 percent of the rural population living below the poverty line, and resulting in the growth of food insecurity, especially during the past ten years (PNSA 2009-2015, 2009).

Prized for their high level of added value, horticultural crops offer an excellent opportunity given the small size of farmers' plots, which average just 5 acres (2.5 ha) per household in several plots. Horticultural crops can offer a solution by making the best possible use of a small cultivable surface (CSDH, 2013).

Horticultural activities carried out during the Kagera TAMP sought to improve the livelihoods of local communities through increased productivity and added-value for agricultural products. Horticultural production techniques were disseminated throughout various producers' organizations using the farmer field school (FFS) approach. Through a participatory evaluation of several species and varieties, PO members selected high-yielding varieties of amaranth and eggplant. They then engaged in seed multiplication for the varieties that were chosen in order to adapt to the impacts of climate change. FFS members also learned about new vegetables.

Good seed quality is a critical factor for a crop success. In Burundi, lack of good quality seed for horticulture is a major problem, together with lack of improved varieties, inappropriate seed production technology, inadequate markets and lack of farmer knowledge about improved varieties.

This chapter presents the results and lessons learned by producer organizations' members trained within the Kagera TAMP.

Methodology

The farmer field school objectives were twofold. On one side, farmers were trained in horticultural technologies and adopted multi-purpose small and large scale vegetable production. Further to that, farmers were also trained in vegetable seed production in order to address genetic degeneracy and make seeds readily available locally.

Horticultural technologies trained and adopted through the Kagera TAMP

The different technologies adopted by the communities through the Kagera TAMP to intensify horticultural production were:

a) Household level production: this involved micro-gardens set-up at household levels. They include, for example, kitchen gardens, sack farming, school gardens and market gardens. Household production has enabled a number of families to have a permanent supply of vegetables and to satisfy their nutritional needs, as well as providing a surplus for sale, thus increasing revenues. The money previously used to buy vegetables is now being spent on household development.

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Figure 1: Amarante (left) and onions (right) grown in a kitchen garden and a porous sack.

b) Large-scale production: this involved intensification, with a view to capture large and distant markets. Harvests were mainly sold at local and distant markets, including boarding schools, military camps and different hotels. Vegetables cultivated intensively included cabbage, amaranth, African eggplant, onions, tomatoes, courgettes and peppers.

Figure 2: Intensification of cabbage production at Gitega (left) and sale of harvested cabbage in a market (right).

In order to address climate change, vegetable varieties adapted to climate variation were introduced, such as drought-tolerant varieties. Cowpeas and *sukuma wiki* (kale) varieties proved popular with members of the FFSs, due to their high resistance to drought. Cabbage, courgette and aubergine varieties resistant to heavy rainfall were also cultivated. Vegetable crops were rotated with other crops to break the pests and diseases development cycle. Agricultural practices which assist in coping with the negative effects of climate change were also demonstrated and applied. These included use of high-yielding and tolerant varieties, application of organic fertilizer, small-scale irrigation during the dry season and mulching.

Figure 3: Intensification of the cultivation of sukumawiki in Kayokwe.

Production technologies for horticultural seed

In order to address the challenges of lack of good quality horticultural seed, FFS members were trained in seed production, especially for indigenous vegetables. The use of good quality seeds leads to increased yield and improves diet and nutrition through making available seed of diverse local vegetable varieties which are preferred by farmers and can be readily marketed; thereby contributing to higher revenue and food security.

Figure 4: : A FFS cultivator collecting the seed heads of amaranth of the Makamba variety.

Results

The participatory evaluation selected amaranth Madira1 and Makamba varieties and the DB3 variety of aubergine for their high biomass and their early maturity. Seed multiplication was conducted for the varieties of amaranth and African eggplant selected by FFS members.

A total of 1 205 farmers belonging to 36 FFSs were involved in training and awareness-raising on the different techniques for horticultural production. These FFSs have set-up their vegetable fields in micro-catchments in the five provinces of Gitega, Mwaro, Muramvya, Karusi and Kirundo, reaching a population of 12 322.

The FFS members were given information about the many advantages offered by vegetable production. They can generate income directly (through sales at market) or indirectly since the horticultural sector creates jobs (in nurseries, large-scale farms and through processing). Vegetables also play an important role in food security. They are a source of essential nutrients for the human body, including vitamin A, carbonates, oils, proteins, vitamin C, fibre, calories and minerals and are useful as side dishes. Moreover the vegetables plant residuals are used as animal feeds and materials for making compost.

Lessons Learned about the vegetable production initiative through the Kagera TAMP

The FFS members are aware that crop diversification can contribute to improved livelihoods for farmers. Indeed, the small size of plots (land fragmentation) and the relatively short growth cycle of vegetables make cultivation of these products an excellent solution for income generation through increased productivity and added value.

Technically, a knowledge of good horticultural practices helps to reduce losses. Good seed quality is another critical factor for a crop's success. The farmer field schools have become key points (catalyst) for scaling-out horticulture to farmers who are not members of an FFS. An observed advantage of horticultural crops is that they take up little space and have a relatively short growth cycle, meaning that producers can have several harvests in the course of a year.

The introduction of new vegetable species to diversify income generating crops – such as peppers and courgettes in Gitega and onions and courgettes in Kirundo – has enabled farmers to supply vegetables to hotels in towns which previously sourced such produce from Bujumbura. The kitchen gardens set-up by the project in primary schools has helped to improve pupils' knowledge and skills in vegetable production as well as food security. Farmer field school members who have been involved in awareness-raising about the role of vegetables in nutrition say that "with each meal, their dietary habits have changed. From now on, each meal will include some vegetables".

The FFS members trained as part of the project agree that there is little chance of malnutrition when vegetables are consumed in sufficient quantity. They observe that malnutrition affects farmers' working capacity, leading to a decline in revenues and an increase in poverty. This link between productivity and malnutrition generates a downward spiral.

Conclusion and recommendations

The FFS approach has been implemented by the Kagera TAMP to support knowledge sharing and the adoption of innovative growing techniques by promoting well adapted horticultural crops in the watersheds of the Kagera Basin. The approach has helped to strengthen farmers' capacities and develop their skills in contributing to more intensive vegetable production. In order to tackle the problem of genetic degeneracy, the FFS approach has also introduced producer members to seed production techniques, especially for indigenous vegetables. Through this strategy, farmers, especially women, have increased their knowledge of vegetable and seed production. Horticulture has become an income generating activity for many households. Horticultural species, which were not formerly grown, have become a source of revenue and food security for families.

Vegetable production should be considered as an alternative solution for improving food security and generating household revenue in the Kagera Basin.

Impacts of farmer field schools on sustainable land management and changes in attitudes in Burundi

1.5

Author: Charles Ntunguka

Affiliation: Provincial Department for Agriculture and Livestock, Coordination Cell in the Ministry of Agriculture and Livestock (MINAGRIE), Burundi

> *"Prompting community awareness and responsibility-taking is vital for ensuring sustainable land management and improving livelihoods"*

Summary

Farmer field schools (FFSs) are an innovative and participatory approach that engages beneficiary communities in the sustainable management of the land resources and agro-ecosystems on their farms an the wider landscape. A farmer field school is a privileged space for learning, observation and experimentation. During the Kagera TAMP, in Burundi a total of 1 205 members of 36 FFSs have learned a range of techniques relating in particular to soil fertility restoration, improvement of vegetation cover, water management, better agricultural practices and improving food security. Furthermore, FFS is a reconciliatory approach that promotes social cohesion, mutual assistance and the peaceful resolution of social conflicts. The activities and achievements of the FFSs set-up under the Kagera TAMP has been a catalyst for wider policy reform, as Burundi now wishes to generalize the farmer field schools approach for adoption country-wide.

Key words: FFS, SLaM, landscape approach, diversification, extension policy reform.

Introduction

More than 95 percent of the population of Burundi is rural and essentially dependent on subsistence or near-subsistence crop and livestock farming and 96 percent of domestic energy comes from wood and biomass products. In the face of a rapidly growing population (3 percent per year), the country is experiencing strong demographic pressures on its agricultural land. This is the driver of the pervasive soil degradation as a result of erosion and the over-exploitation of natural resources, which is leading to lower agricultural production, food insecurity, climate variability, ecological refugees and land-use related social conflict. To tackle this situation, FAO, through the Transboundary Agro-ecosystems Management Project for the Kagera Basin (Kagera TAMP), adopted the FFS approach an adult education approach based on learning, observation and experimentation with innovative technologies for sustainable land development as a means to increase farmers' capacity in terms of knowledge and skills for better managing their land resources.

The FFS approach, which was started in Burundi by FAO in 2010, has shown positive results on the ground for enhancing farmer capacity building, improved management practices and increased production and productivity. The farmer field school approach aims to prompt rural communities and farmers to choose the sustainable management method to be used on their lands that will on the one hand help to resolve conflicts and improve their social well-being (food security, and poverty reduction through raised incomes), while on the other hand make their land use activities more ecologically sound and sustainable.

This paper presents the highlights of strengthening the sustainable land management (SLM) capacities of the communities involved, describes briefly the results achieved and highlights the impacts, constraints and the solutions found through implementation of the farmer field schools approach.

Methodology for the dissemination of the farmer field schools (FFS) approach

Training farmer field schools facilitators

In April 2011, an 18 day facilitators' training workshop on the FFS approach was held at Bene-Tereziya (Gitega). The training was delivered to 24 agronomists from the area (staff of the Ministry of Agriculture and Livestock) as well as five facilitators from the five provinces covered by the project, namely Gitega, Karuzi, Kirundo, Muramvya and Mwaro. The objective of the training was to familiarise with the approach for effective support in the organization and follow-up of FFS activities on the ground.

The expectation was that at the end of their training the agronomists would set-up farmer field schools, which would in the first instance pioneer the adoption of sustainable land management (SLM) practices and agro-ecosystems approaches, and then disseminate those widely in their local communities. Moreover, the methodology used during the FFS facilitators' training allowed the participants to gain not just information, skills, knowledge and know-how but also the changes in attitude(s) needed to be able to set-up and empower FFS to enable them to manage land resources and agro-ecosystems at scale and in a sustainable manner.

Establishing FFS groups in the five provinces

After that training, information and awareness-raising sessions were held for local government, technical services and communities.

After voluntary sign-up of local land users as members of the farmer field schools within the catchment areas being targeted activities to build technical, organizational, institutional and accounting capacity began in June 2011.

By the project final year, 36 FFSs for sustainable land management were operational, comprising 1 185 members of whom 60 percent are women and 40 percent men. These groups underwent over one year field learning activities on various SLaM issues such as crops, soil, forestry, rangelands, livestock management and have already completed the designated SLaM FFS learning curriculum which were predetermined during gap analysis. In accordance to the FFS methodology the next stage was awarding certificates to the FFS participants who fully attended the yearlong FFS learning sessions and adopted SLaM practices in their own fields. Some of these graduate farmers are then invited and supported to establish and facilitate their own FFS groups. If 75 percent of graduates (890) will form independent FFS, each with 30 members, some 26 700 people would be reached through scaling-up of the FFS approach and be able to learn and adopt SLM technologies. This would require continued support from district technical officers and service providers.

Results Achieved through FFS Implementation

A vision of the landscape developed by communities

During the farmer field training, every FFS is asked to develop a vision for the management of their landscape using a multi-year plan, from which an annual plan is then derived. This step consists of involving populations in a critical analysis of the state of their lands in order to prompt them into awareness and a decision to act to reverse the trends that are negatively affecting their environment (soil condition, vegetation cover, erosion etc.) and their socio-economic situation. Such analysis was undertaken using the LADA methodology and tools early in the project period (in 2012) [1].

The main problems relating to land management are: soil degradation caused by erosion, poor vegetation cover, cultivation on bare sloping lands, lack of improved seeds, inadequate socio-economic infrastructure (schools, markets, churches, access roads in good condition), land fragmentation, important natural habitats displaced by farming, etc. All these problems were prevalent across Kayokwe commune, Nyakibari in Mwaro Province

Given that situation, the FFS members, having assessed the extent of soil degradation, characterised in particular by poor vegetation cover, soil erosion and other socio-economic pressures (Figure 1) resolved that by 2022 their landscape would be protected by anti-erosion measures, agroforestry trees and fruit trees. The habitants living in villages along the roads should also benefit from infrastructure such as water, electricity, schools and health centres requiring public and private sector investment.

Figure 2 shows the community's vision for its landscape and the action proposed to improve the situation over a 10-year timeframe.

1 This is backed up by assessment of current practices that are identified as "best" adapted to the local context using WOCAT questionnaires.

Figure 1: State of the landscape in 2012, Kayokwe commune in Nyakibari.

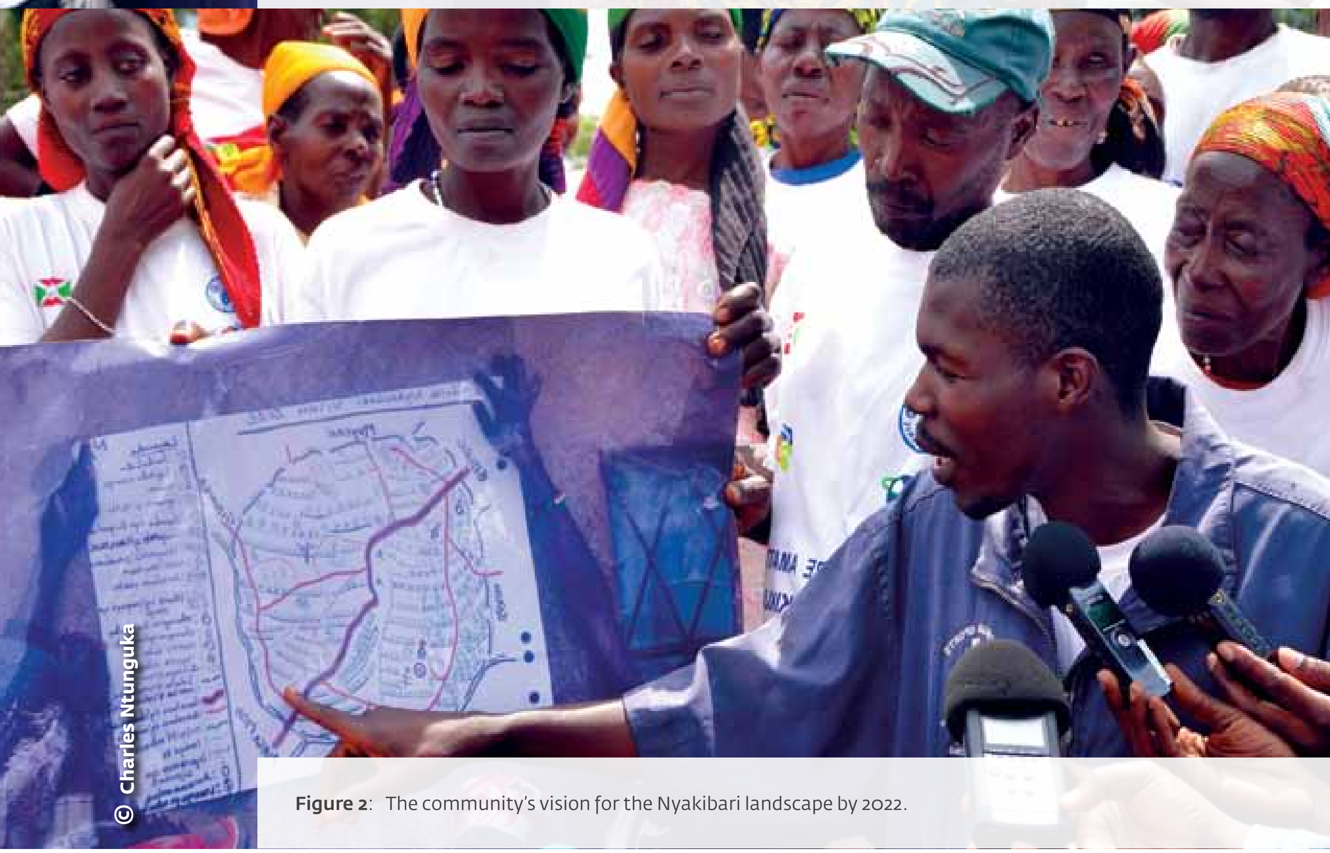

Figure 2: The community's vision for the Nyakibari landscape by 2022.

Diversification of land use systems

Soil and water conservation and integration of crops, agroforestry and livestock were the number one priority of farmer field schools' members.

During the training sessions, members learned how to make and use an A-frame for laying out anti-erosion measures on the contour which helps to conserve rainwater and reduce the loss of soil due to erosion (Figure 3), increase soil fertility and protect against sedimentation of the lowlands and river pollution.

Two rows of grass or shrub fodder species such as *Tripsacum laxum*, *Pennissetum* spp., *Leucena* spp. and *Calliandra calothyrsus* were planted above the contour line, in staggered rows in order to help stabilise the soil, while at the same time providing nutrients for the plants and contributing small branches for a variety of purposes. The feed grasses are also used for small ruminants that are permanently tethered, thus enhancing production of farmyard manure as a means for improving the organic fertilisation. The animals also provide source of food and savings for the family and community at large.

Figure 3: Anti-erosion measures on family farms (*faanya juu*).

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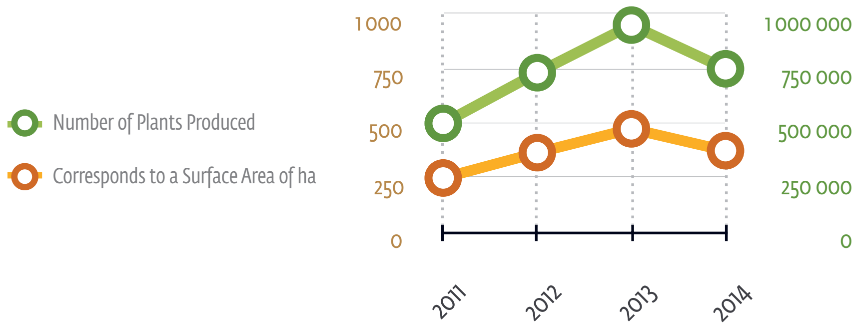
Figure 4: Nursery of *Eucalyptus grandis* in Magamba.

Agroforestry

In order to try to meet the population's need for wood in the context of the shortage of land in Burundi, people learned how to identify tree species that can coexist with crops and that have multiple uses (e.g. food, soil fertility, carbon sequestration, ground cover for soil conservation). The main species available are: *Grevillea robusta*, *Cedrela odorata*, *Maesopsis eminii*, *Alnus acuminata*. These trees are often grown in association with shrubs such as: *Calliandra calothyrsus* and *Leucena leucocephala*. Over the 4 years, the project-catalysed farmer field schools produced and distributed 2 936 000 tree seedlings / cuttings in nurseries (Figure 4), sufficient to cover a surface area of 1 466 hectares. Figure 5 shows how tree planting and the corresponding surface areas in hectares progressed from 2011 to 2014. The total cost of establishing this agroforestry system was estimated at 1 192 $/ha, but the benefits are far-reaching.



	2011	2012	2013	2014	Total
Corresponds to a surface area of ha	250	366	475	375	1 466
Number of plants produced	500 000	732 000	950 000	750 000	2 932 000

Figure 5: Tree seedling production and agroforestry planting by Kagera TAMP (2011-2012) in Burundi.

Promotion of community woodlots

In the framework of the integrated management of the catchment area of Mirama (Gitega), a 45 hectares community woodlot was established at the top of the hill (Figure 6), for the benefit of Haguruka FFS which comprises 40 members (28 women and 12 men). An agreement was signed between the local government, the Forestry Department and the beneficiary FFS on how to share the costs and benefits relating to the establishment and management of the woodlot, in relation to the benefits arising from the use and commercialisation of the forestry products. As per the agreement, 80 percent of the benefit would be for the beneficiary population, ten percent for the commune and ten percent for the Forestry Department.

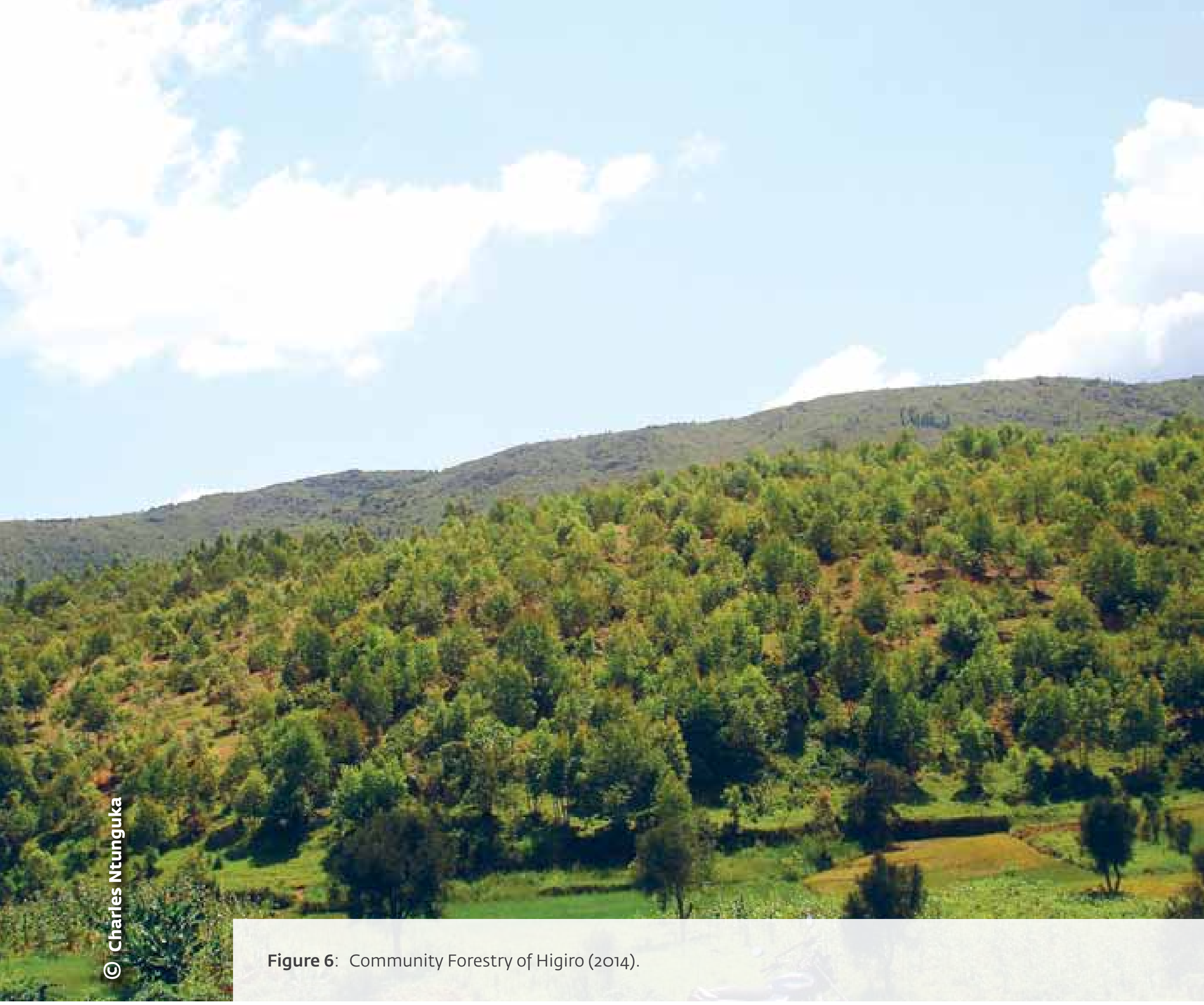
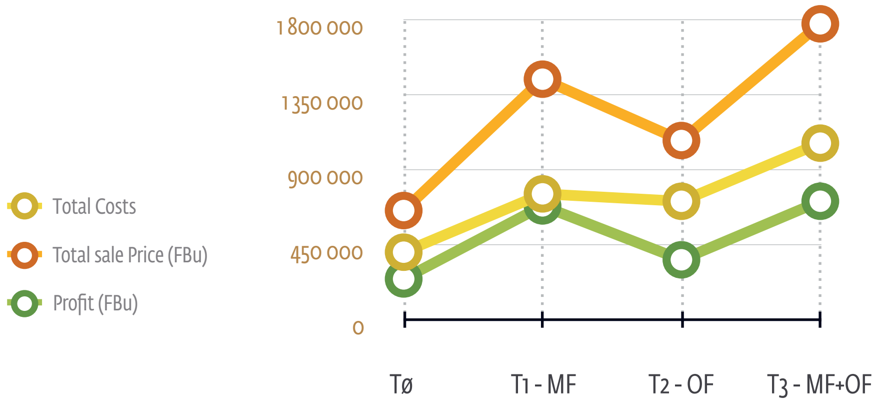


Figure 6: Community Forestry of Higiro (2014).

Intensification of market garden crops

In order to improve food security, the communities taking part in the project adopted improved agricultural practices, notably row sowing techniques, mastery of the agricultural calendar and experimental trials to compare the productivity of certain crops by agro-ecological zone (including potatoes, beans, maize). Experimental trials to assess changes in bean productivity under different fertiliser regimes were carried out by the Biraturabain FFS in the commune of Nyabihanga in Mwara Province, starting in March 2012. The participatory trials were as follows; Tø: field with no fertiliser, T1: application of mineral fertiliser, T2: application of organic fertiliser (farmyard manure) and T3: combination of mineral and organic fertiliser and closely monitored by the FFS to understand the results and inform decisions on members own farms.

The results showed that using a mixture of organic and mineral fertilisers produced the best results. Figure 7 shows the cost/benefit analysis per hectare for the different plots.



	Tø	T1 with Mineral Fertilizer	T2 with Organic Fertilizer	T3 with Mineral Fertilizer & Organic Fertilizer
Total costs	410 250	760 110	715 500	1 064 250
Total sale Price (FBu)	660 000	1 448 000	1 080 000	1 780 000
Profit (FBu)	249 750	687 890	364 500	715 750

Figure 7: Evaluation of the cost and benefits of growing beans in Biraturabain FFS.

Adaptation to climate change

Besides working on reforestation and agroforestry, the farmer field schools learned and applied other techniques to help themselves and land users in their communities to adapt coping strategies for the deleterious impacts of climate change. These technologies included; cultivation of crops that have a short growing cycle and which are resistant to drought (market gardening), using pedal-powered and motor pumps for hillside irrigation, mulching, as well as the installation of micro-dam irrigation.

Lessons learned through implementing the FFS approach: effects and impacts

There are many lessons learned and benefits through implementation of the farmer field schools (FFS) approach that impacts positively on society. The lessons and benefits include political, social, economic and ecological domains.

Political lessons / impacts

The positive results of the FFS approach initiated by FAO through former projects and training of master trainers and by the Kagera TAMP project and other partners are beginning to influence policy on agricultural dissemination. The Government of Burundi, through the Ministry of Agriculture and Livestock, plans to roll-out the FFS approach across the whole country. A coordination structure has been established for farmer field schools, in the Direction that supports Professional Agricultural Organizations (OPA) under MINAGRIE in 2014 with support of another FAO project. FAO continues to support the institutionalisation process.

Social lessons / impacts

- Social cohesion – people with a shared vision can plan and work together.
- Social mutual assistance – people agree to support one another in good and bad times, e.g. education for children and access to health care.
- Reduction in social conflicts – as a result of the continuous dialogue, spirit of equity and the attitude change brought about during the training.
- Social esteem – people who did not take part in FFSs value the level of knowledge and know-how acquired by FFS members and try to imitate FFS activities on their own farms. More than five FFS have already received certificates of merit from the administrative authorities on International Labour Day, in recognition of their efforts to improve sustainable land management practices and livelihoods as well as transforming society.

Economic lessons / impacts

- Easier access to state-owned land – when groups of people are organized and have a legal status that is recognized by local government, access to and use of state-owned land becomes easier. In fact, as a result of land fragmentation, the FFS members did not have enough land to apply the lessons learned. With the support of the project, the administrative authority granted land for 60 percent of FFS groups, where they are developing revenue-generating activities and thus helping to improve food security and living conditions.

- Access to innovations from research centres – when populations are organized in FFS, access to technological innovations from researchers becomes easier.

- Access to community infrastructure – coming together in FFS allowed communities to benefit from from storage facilities for their agricultural produce as well as access to irrigation tools and motor pumps (through investment programmes).

Ecological lessons / impacts on protection of the environment

- The expansion and improvement of vegetation cover, reduction in runoff and erosion, progressive restoration of soil fertility, infrastructure for the management of marshland water and protection of buffer zones are already being recorded across the lands of the FFSs members and wider microcatchments. These positive trends are likely to increase as time passes.

Major obstacles encountered and recommendations

The challenges relating to sustainable land management are diverse and immense. However, the enthusiasm of communities for coming together in farmer field schools is also enormous and the main obstacle encountered was often due to limited financial resources. The involvement of long-term government programmes in continuing to carry-out SLM activities would be an alternative solution regarding that the Ministry responsible is allocated sufficient resources.

One challenge is evaluating impacts of management practices over the project timeframe. It is difficult to quantitatively evaluate the many and varied, often longer-term effects and impacts of sustainable land management practices in protecting the environment, adapting to climate change, improving food security and community livelihoods over a three to four year project timeframe.

Conclusions

The introduction of the farmer field school approach sustainable land management is allowing communities to gain new knowledge and know-how. It has also achieved an attitude change in communities and the development of a long term vision, helping to improve the livelihoods of poor land users through progress towards a more productive and better functioning environment.

In terms of the principles of sustainable land management in Burundi, capacity building focused in particular on protection against soil erosion, the restoration and improvement of soil fertility, the collection and use of rainwater, the integration of agro-forestry-livestock techniques, all contributing to the protection of international water and adaptation to climate change and enhanced food security.

Opportunities and challenges for transformation of farmer field school groups into cooperatives in the Kagera TAMP, Uganda

1.6

Author: **Bernard Mwesigwa, Wilson Bamwerinde, Benard Onzima, Paddy Namurebire**

Affiliation: Kagera TAMP project staff

Summary

The farmer field school (FFS) approach mobilizes and organizes farmers into groups to acquire skills to address their unique challenges through experiential learning and adoption. Forty-two FFS groups were established under the Kagera TAMP in Uganda to undertake sustainable land management in their catchments. The FFS network is a higher level umbrella association of several FFS groups within a common geographical area which enables the groups to address bigger challenges and leverage the economies of scale. In Uganda, there is a government-supported drive to revitalize cooperatives, with rural producer organizations (RPOs) and area cooperative enterprises (ACEs). The government supported system can be considered as an equivalent of and scaling up of FFS groups and farmer field schools networks (FFSNs). The Kagera project approach has sidestepped FFSN formation by the FFS groups and has been directly guided by the district commercial officer to form RPOs which then form ACEs. This will enable the farmer groups to exploit their higher productive and marketing potentials and thereby to improve their incomes and livelihoods. To achieve this, they will have to address key constraints such as small number of groups per location and improve enterprise selection and management to increase their income generating potential.

Key words: FFS, cooperatives, land tenure, diversification.

Introduction

In recent years, the Ugandan Government has shown commitment and interest in reviving the cooperative sector (Kwapong and Korugyendo, 2010). To achieve this, the Uganda Cooperative Alliance (UCA) has focused on organizing and strengthening grassroots farmer organizations to maximize membership and build the commitment of members. Grassroots community based organizations, parish farmers associations and other smaller farmer groups are organized under Rural Producer Organizations (RPOs). At sub-county level, a number of RPOs merge to form Area Cooperative Enterprises (ACEs) which act as smaller cooperative unions for the RPOs. By 2010, 352 RPOs and 55 ACEs had been formed countrywide.

In some parts of Uganda, farmer field school networks (FFSNs) have been established along a similar model to the ACEs and are engaged in running agricultural commercial enterprises on behalf of their members. FFS networks are defined as informal or formal groupings of a number of FFSs with a common interest within well-defined geographical boundaries such as sub-counties, divisions or districts. The FFSNs typically form as the number of FFS groups grow and broaden their level of operations, and new issues and challenges emerge that cannot be solved effectively by the individual groups (Braun *et al*., 2007). The FFSNs provide increased opportunities for the members of FFSs to take advantage of, and enjoy economies of scale.

The farmer field school (FFS) is a group-based extension approach which follows a participatory and discovery learning process built upon principles of adult education. The practically-oriented field study processes involve mobilizing and organizing groups of farmers with a common interest, who regularly meet to study the "how and why" of a particular situation in a given context under the guidance of a facilitator (Okoth *et al*., 2006). In this way, the FFS acts as a forum where farmers meet and make regular field observations, relate their observations to the ecosystem and, building upon their own knowledge and experience, make appropriate crop/livestock and other agriculture – or agro-ecosystem – related land management decisions under the guidance of the facilitator.

Under the Kagera TAMP in Uganda, at total of 42 FFS groups with an average membership of 30 were established in the six project districts (Table 1).

District	Subcounty	Parish	Number of FFS
Isingiro	Bwentare	Ntundu	1
	Kikagate	Kikagate	2
	Ngarama	Kakamba	3
Kabale	Bubare	Kagarama	2
	Kitumba	Bukora	4
Kiruhura	Sanga	Nabigasa	1
		Nombe I	1
		Rwabarata	2
Mbarara	Mwizi	Bushwere	2
		Kigaaga	3
		Ryamiyonga	1
Ntungamo	Kitwe	Kitwe	3
		Nshenyi	2
	Rukoni	Rukoni	2
Rakai	Kakuuto	Kakuuto	4
		Katovu	2
		Kyebisagazi	2
		Mayanja	2
		Sango Bay	1
	Kyebe	Kanabulemu	2

Table 1: Locations of FFS groups established under the Kagera TAMP.

The enthusiasm to form more farmer field schools was generally high as farmers were even willing to form new schools with minimum support from the project. During training sessions, farmers are able to evaluate and select enterprises based on well-developed criteria set by the group and facilitators. The enterprises selection by farmer field schools usually depends on their ability to provide basic food needs as well as generate income. The other reason identified for cooperation is to be able to work together on sustainable land management problems that cut across and affect the watershed for wider impact on water resources, carbon sequestration and flood and drought risk management.

Opportunities and Challenges

The equivalence of the FFS group under the new Uganda Cooperative Alliance (UCA) guidelines is the RPO while the equivalent of the FFS Network is the ACE (see Figure 1).

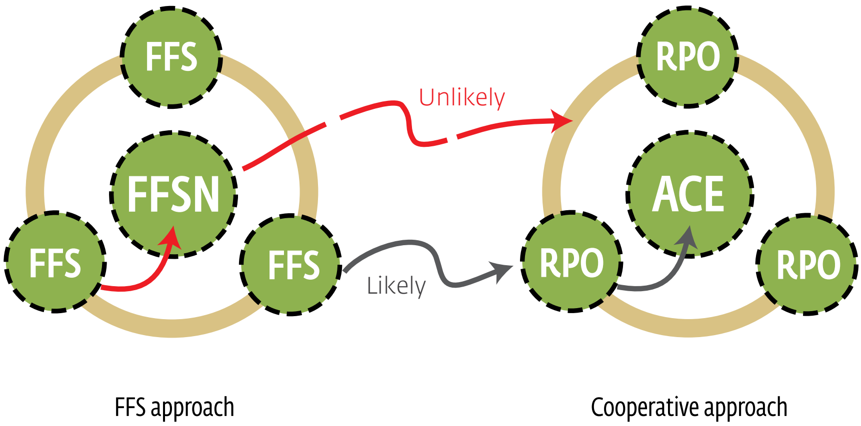


Figure 1: Possible pathways for transformation of FFS groups into cooperatives.

The FFS groups catalysed by the Kagera TAMP rather than forming FFS Networks, instead opted to form RPOs directly. The most feasible route to transform FFSs into structured cooperatives is as follows:

- Step 1: Formation of RPOs through formalized registration and restructuring processes.
- Step 2: Association of several RPOs into ACEs under the guidance of the District Commercial Officers.

Opportunities

The mean land size owned or accessed by each of the FFS member households is about four hectares (ten acres) in south-west Uganda in the Kagera basin (Figure 2), which is relatively higher than the average land holding in most parts of the country. This makes the potential for market-oriented production possible, especially when done under organized groups.

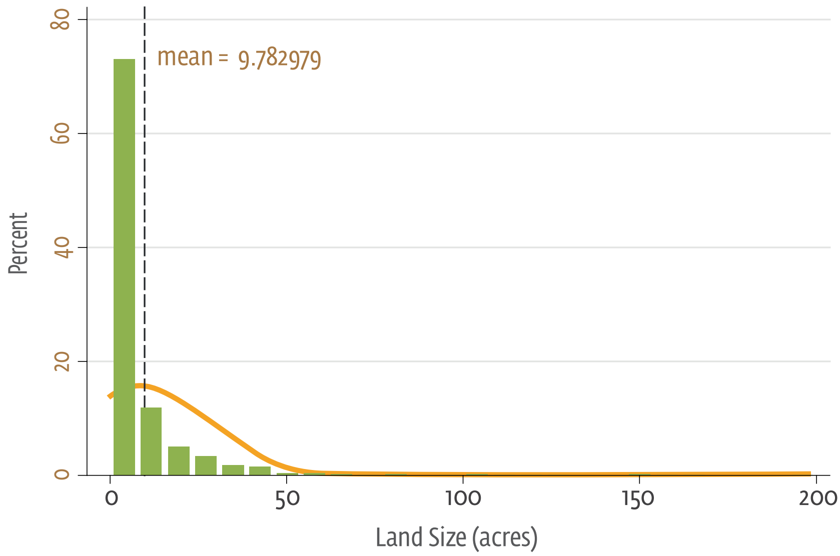


Figure 2: Average land holding per household.

By organizing into groups, the individual households' high potential for agricultural production translates into aggregations of economically viable units that can participate in commercial cooperative production.

The majority of farmers hold about four hectares implying that they are more viable as cooperative small-scale producers than as independent commercial farmers. A very small proportion of the farmers hold over 20 hectares (50 acres), so the majority of group members do not have the land sizes required to independently and viably commercialize their production. It is important to note that farm-size varies widely between farm-households and within and between districts and land quality also varies considerably.

As shown in Figure 3, the majority of farmers own their land under the customary tenure system which is not suited to individual large-scale production. Only one percent own mailo land[1] and only 10 percent own leasehold land. Again, this implies that with appropriate training and facilitation it is more appropriate and feasible for small-holder farmers to be organized under groups and form viable RPOs and ACEs. Indeed the smallholder arrangement and the land tenure system may not pose a serious threat to formation of cooperatives. There is also a provision of government support through general land mapping and registration for farmers who are working together.

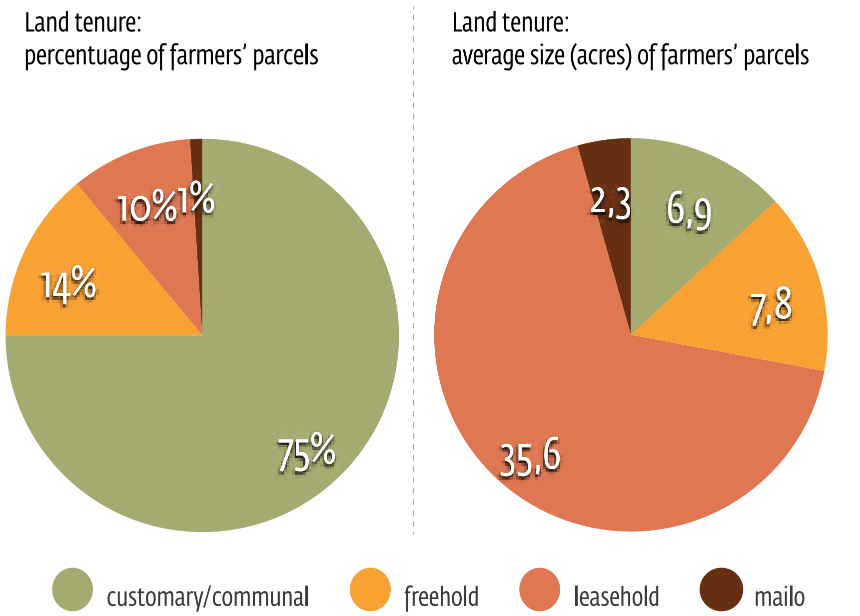


Figure 3: Land tenure.

The major crops grown in the project area are beans, bananas and maize (Figure 4), all of which can be produced commercially and cooperatively. Several other crops are important for household nutrition and good agronomic practices such as rotations, pest control, soil fertility management (Figure 4).

1 Mailo land is the tenure system that guarantees long term or perpetual ownership security and collateral possibilities that are usually required to invest in large commercial production. This can also be done under leasehold, but to a lesser extent as the expiry of the lease reduces the incentive for the farmer to invest heavily especially in fixed costs.

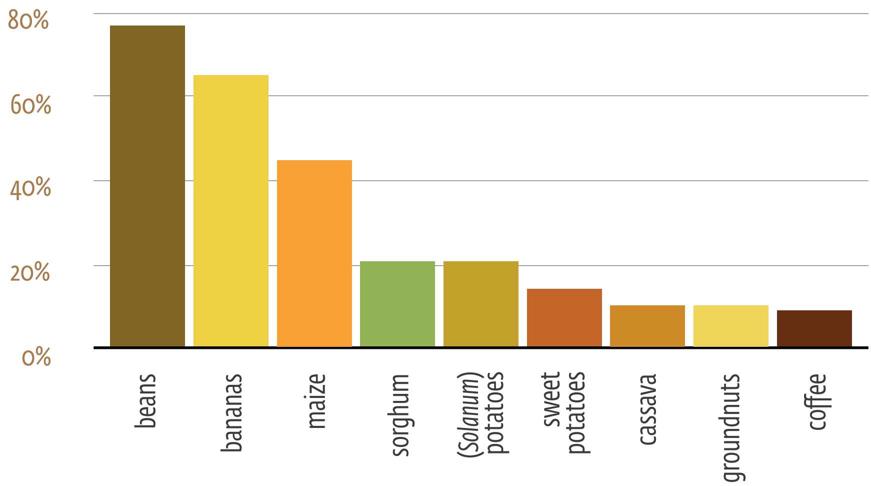


Figure 4: Major crops grown.

The three key crops grown by FFS were analysed for trends in production quantities, income and prices over two time periods of the Kagera project – 2010/2011 and 2013/2014 (Table 2). The quantity produced by each household has evidently increased for bananas, though for beans or maize this change is not so distinct. However, the incomes have increased in all cases (almost doubled for bananas) due to higher prices among other factors. Such an increase has been partly attributed to learning and sharing information through FFS, which leads to improvements in the bargaining capacity of farmers for better crop sale prices as a result of collective marketing.

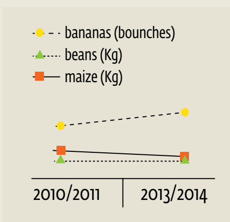
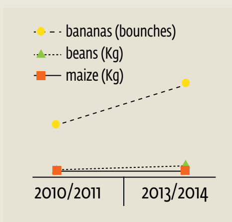
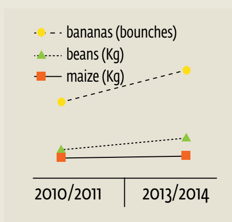
Crop	Production Quantities / hh		Total Income / hh (UGX)		Computed Average Price (UGX)	
	2010/2011	2013/2014	2010/2011	2013/2014	2010/2011	2013/2014
bananas (bunches)	457	579	1 801 979	3 251 664	3 943	5 616
beans (Kg)	162	163	231 768	333 663	1 431	2 047
maize (Kg)	232	196	229 876	212 019	991	1 082
						

Table 2: Production and income from three key crops.

The conclusions that can be drawn from these increases in production, prices and the implications in terms of opportunities for cooperative formation out of the FFS groups, are that:

i. The productivity at household level benefits from the skills and practices learnt through the FFS approach and particularly applied at group level (through sustainable land management practices). The cooperative farmer groups enhance individual household production and collective group production through organising access to quality inputs;

ii. Household incomes are improved by increased yields, but also by improved prices for the produce through collective marketing. This has the potential to improve the bargaining power and therefore prices attained for produce, ultimately enhancing the livelihoods and security of individual farmers.

In the FFS, the livestock production and income trends (Table 3) follow similar patterns as the crop production, with an increase in incomes over the two time periods monitored.

Livestock type	% of hhs	Average income / hh	
		2010/2011	2013/2014
Cattle	44%	2 668 053	3 301 919
Sheep/goats	68%	528 318	788 699

Table 3: Incomes obtained from livestock production.

Challenges

- The scattered nature and small number of the FFS groups within particular administrative units is a challenge. This can be overcome through institutionalising FFS by increasing the number of master trainers, facilitators and support of the Government since farmers desire to form and benefit from farmer field schools is high.

- The wide diversity of enterprises (three major crops and at least five others produced by over ten percent of the farmers), reduces the potential for leveraging economies of scale through specialization or intensification of production at household level. This challenge can be overcome through RPO and ACE and continuous improvement of enterprise development.

Conclusion and recommendations

The conclusion is that FFS groups established under the Kagera TAMP are viable links for transforming into RPOs and then forming cooperatives. Using this approach, the new farmer field schools formed are being co-opted into established cooperatives based on the similarity in enterprise and benefit products generated from use of sustainable land management practices.

In this way, the member farmers can expand their incomes by exploiting their productive and marketing potential gained from collective action. Currently, the challenge appears to be the small numbers of groups per location and the excessive diversity of enterprises. However, with time more farmer field schools are being formed as sustainable land management practices translates into increased incomes and productivity. As farmers go through agro-ecosystem analysis, farmers are discarding lower yielding options and preferring opportunities generating more income.

Main recommendations include continuous learning and experimentation to improve farmers' understanding of agro-ecosystem analysis and enterprise selection. Secondly, district commercial officers need to increase their support for and nurture the young cooperatives formed. Thirdly a policy is needed to recommend FFSs for sustainable land management, so that rural farmers can work together to solve problems that require an integrated approach and evolve into cooperatives around selected enterprises, enabling enhanced input supply, support services and marketing of produce.

Conclusion Theme 1

1

Farmer field school for learning and uptake

Through the FFS groups established by the project, a good number of farmers had access to training in SLaM. This has led to a high adoption rate of SLaM practices among FFS members within the catchment communities. Thus the FFS methodology has proved to be efficient for learning, adoption and dissemination of SLaM technologies and practices among FFS members and non-FFS members in the catchment communities.

The capacity (particularly on SLaM practices and the FFS methodology) of extension staff/service providers and FFS facilitators has been well enhanced, equipping them with the capacity to train and technically backstop communities on learning and adopting SLaM. The trained FFS facilitators and service providers were instrumental in enhancing learning of SLaM technologies and their dissemination.

Various SLaM technologies learned through FFSs have already had positive results and impacts on soil erosion control, increased crop yields and livestock production, particularly using sound integrated crop management (ICM) practices and integrated livestock management respectively. Some of the technologies learned and practices used also address climate change in terms of both adaptation and mitigation.

Throughout the project activities, SLaM FFS benefits have demonstrated to be environmental, social and economic.

The present conclusions can also be used to inform scaling-up as follows:

How FFSs work to enhance SLaM

Experience on the Kagera TAMP shows that four key steps enhance SLaM understanding and adoption through FFS, namely: 1) generation of SLaM knowledge and technologies in a common study field; 2) adoption of good practices in farmers' own environments; 3) dissemination of good practices in the whole catchment (mass adoption); and 4) sharing of experiences and harmonization (synchronization) across different land use types.

Generation of SLaM technologies in a common study field

The chapters of this theme demonstrates that a diverse range of SLaM knowledge and practices have been learned, validated, adapted, and adopted through the common FFS learning system. Through the SLaM FFS study fields, farmers have been able to test and validate technologies and practices of their own choice, based on their expressed needs and priorities, with the guidance of trained facilitators.

Various learning approaches have been followed to enhance the already deep understanding of SLaM practices known to the farmers through the FFS learning groups and study plots. These include, but are not limited to: 1) field comparison studies of various integrated soil fertility (ISFM) and integrated crop management (ICM) management options; 2) validation trials such as assessment of different varieties of individual crops (varietal gardens); 3) field experiments on different composting techniques, etc. A range of discovery-based learning activities were conducted through the FFS learning approach.

Also farmer field schools have been conducting regular assessments and data collection on soil and crop development for further decision making through the "soil" ecosystem analysis (SOESA) which evolved from "agro"-ecosystem analysis (AESA) which focused on the crop plant and its interactions.

Adoption at individual fields

The objective and desired end result of the common study plot is the uptake of validated good practices to farmers' own fields. Site-specific problem solving and technology adjustment drives farmers' adoption interest. One of the major interventions in SLaM FFS groups was the introduction and execution of "adoption contracts". The aim was to support and ensure that members are willing and able to adopt SLaM technologies and practices in their own home environments.

Dissemination to the wider community

Through FFS approaches, various techniques are applied to ensure wider dissemination of already proven good practices. Activities such as field days and farmer to farmer cross visits have been used to expose more farmers to technologies and their applications. Wider adoption of SLaM practices has also been made possible through farmer to farmer learning (diffusion).

Catchment approach to FFS

Adoption of SLaM FFS activities went wider to all land uses and many different enterprises. Unlike the classical integrated pest management FFS model, the SLaM embraces a number of interrelated enterprises, towards the final goal of sustainable use of land resources. The FFSs address a wider range of aspects of the ecosystem/ecology related to production such as soils, climate change as well as pests, diseases, productivity per unit of land and labour, etc.

Within the same micro-catchments, various FFS groups with different enterprise focus were formed. These SLaM FFS groups shared different experiences, learned from each other, and harmonized best practices for addressing different land degradation problems and enhancing sustainable and productive land management.

In one area, the FFSs are grouping together to exploit their higher productive and marketing potentials to further improve their incomes and livelihoods.

Capacity development at multiple levels for effective implementation of sustainable land management

Authors: Janie Rioux* and Patrick Kalas ¥

*Affiliation: * Kagera TAMP project staff*
¥ FAO expert

How will the transition towards sustainable management of land and water resources materialize? Who will own and drive this transformation at field, district and country level? What are the national and subnational capacities of individuals, organizations and institutions that need to be strengthened in order for implementation to succeed and how will countries be supported in this process? The thinking and practice around capacity development addresses these issues. Capacity development is defined as "the process whereby individuals, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity to set and achieve their own development objectives over time". An effective capacity development approach is anchored in development effectiveness principles and reaches beyond isolated training events, technical assistance and policy support. It aims to facilitate an endogenous development process rooted in national empowerment, thus contributing to more sustainable and impactful results.

In good capacity development practice, this change process can be facilitated by external factors, such as the SLM community actions and FFS supported by Kagera TAMP, and national and regional consultation processes. Country capacities should be developed across the individual, organizational and enabling environment, and include technical as well as functional capacities, using context-specific capacity development modalities. The facilitation role of a trusted convenor such as FAO may be important to: (i) foster inclusive participation of all stakeholders; and (ii) overcome ministerial and stakeholder silos for integration of SLM to materialize.

Country assessments indicate that most countries lack effective capacities to address SLM effectively as a cross-cutting issue across different Ministries. Capacity development is needed in administration of natural resources in terms of human and financial resources, organizational strengthening and a more conclusive institutional framework.

Capacities should be developed across all levels (national, subnational, local) among all relevant stakeholders (Figure 1). The first step, anchored within a broader context and stakeholder analysis, is a detailed and facilitated capacity "self-assessment" process among stakeholders to diagnose what and whose capacities need to be developed, determine a baseline to track progress and define appropriate capacity development modalities for improvement. These modalities may include awareness raising, dialogue, training, technical support, and coaching during the implementation of activities, establishing and facilitating multi-stakeholder consultations and strengthening organizational performances.

Involving stakeholders throughout the capacity development process is key to enhancing ownership, commitment and understanding of local players on their role in SLM; improving management and negotiation capacities of actors involved in NRM; facilitating information sharing and creating transparent processes; and providing insights in dispute resolution and conflict management. Stakeholders should be made aware of existing mechanisms and their requirements. This is particularly important for people, local communities and indigenous peoples who are using and/or managing forests. They should be supported to claim their rights and the benefits of sustainable land management. Clear capacity development results should be defined in order to track progress throughout the capacity development process.

Establishing and facilitating effective, participatory multi-stakeholder processes is key to strengthening systemic capacities within countries when integrating SLM. This could strengthen existing institutions at all levels, build awareness and common understanding on the importance of addressing SLM in a coordinated and holistic manner and foster political will critical for implementation. At national level it can create inter/intraministerial synergies and at local level it can be a means to integrate SLM into territorial and landscape governance.

Bringing together SLM requires knowledge creation and increased collaboration and information sharing on all sides. A starting point in the SLM planning process should be mapping of actors and institutions involved in both SLM and NRM and the assessment of their capacity development needs. This will help orient the capacity development support and guide the review of business and coordination processes between players and institutions. To be able to work together, actors should reach a common understanding of SLM and of each other's roles and responsibilities.

Figure 1: The multiple levels of capacity development.

Some example of capacity development activities include:

- Knowledge base created in selected catchments and communities.
- Training methods and materials develeped with subject matter specialists and trainers to support integrated agro-ecosystem and FFS-SLM approaches.
- Community awareness and training session on the effect of current practices on farm.

- Opportunities identified for reducing or preventing negative impact and to generate benefits.
- Sites identified and agreed with communities for SLM demonstrations.
- Training to service providers and community leaders on integrated agro-ecosystems approaches and benefits of agricultural biodiversity.
- Exchange visits for knowledge and experience sharing among local innovators and staff in districts and technical sectors.
- Collaboration between researchers, service providers and land users on the promotion of diversified, productive and sustainable farming system.
- Awareness raising on the importance of SLM for water quality supply and climate adaptation (resilience) and mitigation (carbon sequestration; reduced burning).

Figure 2: Project supervision mission with Katongero catchment community, Rakai district, Uganda. The team seats on a stone line for soil erosion control.

Catchment planning and local governance for integrated land resources management

2

Introduction

The natural resources of the Kagera River Basin, shared by four riparian countries (Burundi, Rwanda, Uganda and Tanzania) support the livelihoods of over 16.5 million people, wherein the majority are rural and depend directly on farming, herding and fishing activities. However, the resource base and the ecosystems are facing increasing pressures as a result of rapid population growth, agricultural and livestock intensification characterized by progressive reduction in farm sizes and unsustainable land use and management practices. As a result, the basin's land and freshwater resource base, associated biodiversity and populations whose livelihoods and food security depend on those resources, are threatened by land degradation, declining productive capacity of croplands and rangelands, deforestation and encroachment of agriculture into wetlands.

While the government of each of the riparian country has put in place institutional arrangements, policies and laws to protect the environment and natural resources, there are inadequacies in their implementation. This has led to growing recognition among district local governments and rural communities who depend on land and water for their livelihood needs, as well as among the development partners, that an integrated approach based on community participation is urgently needed to manage and utilize their water and land-based resources in a sustainable manner. These local actors call for the promotion of a natural resources management approach that is appropriate, community-based, low cost and sustainable.

In recognition of this need, the Kagera TAMP combined the principles of catchment management planning and local governance strategies to promote conservation and sustainable use of land and water resources in a balanced human-ecological manner. The specific processes and activities that were implemented to demonstrate the application of catchment management strategies and practices as an effective tool for sustainable, integrated land resources management are described under this theme, through the following six chapters:

Chapter 2.1 describes the step-wise methodological approach used in participatory integrated watershed management planning and implementation in Burundi, as well as the resulting outcome from diversified application of technologies.

Chapter 2.2 illustrates the importance and application of participatory village land use planning as a tool for addressing serious land management problems and conflicts in Tanzania. It highlights some of the core steps and activities required for developing a participatory land use plan as well as the achievements to date and challenges encountered.

Chapter 2.3 presents the policy framework for land use planning in Uganda and the application of participatory approaches, including use of LADA-WOCAT tools to inform the development of land use action plans. It also describes some outcomes obtained from the implementation of sustainable land management practices.

Chapter 2.4 describes the use of integrated watershed management approach to enhance water availability in Tanzania and emphasizes the use of participatory tools for watershed assessment, characterization and planning of community-based interventions. A wide of technologies and practices, including tree planting, buffer zone demarcation, formation of catchment committees, water source protection and rehabilitation are demonstrated.

Chapter 2.5 describes the unique characteristics of Karambo and Gatebe II micro-catchments in Rwanda. It shows how participatory land degradation assessment was undertaken to involve communities in identifying priority issues and appropriate local actions for soil erosion control. It also highlights the importance of constructing terraces in combination with biological and agronomic measures to enhance their up-scaling and uptake among communities.

Chapter 2.6 presents how a community-based strategy was used in the application of bamboo as a technology for river bank stabilization in Burundi. It describes the methods for multiplication and planting of bamboo and the multiple benefits from its application.

2.1

Participatory integrated watershed management for sustainable food security in Burundi

Author: Jean Pierre Twagirayezu

Affiliation: Soil and Water Conservation Management Programme, Institute of Agronomic Sciences of Burundi (ISABU), Burundi

"Those who plant trees while they're young, shall have shade in old age"

Madagascan proverb

Summary

The Kagera TAMP provided the project beneficiary communities a forum for reasoned, collective reflection about their physical environment, in order to investigate alternative solutions to environmental degradation and unsustainable natural resource use and to mitigate climate change. The project managed watersheds in Gitega, Muramvya, Mwaro, Karusi and Kirundo provinces. The capacity-strengthening activities focused on SLM best practices for promoting climate change adaptation and mitigation. The project also facilitated experience-sharing sessions between extension agents and farmers from the beneficiary communities.

Key words: watershed management, biodiversity, participatory approach, agro-ecosystems, prioritization, planning, climate change.

Introduction

The Burundian agro-ecosystems are under increasing pressure due to rapid population growth and agricultural and livestock intensification. This has led to a progressive reduction in farm sizes, as well as to unsustainable land use and management patterns. Coupled with climate variability, this is most notably through the increasingly destruction of habitats and loss of biodiversity which directly impedes on agro-biodiversity and rural livelihoods.

The overall goal of the Kagera Transboundary Agro-ecosystem Management Project (Kagera TAMP) is adoption of an integrated ecosystem approach for the management of land resources in the Kagera River Basin. This approach aims to promote the restoration of degraded lands, carbon sequestration and maintenance of the water regime.

In Burundi, Kagera TAMP is contributing to the implementation of the Strategic Framework for the Fight against Poverty (CSLP) by promoting fair and sustainable economic development based on the management of natural resources. The project's objective of restoration and sustainable natural resource management was in alignment with the country's National Agricultural Strategy for the 2008-2012 plan. It is also aligned with the National Plan for Agricultural Investments 2012-2017.

Methodological Approach

In 2011, Kagera TAMP began participatory natural resource management with a pilot micro-catchment as a physical planning unit. Through this approach, joint solution to issues related to production systems, water and land management were achieved. Service providers in the sector were invited to contribute to the natural resource management joint plan of action.

A critical analysis of the state of the land resources was jointly undertaken with the beneficiary communities in their community territory. This exercise raised their level of awareness and willingness to reverse the current negative impacts on their environment (Figure 1) and socio-economic status.

The integrated watershed management in the Kagera TAMP area was implemented in phases.

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Figure 1: Soil degradation due to erosion in Mwaro.

1. The preparatory phase

During the preparatory phase, sites were selected. The selection of the micro-catchment was in collaboration with the Provincial Directorate of Agriculture and Livestock and Ministry for Environment. Several criteria were taken into account in selecting catchment areas.

An analysis of the socio-economic, topographical (Figure 2), pedological and hydrological data of the selected sites was conducted. The extent of degradation, site visibility and accessibility, relevant policies and strategies, opportunity for cross-border activities and relevant interventions by other actors and a needs assessment of the communities were factors that guided the choice of sites.

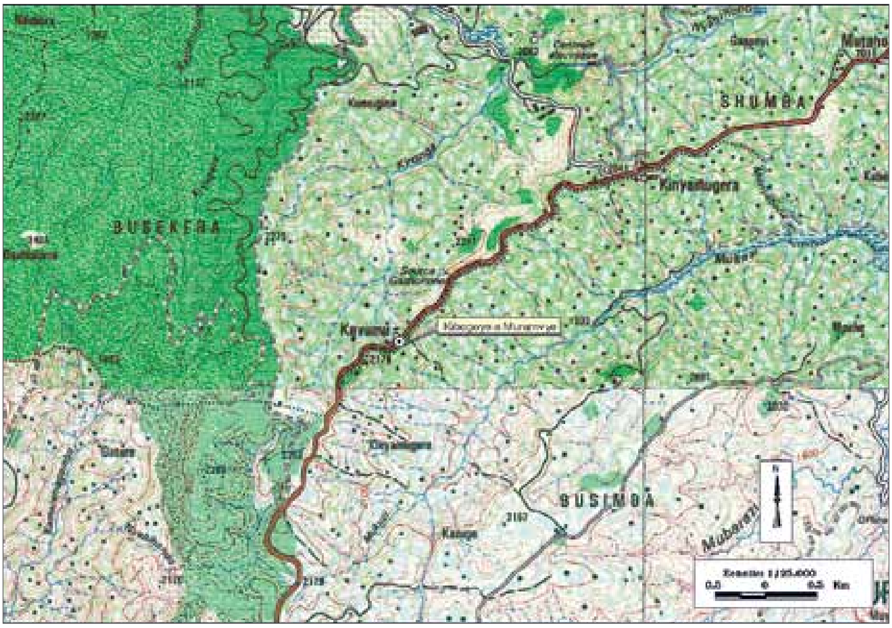

Figure 2: Topographic map of Giheta in Gitega.

2. Information and awareness-raising phase

A series of meetings (Figure 3) were held with the local administrators, elected representatives, decentralised technical services and beneficiary communities in Kagera Region. The meetings were premised on the importance of an appropriate and effective management of their natural resources and their buy-in.

3. Collaborative diagnosis phase

A quick survey using LADA methodologies (FAO, 2011b) of the area was organized in collaboration with the local population. The survey took cognizance of the current condition of their environment (Figure 4). The socio-economic survey also analysed agricultural production activities (crop and livestock farming, bee-keeping), technical services, as well as socio-economic infrastructures in the area. The environmental description focused on vegetation cover, current land use, soil fertility and indicators of soil degradation.

Figure 3: Meeting with beneficiaries.

Figure 4: Field assessment of the current land degradation status of the area using the LADA methodology for local level assessment.

4. Participatory analysis phase

The results of the diagnostic survey were presented at a follow-up meeting with the beneficiary communities (Figure 5). The result of the survey and the implications of the progressive degradation of their agricultural land were discussed.

An analysis of the problems illustrated was realised by the communities. They listed and prioritized the five major problems in their micro-catchment. A problem tree analysis exercise enabled them to analyse the causes and effects of their environmental problems. Armed with this new knowledge, an action planning participatory approach was adopted for the determination of how these problems would be addressed.

Figure 5: Sharing information on the findings with the community.

5. Participatory planning phase

In the second-last phase, a joint plan of action was drawn. This included a schedule of activities, and allocated roles and responsibilities.

A watershed committee was democratically established. This was to ensure effective monitoring of activities during and after the project intervention. The committee was responsible for the management of the planned actions. Members were also mandated to act as intermediary between the local population and the project. With the support of the project, the committee organized a multi-year programme and a work plan for the first year of the project.

6. Physical implementation phase

The physical implementation of the project's activities was carried-out by appointed service providers, the local administration and the local population. The implementation committee was constituted to promote efficacy and sustainability of activities.

Results

Between 2011 and 2014, Kagera TAMP managed 14 micro-catchments with a total surface area of 4 154 hectares. The managed micro-catchments are spread across five provinces (Gitega, Mwaro, Muramvya, Karusi and Kirundo) and have a population of 12 322, as shown in Table 1. Within the population, there are 36 farmer field schools (FFSs) with a total of 1 205 members. These members and their households benefited from the project activities through an improvement in food security as a result of enterprise crop diversification (bananas, potatoes, beekeeping, market gardens and fruit trees).

Province	Managed micro-catchment	Surface area (ha)	Rivers	Technologies used	Population
Gitega	5	1 124.50	Waga, Ruvubu, Mubarazi, Mutwenzi	• Digging of contour lines, planting hedges and agroforestry trees over 100 km • Planting 10 000 banana trees (phya 23) • Protection of the banks of the Ruvyironza River using *Pennisetum laxum* and *Tripscacum* spp. over 375 km • Micro-dam for irrigation of 10 ha of diverse food crops • Planting of a communal woodlot of 45 ha	4 304
Muramvya	1	301.60	Mukuzi, Mubarazi	• Digging of contour lines and planting hedges and agroforestry trees over 150 km • Planting 4 500 banana trees (phya 23)	1 120
Karusi	1	457.50	Ndurumu	• Digging of contour lines (*fanya juu*), planting hedges and agroforestry trees over 175 km • Planting of 6 000 banana trees (phya 23) • Fishing lake of 14.5 acres associated with rearing of pigs (5).	2 481
Kirundo	3	1 447.60	Lake Cohoha and Lake Rweru	• Digging of contour lines (*fanya juu*), planting hedges and agroforestry trees over 300 km • Planting 6 000 banana trees (phya 23, 25 and 17) • Rehabilitation of natural Murehe forest by planting native trees over 25 ha • Protection of the Lake Rweru and Lake Cohoha through agroforestry buffer zone of over 40 km • Rainwater collection and hillside irrigation using motor- and pedal-powered pumps	1 120
Mwaro	4	822.80	Waga, Kayokwe	• Digging of contour lines (*fanya juu*), planting hedges and agroforestry trees over 290 km • Planting 6 000 banana trees (phya 23) and potato plants (14 ha) • Protecting the banks of the Kayokwe River using bamboo (100 000 plants) over 37 km, communal woodlots over 10 ha and private micro-woodlots over 9 ha • Hillside irrigation over 10 ha using motor- and pedal-powered pumps	3 297
Total	**14**	**4 154.00**			**12 322**

Table 1: Technologies introduced by micro-catchment.

Some of these technologies can be seen in the next photos (Figures 6 and 7).

Figure 6: Management of the catchment areas in Magamba.

Figure 7: Management of the micro-catchment area of Karusi to protect crops in the lowlands.

As a follow up the Lake Victoria Environmental Management Program (LVEMP II), with a proposed target of 18 000 beneficaries, introduced the Kagera TAMP sustainable land management technologies and practices across a wider area (part of the aimed-for scaling-up).

To consolidate the managed catchments, the project introduced:

- Improved bean seeds over 2 ha, potatoes over 23 ha, market garden crops over 50 ha, 20 000 banana trees on family farms, grafting techniques and two fish ponds, with the aim of improving food security over the whole project intervention area.
- Livestock for manure, productive land, food and resilient households [35 cows donated by the Projet de Productivité et de Développement des Marchés Agricoles (PRODEMA) in the context of a collaboration with the Kagera TAMP project, 28 pigs, 1 451 goats in the form of a community solidarity chain].
- Better composting techniques (using heaps and pits – detailed results are reported in Chapter 1.2 of this book) to restore soil fertility at all project sites.
- 1 145 improved cooking stoves across the project intervention area, to reduce deforestation and mitigate climate change.
- Rainwater management technologies, using motor pumps in Gitega, Mwaro and Kirundo; pedal-powered pumps in Gitega; micro-dams in Gitega; rainwater collection in Kirundo; mulching techniques in Mwaro, Gitega and Kirundo; and cover crops (cassava and *Mucuna* spp. (Velvet bean) in Gitega and Kirundo).
- Capacity strengthening of watershed committees on good agricultural practices, grafting of fruit trees and management of the infrastructures put in place.

The technologies introduced by the Kagera TAMP have had a positive impact on the environment and contributed to improved food security through crop diversification (including bananas, potatoes, bee-keeping, garden crops and fruit trees). The incomes of beneficiary populations also improved. Consequently, floods and their impacts have become far less frequent within the managed micro-catchments, while agricultural production and household income have increased by at least 30 percent.

Analysis (impacts, lessons learned, and constraints)

The following impacts can be linked directly to the integrated watershed management activities:

- Participation of stakeholders in a "bottom-up" approach ensured the sustainability of the action taken.
- Crop yields increased by at least 30 percent as compared to before the intervention securing improved livelihoods.
- There was increasing food availability and therefore beneficiary communities were more food secure and surplus was sometime available for market sale.
- Social cohesion and reduction in the number of land-related disputes was observed.

The following lessons can be drawn from implementation of Kagera TAMP integrated watershed management activities:

- Partnership and complementarity is pivotal for integrated management of catchment areas.
- Watershed management is a flexible and progressive process that takes into account the real needs expressed by communities at the specified time.

A major impediment to some of the activities initiated by the project, especially in the Bugesera Region, was increasing weather and climate variability. There is evident shortage of rainfall during the planting seasons. A part of the proposed technologies (i.e. hydro-agricultural dams) are difficult to diffuse as they require considerable financial resources. However, given their importance for increasing agricultural production, donor intervention is advocated.

Recommendations

In conclusion, it is recommended that community members are provided with the skills for planning community activities and implementation of technologies at catchment or wider watershed scale. These would both increase their levels of adaptation and alleviate the effects of climate change as well as reduce land degradation and contribute to food security. Also, farmers need capacity strengthening on weather forecasting and global trends in climate change adaptation and mitigation. Lastly, the technical services provided in the areas should ensure that the technologies delivered to the population are effective and adaptable.

2.2

Enhancing water availability through an integrated watershed management approach in selected sites in Tanzania

Author: Jasson R. Rwazo [*]
Vicent M. Pamba [¥]
Iddifonse Mwasikundima [≠]
Fidelis B. Kaihura [*]

Affiliation: [*] *Kagera TAMP project staff*
[¥] *Executive Director's Office of the Bukoba District, Tanzania*
[≠] *Executive Director's Office of the Ngara District, Tanzania*

Summary

The Kagera TAMP, in collaboration with district staff, community members and a technical team from the Ministry of Agriculture, conducted site characterization exercises in selected locations in Karagwe, Ngara, Missenyi and Bukoba Districts in Tanzania using an integrated watershed management approach (IWM). The objective of this exercise was to determine the types of land degradation, their cause and impacts and propose actions to restore the degraded areas. One of the major consequences of land degradation observed in almost all sites was water scarcity for domestic, agriculture and livestock use. This paper focuses on how IWM was implemented to enhance water availability in the selected sites. Although this approach was used in all the selected sites with almost similar interventions, this case focuses on the results from the Kyazi catchment in Missenyi District. Finally, it also highlights some relevant examples and descriptions from the other sites.

Key words: watershed management, FFS, participatory approaches, prioritization, planning.

Introduction

The Kyazi microcatchment is located in Kyazi Village in the Missenyi District. It is divided into three sub-villages (hamlets), namely Bwatangabo, Rubumba and Rubaya. Kyazi village is found in the eastern part of Missenyi District, in a ridged, undulating landscape, with ridges extending from the south to the north. To the west, the village is bordered by Ngono River which runs northward and drains its water into the Kagera River. Kyazi is part of the medium rainfall agro-ecological zone, with a bimodal rainfall pattern with the average annual rainfall ranging from 1 000 to 1 400 mm and an annual average daytime temperature of 20°C. It has a population of 1 380 people part of 317 households, and the average farm size is 0.6 hectares per household. More than 90 percent of the community members are smallholder farmers with a focus on livestock rearing.

The Kyazi microcatchment drains westward into the Ngono River and is mainly occupied by Rubaya and Rubumba sub-villages. The predominant land use types include: *Kibanja* (settlements associated with plots of permanent crops, mainly banana and coffee); *Kikamba* (abandoned *Kibanja* used for growing annual crops such as cassava, sweet potatoes and ground nuts); *Rweya* (mainly used for communal grazing and grass cut for mulch, while crop production is mostly limited to Bambara groundnuts) and natural and planted forests (Figure 1).

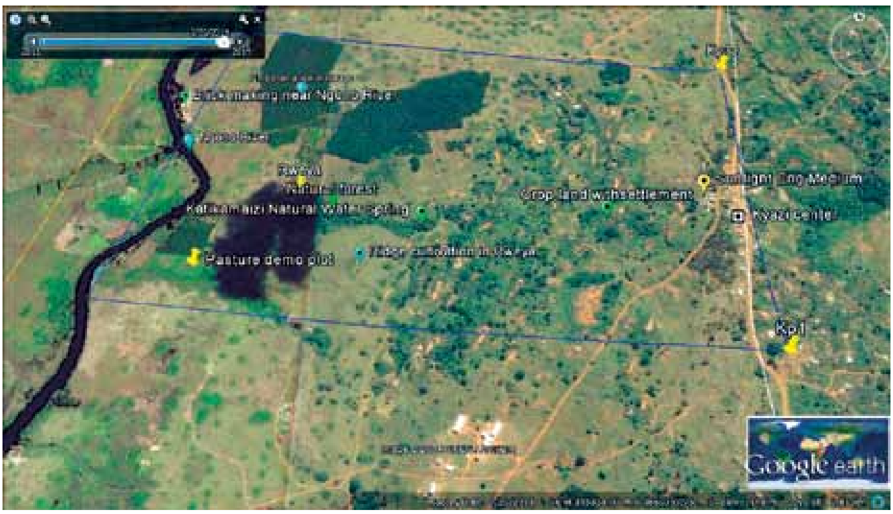

Figure 1: Satellite image showing the boundary of Kyazi microcatchment and a mix of features including Ngono River, natural spring and pasture demonstration plot.

Like other microcatchments in the Kagera Basin, rural communities in Kyazi microcatchment are increasingly faced with water scarcity for domestic, agriculture and livestock use. There were reported decreased flows of water from major Rivers (Mwisa, Ngono and Kagera). During the dry season, the streams and springs dry-up with siltation of water bodies due to sheet erosion (mainly from croplands and rangelands). Other problems include eutrophication and decreased soil moisture content. These problems are mainly caused by poor farming practices, overgrazing, deforestation, and poor land use planning. These issues are exacerbated by rapid climatic change and increased human and livestock pressure on the natural resource base. As a result of the water scarcity, women and children have to walk 0.5 to 1 km every day to fetch water for domestic use. There are also increased incidences of typhoid and other water borne diseases, especially in Bujuruga. This is linked to the transport by runoff of solid animal/human waste in water sources during the rainy season. In addition, the community members are also forced to share their water sources with cattle herders, also resulting in water conflicts between herders and other water users.

The main objective of the activity was to improve food production and water availability in Kyazi microcatchment by improving soil moisture and fertility through controlling erosion and increasing quality, quantity and duration of vegetative ground cover.

Methodology

The integrated watershed management approach was initiated through site characterization exercise. This involved collection of biophysical and socio-economic data using participatory rural appraisal (PRA) and LADA land degradation assessment tools. The data collected were used in the development of a participatory community action plan with organized group activities including communal actions, farmer field schools (FFSs) and income generating activities. The first ones were managed by the communal grazing area managers (*Wakondo*) selected by the village chief (*Omukama*) to rehabilitate tree and grassland areas and water sources. The FFS focused on sustainable crop growth on wider watershed demonstration plots. Finally, incoming generating activities focused on the least advantaged members of the watershed community.

Main water sources and their uses: During the survey and discussion which preceded activities start-up, the community members were led through a problem ranking exercise. Water scarcity ranked third among the ten key land degradation problems, while the loss of soil fertility was ranked first. From the survey conducted, it was also observed that there are a total of twelve main water sources in Kyazi village. Of the twelve, eleven are natural springs and one the perennial Ngono River. The community solely depended on the water from the natural springs for domestic use. Apart from watering livestock, there was no other reported use of River Ngono other than for brick-making. It was also observed that, out of eleven natural springs, only three have a continuous water flow all year around. The remaining nine water sources have continuous but low water flow for parts of each year and run dry during the dry season.

Observed causes of water degradation: The major causes of water resource degradation in Kyazi and other microcatchments in Kagera Basin were (also see Figure 2):

1. Direct watering of livestock from water sources;
2. Ridge cultivation down the slope on the *Kikamba* and *Rweya* which resulted in sheet and gully erosion as well as siltation of water sources;
3. Tree planting and cultivation on communal grazing areas on the low land is causing concentration or shift of animals to marginal or sloping land hence overgrazing, compaction and poor rainfall infiltration;
4. Decreased soil fertility and moisture content on the *Kibanja* River catchment. This has lead farmers to displace production and to increase seasonal cultivation in the wetlands around the Ngono and Mwisa Rivers;
5. Overgrazing in the upper and low land;
6. Tree cutting and cultivation around water sources.

Figure 2: Examples of land and water degradation: tree cutting for charcoal burning (left), cultivation around water sources (centre) and overgrazing (right) which leads to erosion.

Project Intervention: The Kagera TAMP planned a series of activities to address the recognized linkages between land degradation, water degradation and livelihood. In order to address water scarcity in the Kyazi microcatchment in Missenyi District and other sites in Ngara, Karagwe and Kyerwa Districts, a selected set of interventions were proposed. They were grouped into communal, farmer field schools (FFSs) and income generating activities. These activities focused on:

1. Controlling soil erosion through the reduction of rainfall runoff and thereby increasing water infiltration in the upper land;
2. Retention of soil moisture by improving ground cover through mulching in the cropland;
3. Tree planting and closing areas to grazing livestock (also known as "set-aside" areas) to provide protected buffers around water sources, wetlands and grazing areas;
4. Allocating small ruminants to disadvantaged farmers to enhance manure production and soil amendment.

Results and Discussion

Communal activities results: A total of 2 556 households from Kyazi and Minziro catchments in Missenyi District, Murongo and Kihanga catchments in Kyerwa District and Bujuruga catchment in Karagwe District were involved in the proposed communal activities (see Figure 3):

- Planting 33 748 tree seedlings in appropriate sites (this includes 45 students from Sunlight English Medium School in Kyazi, Missenyi who planted 95 improved varieties of mango seedlings on their school compounds. Most of the seedlings planted on hilltops by communities was geared towards improving soil cover to reduce soil erosion and increase infiltration rates.);
- Rehabilitation and protection of water sources through enforcement of by-laws restricting direct human activities in protected areas. The restricted activities are notably crop cultivation, brick making and planting cover plants in the buffer zone;
- Demarcating buffer zones along major rivers (Mwisa, Ngono and Kagera) by planting water friendly indigenous tree such as *Ficus* spp. and *Euphorbia* spp.;

- Pasture improvement of the grazing Kyazi catchment by closing and reseeding two acres of land (0.8 ha) with a combination of pasture species including *Canavalia brazile* (jack bean), *Clitoria tenate* (blue pea vine), *Sesbania sesban*, *Stylothantheses pubensis* and *Cajanus cajan* (pigeon pea) in one meter alternating strips for demonstration porpuses;

- Closing 31 hectares (77 acres) of land at Kamatenderi A in Rusomo catchment in the Ngara District through the construction of a 310 m long cut off drain as well as a 48 1 000 m long vegetative contours planted with Elephant grass (*Pennisetum* spp.) to control erosion and improve fodder availability;

- Restricting livestock movement from the neighboring village to graze on the remaining grazing area;

- Formation of one catchment management committee with ten members in each catchment;

- Strengthening of by-laws against bush fire.

Farmer Field Schools results: The main FFS activities included soil fertility improvement, soil erosion control and soil moisture improvement. The test crops were banana, maize and cassava. Different SLM technologies, including mulching, construction of contour bund for retaining rain runoff and controlling

Figure 3: Area closure around Katikamaizi water spring (left), around the grazing area and on the buffer zone around Ngono River using cut and carry system (centre) and establishment of a tree nursery (right) in Kyazi microcatchment.

erosion, and farmyard manure application were used in seven different demo plots (Figure 4 and Figure 5). A total of three participatory farmer groups (PFGs) with a total of 36 community members in Kyazi microcatchment (26 females and ten males) and one PFG with 45 students from Sunlight English Medium School were involved in the FFS.

Figure 4: Photograph indicating improvement of an old banana field using goat manure and grass mulch.

Figure 5: A newly establishing banana field using SLM technologies adopted from the FFS.

Income generating activities results: The project supported various income generating activities, including allocating 14 dairy goats and two pigs to 16 disadvantaged households and allocation of improved beehives to selected community members. Due to the application of manure collected from the animals, local farmers' report that the size of banana bunches has considerably increased in size. Over the coming seasons the benefits should be quantified more precisely.

Project outcomes

The following results have been achieved over the project period 2010-2014:

- Regeneration of the vegetation cover around water sources, grazing area and on the buffer zone around the wetlands near Mwisa and Ngono Rivers;
- Increased water levels and water flows observed in almost all conserved sources (e.g. at Kinyamgera water source in Kihanga/Katera microcatchment, after conservation,the water started to flow again on its natural stream to a distance of 2.5Km;
- Increased availability and application of mulching materials in almost all the catchments as result of reduced indicence of bush fires in the microcatchments (fire incidence reduced by more than 80 percent);

- Increased SLM adoption rate, for example 16 new farmers have adopted dairy goats keeping in their banana field for manure production and soil amendment and ten newly established banana fields using either two of the following practices: mulching, manure application or construction of water retention ditches;
- Increased food availability in the catchment due to increased crop yields, especially of banana.

Figure 6: Satellite images showing the land cover of Kyazi microcatchment before project implementation started (upper) and after in 2014 (lower). Source: Google Earth.

Figure 7: Demonstrating different soil and water conservation technologies.

Challenges and lesson learned

Protection of water resources poses a big challenge in areas where more that 80 percent of the population are poor and are heavily dependent on the natural resources base for their their survival. The challenges include illegal distillation of local brew using precious water resources, brick making directly on water sources and encroachment into wetlands for horticulture production. Lessons learned from the project clearly indicate that the problems cannot be solved without the provision of alternative sources of income and sensitization of the disadvantaged communities.

Recommendations and the way forward for scaling-up

Addressing water scarcity in the catchment should go hand in hand with the following capacity strengthening activities:

- Continue community level assessment and planning activities in order to prioritize interventions;
- Proper in-service training of involved staff and the community on the applicability integrated watershed management and its tools;
- Increased community water availability by introducing simple domestic rain water harvesting schemes;
- Repair and rehabilitation of existing water conservation and harvesting tanks;
- Provision of more training to herders on rangeland management, improvement and use;
- Provision of alternative sources of income, which are more environmental friendly i.e. bee-keeping;
- Reduced depletion of nutrients in *Rweya* extensive land use due to the collection of grass mulch and its application to enhance soil fertility in cultivated in *Kibanja* areas;
- Farmers must be encouraged to use banana trashes to maintain soil organic matter levels in their banana fields as an alternative to grass mulch to be collected from *Rweya* or to grow mulching material around their farm boundaries.

Conclusion

Through a combination of indigenous and improved soil and water conservation practices, the impacts of land degradation have been minimized in the targeted project communities. These practices include crop–livestock integration in *Kibanja* to improve soil fertility, and mulching using cut grass or banana trashes to suppress weeds. In the communal grazing areas, in order to increase soil water retention capacity and control of over-grazing, water harvesting ditches were built along the footpaths and more widely across the micro catchment (e.g. around farm buildings, in banana fields and in the well-established *Kibanja*, *Kikamba* and *Rweya* land use systems decreasing intensity of use with distance from the homestead).

To sustain this positive result, more efforts are still required (including: training for better understanding on how IWM works; involving communities in neighbouring microcatchments; investing in rainwater-harvesting structures for poor community members). These further accomplishment are required before all the efforts of the four year Kagera TAMP will be fully realized by the wider community (i.e. the Kagera Basin).

Land use plans for sustainable management of natural resources in Uganda

2.3

Author: Grace Nangendo ±
Dennis Babaasa ≠

Affiliation: ± *Wildlife Conservation Society, Uganda*
≠ *Institute of Tropical Forest Conservation, Mbarara University of Science and Technology, Uganda*

Summary

With increasing pressure on limited land resources, land use planning is key to ensuring increased production, associated livelihoods and food security while sustaining the natural resources and ecosystems. In the Kagera TAMP area, a systematic approach was used to guide the site selection for the SLM activities. The existing land use systems were identified through a mapping process. An assessment of the levels of degradation/conservation using the LADA-WOCAT method was undertaken. Participatory approaches were adopted in the development of a resource map and an action plan for each catchment in 2011. Identified SLM activities have since been carried-out based on the developed plans. New resource maps were developed in 2014. A comparison of the resource maps before and after intervention revealed that large areas that were under extreme degradation has been restored. For the Nyakayonjo catchment in Kiruhura District, most of the activities laid out in the 2010 action plan have been implemented and the areas that were degraded has significant improved conservation status. Soil erosion has been controlled. There is also evidence of new enterprises. These sustainable conservation efforts have resulted in increased land productivity. From the observed benefits of the project, communities have developed future action plans that would ensure further increase in SLM benefits.

Key words: sustainable land management, land use, policy, watershed.

Introduction

> *Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it.*
>
> FAO/UNEP (1999)

Land use planning is a process which promotes sustainable use of the land considering its potentialities, limitations and the user needs. Land use planning also involves a series of procedures, participation and commitment by all stakeholders.

A successful land use plan is not necessarily one that produces most. It is one which balances what can be obtained sustainably within the limits of the natural potential of the land. It also considers the aspirations of the people (Kutter *et al.*, 1997). Land use planning is based on a land use policy, which is essentially the government's perception of the direction to be taken on major issues related to land use and the proposed allocation of the national land resources over a fixed period of time.

In the past, the land use policies had production and conservation components. In recognition of the increasing pressure on limited resources, we need a land use model that promotes increased production, livelihoods and food security while sustaining the natural resources and ecosystems.

This paper is a synopsis of land use planning in the Kagera TAMP area of Uganda, which covers the high rainfall, highland districts of Kabale and Ntungamo and the drier lowland districts of Isingiro, Kiruhura and Rakai. Planning and output details of one catchment and community land use plan are provided, but lessons learned in each of the other five watersheds are also highlighted. The benefits of proper assessment of the status of land resources, the trends and livelihoods derived from those resources in developing knowledge based plans are highlighted.

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Figure 1: A farmer in his coffee field in the Kagera project area in Uganda.

Methodology

Policy framework for land use planning

The Ugandan Government Land Use Act and Policy are :

a) The Physical Planning Act 2010: The Act declares the entire country as "a planning area", for effective land use management;

b) The National Land Use Policy 2014: The overall goal of the National Land Use Policy is to achieve sustainable and equitable socio-economic development through optimal land management and utilization in Uganda. Some of the specific objectives are to:

- Adopt improved agriculture and other land use systems that will provide lasting benefits for Uganda;
- Reverse and alleviate adverse environmental effects;
- Promote land use activities that ensure sustainable utilization and management of environmental, natural and cultural resources for national socio-economic development

Other national and district legal documents which must be adhered to are: the Land Act of 1998 which was amended in 2010; the National Land Policy of 2013; the Agriculture Sector Development Strategy and Investment Plan (2010); the Water Policy (1995); the Wetlands Policy (1995); the Wetlands Sector Strategic Plan; the district environmental policies and the bylaws and regulations.

The details of the latter policy vary with district, each seeking to provide a framework for quality environment and natural resources protection. They address strategies for appropriate use of the environment and conservation of natural resources. They also support operationalization of the National Land Use Policy 2014, Land Act Cap 227, at the district level. This is achievable through the set structures of District Land Boards which enforce regulations and standards. The Lands Offices / registers and the Area Land committee at sub-county levels are mandated to monitor land use activities.

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Figure 2: Kagera river and border between Uganda and Rwanda.

Planning process

The planning process started with a mapping of the land cover/use of the project area. The land cover map was then combined with other data layers of the same location. The data layers included livestock intensity and dominance, wetlands, population, elevation, ecological regions and protection status. This activity generated a land use systems map for the project area. Using the LADA-WOCAT method (FAO-WOCAT, 2011), district officers and prominent farmers from each district were guided to assess each land unit in terms of degrees of degradation, and existing SLM approaches being practiced in the area. The generated maps of the levels of degradation and SLM approaches were used to analyze the different technologies and practices adopted by the Ugandan Government, development partners and local actors. It also served to identify areas that needed immediate attention. On the basis of agreed selection criteria, priority areas for implementation of sustainable land and agro-ecosystem management (SLaM) technologies and target catchments were selected. The focus of this study was prioritizing and designating catchment activities to ensure community engagement and visible results over the short project duration. The selected catchments were subjected to a more detailed diagnostic and characterization using some LADA-Local tools and methods (FAO, 2011b).

At the catchment level, community-level group discussions were held. A watershed action plan was developed. This action plan was based on the current land use, status of agro-biodiversity, soil and water resources. Current communal efforts towards combating degradation were mapped to establish options for further SLM interventions.

The land management constraints, their characteristic, their associated productivity potential, the causes of land degradation and existing land management practices were discussed. Historical trend analysis tool was used to determine the changes in land use, productivity and extent of degradation over the past ten years. Other tools used were the transect walk, institutional analysis, resource mapping, seasonal calendar and review of historical data (FAO, 2011a). As a final step, the district SLM experts and national Kagera TAMP consultants guided the communities in the use of the Driving forces, Pressures, State, Impacts and Responses (DPSIR) framework. This approach was used to establish the land use status at the start of the project and design a five year action plan for the catchments.

Results for the planning process in the Nyakayonjo Catchment, Kiruhura District

The Nyakayonjo watershed is presented as a case study, showcasing the planning activities carried-out and the benefits attained. The catchment is located in the area adjacent to Lake Mburo National Park. It has a population of 2 620 people and a total of 425 households Table 1 below shows the number of community members that participated in assessment of the natural resource.

Activity	Participants
Community mapping	20 community members and 1 facilitator
Focus group discussions	20 community members and 3 facilitators
Transect walk	11 community members and 4 facilitators
Soil, water and vegetation assessment	11 community members and 4 facilitators (This was carried out during the transect walk)
Livelihood assessment	2 cattle keeper households and 2 crop grower households assessed
Problem identification and analysis	Selected community members (55)
Compiling report and finalizing maps for presentation	Facilitators and community leaders

Table 1: Community participation in the catchment characterization and analysis at project commencement.

The outputs from this meeting were the community resource map (Figure 3), data on community members, community resource mapping, problem analysis, a seasonal calendar, video of activities and a transect walk profile.

It was observed that the watershed was bigger than the area the community had selected to work in. The community therefore indicated from the start of the project that there was needed to expand project activities to the whole watershed.

Figure 3: Resource map of Nyakigando-Rwamuhuku in Kiruhura Districts drawn by the community in 2010. The resource map (left) include a map legend (right).

The map in Figure 3 illustrates that a large portion of the watershed is overgrazed. Gully erosion is also a dominant feature in the landscape and almost all grasslands have invasive shrubs and thickets. This has reduced the coverage of palatable species in the area. The causes of degradation as well as the proposed strategies and opportunities are presented in Table 2

Problems	Causes	Effects	
Soil and water erosion	Overstocking, burning, overgrazing, trampling, soil compaction (reduced porosity, aeration and infiltration)	Gullies, silting of water reservoirs, drying of swamp edges resulting in water shortages	
Reduced vegetation cover and bush encroachment	• Overgrazing, prolonged and frequent fires, soil pulverization • Reduction of communal grazing areas, low intensity fires, invasive species	Change in botanical composition – fire tolerant but unpalatable grass species dominate Increase in density of woody species (mainly *Acacia hockii*), reducing carrying capacity for grazers especially cattle	
Water pollution and silting	• Tick control facilities constructed near wetlands • Watering large number of cattle directly from water sources or drinking troughs at the edge of water sources • Stones, gravel and silt washed down the hills from gardens by rain water • Cattle watering mud troughs near water sources easily erode and disintegrate into water bodies	• Persistent chemicals go into wetlands causing biological accumulation within food chains and webs. Potentially dangerous to all living organisms • Cow urine and dung foul the water and even cause local eutrophication, which has adverse impacts on aquatic organisms • Drying of swamps	
Land tenure	• Cultural inheritance of land leading to land fragmentation • Government policies where the land protection status has been changed several times and there has been irregular land distribution • Fencing of areas near the catchment into ranches, forcing local communities into remaining communal areas • Existing land tenure (i.e. mainly communal land in project area and leasehold in neighboring areas)	• Low interest in sustainable land management • Land insecurity • Human influx in the hope of getting free land • Increase in numbers of cattle	

Table2: Major degradation problems, their causes, identified strategies and opportunities.

	Coping strategies	Opportunities
	• Watering of cattle at permanent sources (e.g. Lake Mburo) • Increase of area under sustainable cultivation • Securing land rights • Use SLM technologies to conserve soil moisture, reduce runoff, increase soil cover (e.g. mulching, check dams, tree planting)	• Change in patterns of cattle movement • Sensitization to break cultural belief about large cattle numbers • Cross breeding • Sinking of boreholes • Intensify use SLM technologies to improve soil and water conservation
	• Extensive pastoralism • Improving access to fodder resources • Paddocking of livestock • Training and awareness raising on soil fertility management methods (e.g. compost preparation)	• Care breeding for stall-fed and intensive cattle keeping. • Reduced cattle numbers to meet carrying capacity of the area • Paddock areas for resident cattle and allow areas for extensive pastoralism • Fodder crop planting • Adjust fire regimes • Active removal of unpalatable colonizers • Sensitization to break cultural belief about large cattle numbers
	Moving cattle long distances to larger water bodies	• Changing location of watering points to further away from wetlands • Bulk water transfer from wetlands to watering points • Construction of more erosion-resistant watering points • De-silting
	• Extensive pastoralism instead of investing in sustainable land management • Beginning efforts to acquire land titles for some of the land	• Access to opportunities to acquire land titles • Land consolidation and joint land use planning for the consolidated land

Impacts

Both an action plan and resource maps were developed for effective and efficient impact monitoring of the SLM activities in the project. Figure 4 below indicates some of the land use/cover changes that have taken place in the four years of implementation of the Kagera TAMP project.

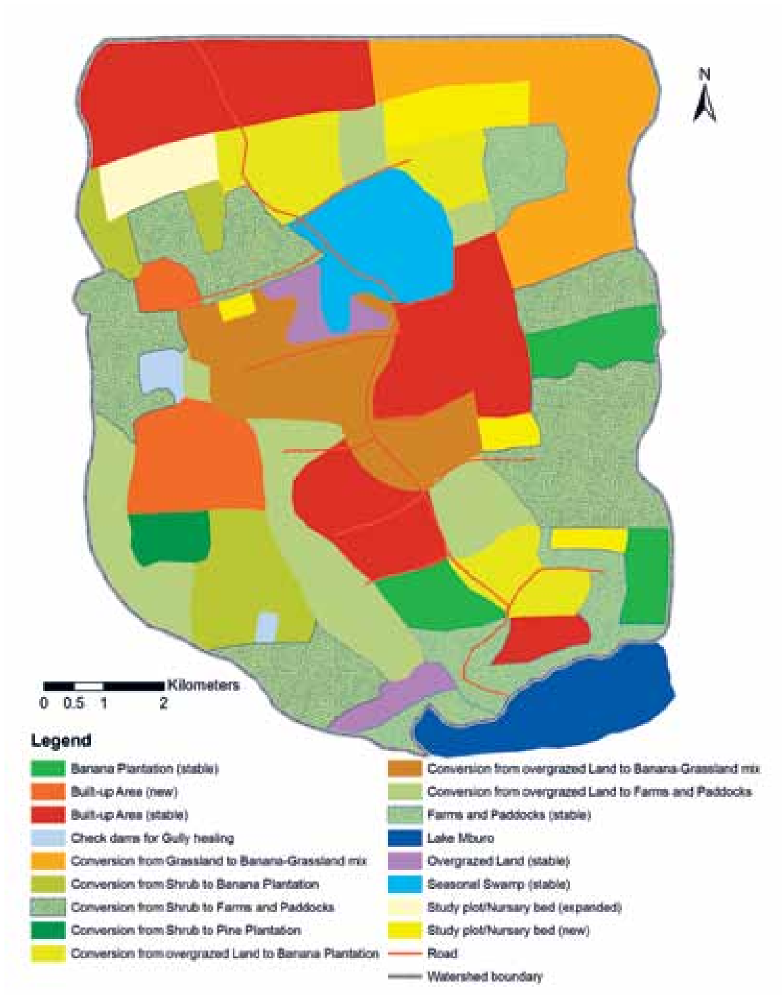

Figure 4: Land cover/use changes in Sanga-Nyakigando watershed, Kiruhura District[1].

1 Map generated through a comparison of the 2014 and 2014 resource maps

From the map in Figure 4 it is evident that there has been efforts to diversify agricultural activities. A large part of the area mapped as overgrazed in 2010 had been converted to a banana plantation by 2014. Other parts of the overgrazed land were converted into sustainably managed farms and paddocks. These farms and paddocks also have more grass for the cattle. A pine plantation for income generation and woodlot were also part of the improved use of the land. Other signs of change are the building of check dams for gully healing, expansion of the existing tree nursery and establishment of new nursery beds. In areas where gardens were established, the agroforestry system is now being used for sustainable environmental and food security benefits. The tree species planted are mainly species which provide fruit or fodder. The trees will also be useful for fuel wood. In some of these areas, bananas are intercropped with coffee. This is because these areas have become more conducive for settlement, hence new built-up areas have been established.

Although many project-based activities have been carried out during the project frame there are still some outstanding project-set targets. To address this gap, a new action plan and associated land use plan were developed. These are shown in Table 3.

Figure 5: A pastoral area with signs of land degradation due to overgrazing in Uganda.

Opportunities	Action	Resources	
Minimize soil erosion and runoff through			
1. Change in cattle moving patterns	1. Plan for alternative routing, construction of route diversion points in parts of current route	1. Planning meeting for alternative routes, land, materials for route diversion points construction, manpower	
2. Cross-breeding	2. Artificial insemination	2. Semen supply, collective sites for insemination, veterinary services	
3. Sinking of boreholes and build valley dams	3. Drilling site identification and excavation	3. Land, drilling equipment, fuel, labour, power, tanks, pipes, water lines, excavation	
4. Intensify use of SLaM technologies to improve soil and water conservation	4. Intensification of bench terraces and agroforestry activitie	4. Grass stock, hoes, tree seedlings	
Improve grazing and livestock management			
1. Reduction of no. of cattle and adopting higher yielding breeds	1. Artificial insemination, increase cultivation	1. Semen supply, veterinary services, land, hoes, seeds	
2. Fire regime management	2. Fire management plans	2. Meet to plan fire regimes, draw fire plan, implement plan	
3. Fodder increment	3. Fodder planting	3. Land, identify suitable fodder seed/crop, identify land sites, plant	
4. Mixed farming (crop and fodder)	4. Increase crops coverage, use terraces for fodder	4. Land, good seed source, labour, site selection for crops	
5. Active removal of unpalatable colonizers	5. Cutting and/or uprooting undesired species	5. Hoes, pangas, saws, manpower	
6. Sensitization to break cultural belief about large cattle numbers	6. Meetings with cattle keepers, study tours to good cattle farms	6. Social workers, meeting venues and meetings, travel facilitation	
Improve water quality, livestock access to water by			
1. Changing location of watering points to further away from wetlands	1. Identify land for watering points, excavate and construct watering points	1. Land, meeting to agree on suitable locations of watering points, technical knowledge of watering points suitability	
2. Bulk water transfer from wetlands to watering points	2. Pumping of water	2. Power, tanks, pipes, water lines	
3. More erosion resistant watering points	3. Construction of more erosion resistant watering points		
4. De-silting	4. Soil removal from wetlands and existing watering points	4. Hoes, spades, wheel burrows, manpower	

Table 3: Land use action plan.

	Community contribution	External contribution	M&E indicators
	1. Members availability, land, building materials	1. Meeting facilitation, supervision	1. Level of reduction of degradation by animal movement
	2. Sites for insemination, 25% payment for semen	2. Semen purchase resources (75%), payment for veterinary services	2. No. of animals cross-bred
	3. Land, local labour, 25% contribution towards tanks, fuel	3. Drilling equipment, expert labour, pipes, water lines	3. Proportion of animals accessing water from valley dams
	4. Hoes, tree nursery management	4. Good tree seeds, equipment, technical backstopping	4. No. of meters of conservation structures; No. of farmers trained in SLaM conservation technologies; No. of farmers practicing soil & water conservation technologies
	1. Sites for insemination, 25% payment for semen	1. Semen purchase resources (75%), payment for veterinary services	1. No. of animals cross-bred
	2. Community members' availability, Implementation of fire plan	2. Facilitation of meetings, supervision/ monitoring of implementation	2. Area (ha) where fire management plan has been implemented
	3. Land, availability of community members for meeting, fodder planting and maintenance	3. Seed sourcing, meeting facilitation, supervision/monitoring of implementation	3. Additional area (ha) under mixed farming
	4. Land, site selection. 25% contribution on seeds	4. 75% contribution on seeds, technical guidance on seed sourcing, management support	
	5. Hoes, pangas, manpower, local labour	5. Saws, expert labour, supervision/ monitoring of implementation	5. Area (ha) where unpalatable colonizers have been removed
	6. Availability of cattle keepers, 25% contribution towards tours	6. Meetings facilitation, tour facilitation (75 %), payment of social worker	6. No. of sensitization meetings; No. of farmers that are reducing cattle heads
	1. Land, community members availability	1. Meeting facilitation, technical supervision of construction	1. No. of watering points relocated
	2. Excavation of water lines, tanks	2. Power (rural electrification), pipes, tanks, technical human resource	2. No. of bulk transfer points developed; Litres of water transferred
	3. Land, hoes, manpower	3. Cement, sand, technical guidance on site selection and backstopping of construction activity	3. No. of more resistant watering points developed
	4. Hoes, spades, wheel burrows, manpower	4. Technical backstopping of construction	

1. For each problem, the numbering corresponds in all the header lines e.g. in the soil and water erosion problem, opportunity 1 has action 1, resources 1, community contribution 1, external contribution 1.
2. Community financial contribution is necessary to motivate ownership of activity (Note: percentage contribution needs to be agreed upon).
3. External supervision/ monitoring of activities is necessary because community members may not have adequate knowledge to determine if technology will produce the desired results or long term objectives.

New land use plan

Details of the new land use map will be generated with the participation of the community members.

Lessons learnt and best practices

This section is an extract of combined lessons learned from all the six districts:

1. Involvement of local leaders is a key for the success of any community project. Their help in mobilization of farmers, encouraging farmers' participation, site selection and resource mobilization, is to be highlighted among other factors that were important for project success.

2. Farmers have indigenous agricultural knowledge, skills and experiences. If supplemented by SLM facilitator's relevant technical information, they are a vital resource for successful implementation of SLaM activities. This was made evident in the way that farmers (and wider communities) made significant contributions towards the watershed planning and mapping discussions.

3. The farmer to farmer approach through farmer field schools (FFSs) is very important for the adoption of sustainable land management practices among farmers. Unlike the formal agricultural extension approach, which views the extension officer as the dispenser of agricultural knowledge, the FFS approach appreciates the knowledge of farmers and their ability to solve their own problems. When preparing land use plans, it is useful to ensure that farmers within the same locality are allocated similar enterprises so as to share knowledge.

4. The watershed mapping done at the beginning of the project was invaluable, since it formed the baseline upon which the project activities at sites in the landscape could be evaluated to determine project impact.

5. Enabling policies and regulations are important for the development and implementation of action plans.

6. Existing land tenure regimes and good governance within a specific area greatly influences the level of adoption of developed plans.

Conclusions

Implementation and adaptation of sustainable land and agro-ecosystem management (SLaM) practices depend on the willingness of individuals within the selected watersheds. In reverse, land use planning requires enterprises and technologies which should be systematically allocated in areas where they will most benefit a whole watershed. The enterprises and technologies need to be adapted to the local context and built on local knowledge, experiences and innovations of the farmers and livestock keepers. They should also meet the demands of the wider community and external users of the resources.

Recommendations

Farmers should be trained in farm planning as an aid in SLM. This can also be further developed in community farming plans to provide a consolidated approach to sustainable use of natural resources within each community.

Action plans must have timelines. It is therefore important that funds for implementing the selected activities be released on time. Budgets associated with the various action plans should be revisited at least once a year, to ensure that the prevailing inflation is built into the budget.

In addition to community planning, the plans developed should be linked to sectoral plans. This is because some of these plans require transboundary linkages since some of the challenges encountered are transboundary in nature (e.g. animal movement).

2.4

Importance of land-use planning in supporting sustainable land management – Ngara District, Kagera Region, Tanzania

Author: Philip Illeta

Affiliation: Executive Director's Office of the Ngara District, Tanzania

Summary

With the increment of land related conflicts, the importance of cross-sectoral and integrated land-use planning (LUP) is increasingly recognized in Tanzania. This paper presents the Kagera TAMP implementation of Participatory Village Land Use Plans (PVLUP) process in the Ngara District. The paper describes the collaboration established and the district, village, and field level methodology used to issue Customary Certificates for the Right of Occupancy to beneficiaries. The paper also depicts the importance of capacity building and continued land resources studies, and recommends increased local level institutional coordination and sensitization campaigns so that the methodology is further scaled up.

Key words: Participatory Village Land Use Plans, Customary Certificates for the Right of Occupancy, planning, participatory methods, participatory land use management.

Introduction

With a growing population and economy, Tanzania has been experiencing land management challenges due to uncoordinated expansion of different land uses and the overlapping of new land development plans and priorities. The importance of cross-sectoral and integrated land-use planning (LUP) is increasingly recognized by all stakeholders in Tanzania - at grass-root, districts and regional levels - as more conflicts regarding land use occur.

Historically, the major land use problems emerged in the aftermath of ethnic conflicts in Rwanda and Burundi when the district hosted a large population of refugees with their livestock from 1994 to 1997. At the time, the refugees outnumbered the resident population by two-third (refugees 558 000; local population 220 000) according to a UNHCR Report of 1996. In mid-1997, about 400 000 Rwandese refugees returned home while 150 000 Burundi refugees remained for another ten years before returning home in 2007. However, large numbers of livestock were left in Ngara, to be looked after by close relatives.

The serious negative environmental impacts of the refugee influx exacerbated the land use management problems in the country, such as: acute deforestation; changes in traditional land use systems; soil erosion; destruction of water sources; overgrazing; encroachment of protected areas and illegal game hunting. Conflicts between farmers and livestock owners also increased tremendously and resulted in loss of many human lives, damage to properties and killing of livestock by rival communities. About 72 villages in Ngara District bordering Rwanda and Burundi were the most affected.

As a response to these challenges, Ngara District in Kagera Region began in 2005 the implementation of Participatory Village Land Use Plans (PVLUP) in-line with the national vision.

Participatory Village Land Use Plans (PVLUP)

The Ngara District's need for participatory village level land use planning is consistent with the District Annual Development Plans of 2005 and onwards as well as the Medium Term Expenditure Framework (MTEF) between 2005 and 2015. The PVULP strategy conforms with national policies and existing legislation, including: the National Environmental Policy (2004); the National Land Policy (1995); the Land Act (1995); the Village Land Act (1999); the Village Land Use Planning Act (2007); the National Land Use Dispute Legislation (2002); and numerous other environmental sector laws in forestry, agriculture, wildlife and livestock management.

The objective of participatory land use planning is to achieve sustainable land use that is socially just and desirable, economically viable, environmentally sound and culturally and technically compatible. It sets in motion social processes of decision-making and consensus-building concerning the use and protection of private, communal or public land (GTZ, 2010).

In these three years between 2011 and 2014 the district managed to establish VLUP plans in eleven seriously affected villages out of a total of 72 villages. This has been achieved first by Kagera TAMP and thereafter the district managed to secure co-funding from other development partners as shown in Table 1.

Name of project	Villages involved	BUDGET - $
Kagera TAMP	*Rusumo, Kasharazi*	5 500
Local Government Capital Development Grant (LGCDG)	*Kasulo,Ntanga, Murubanga, Kumubuga*	8 600
Property and Business Formalization Program (MKURABITA)	*Buhororor, Munjebwe*	30 000
CONCERN NGO	*Muganza, Katerere, Mukalinzi*	20 600

Table 1: Facilitation of PVLUP by various projects in Ngara District 2011-2014.

Methodology

The key strategies used in the implementation of PVLUP were capacity building of district and village level teams through sensitization workshops and practical hands-on training on land use planning and management procedures as well as on supporting legislation to improve performance.

District level

The District Council Planning, Economic and Environment Committee and the Council's Management Team benefited from one-day workshops. In addition to 40-50 participants, the councillors and heads of all departments in the district also attended the workshops. These committees have the function to discuss and endorse the Participatory Village Land Use Management (VLUM) plans upon their completion. The training was performed once by Kagera TAMP in 2011 and later by MKURABITA in 2013 when obtaining Customary Certificates for the Right of Occupancy (CCRO), a land title deed for the farmers, was included in the PVLUP process for the first time.

An important output from this workshop was the selection and formation of the District Participatory Land Use Management (DPLUM) team. Following the one-day workshop, a team of ten technical staff was selected for a further four days training on the following disciplines: land, natural resources, environment, agriculture, livestock, planning, water, legal affairs and community development. This group of experts performed a leading and facilitating role in the establishment process of PVLUM in all the eleven villages.

Village Level

Short-duration training workshops of one to two days were conducted at the target villages. These workshops were focused on building the capacity of village councils and village land committees on land use legislations and procedures for PVLUM planning. Between 35 and 40 members from each village participated in the workshops. It was considered very important to internalize these sessions, because the village leaders are expected to lead the planning process and explain all the contents during public meetings.

Field activities

The methodology used for VLUP consisted of six to eight steps depending on facilitators' choice and the process used the main principles of VLPA (Village Level Participatory Approaches). The main activities in the village included the following (adapted from the LADA local level assessment approach):

- Collecting and reviewing baseline information (existing institutions, leadership, education, population, main activities, maps, crops, livestock, soils, vegetation, etc.);
- Conducting transects walks across the village to cover all existing land use types;
- Participatory identification of major problems, obstacles and opportunities for development in the villages;
- Formulation of strategies to address the identified problems;
- Establishment of Community Action Plans (CAP) of short, medium and long (ten years) term;

- Obtaining GPS coordinates for various land use boundaries, water sources and village centers for map drawing;
- Preparation for village assembly meetings to discuss, amend and endorse the land use plan.

Results and achievements

A total of 440 village council and village land committee members were trained who subsequently led the formulation of VLUP in their respective villages. The discussions were participatory, involving the trained officials in public meetings from sub-village levels to general assembly meetings, notably:

- The participatory land use management (PLUM) team succeeded in compiling all necessary data and prepared eleven village land use reports with maps indicating various land uses proposed and agreed upon for current and anticipated use (ten years). The types of land uses identified includes areas for agriculture, settlements, livestock grazing, wetlands, village institutions, village centres and open spaces. Others were village forests, hills and buffer zones for all natural water sources such as springs, dams, streams and rivers.
- Ten district PLUM teams gained more knowledge and skills to conduct village land use planning, GIS applications and Customary Certificates Right of Occupancy (CCROs) issuing procedures.
- In the six villages that completed the process of issuing CCROs, a total of 60 villagers and ward team members were trained to undertake land measurements on their own using GPS and compilation of field data as part of the adjudication process of land parcel.
- A total of 1 500 CCROs have been issued to-date to farmers in the involved villages (over a period of two years). The initial target was to offer 3 000 CCROs. This represents 50 percent achievement.
- Women from all the villages have been attending in large numbers to enquire about land title deeds and have been empowered to claim them unlike in the past system of customary land ownership. Among the 1 500 CCROs already issued, 300 belong to women, 600 CCROs to both spouses and 600 to men alone.

- A reduction of land conflicts was noted by 75 percent using local level teams for mediation and finally agreeing on disputed boundaries before official mapping procedures commenced.
- The district obtained modern computer hardware and software for preparation of land-use planning maps, CCROs and color printing devices. Office cabinets for safe keeping of copies of all CCROs have also been obtained. This is a leading step towards establishment of the District Land Registry.
- More people from other villages have been sensitized to apply and contribute money to enable formal procedures to begin to demarcate their land plots and for CCROs acquisition. The district Land and Natural Resources Department is now capable to offer this service upon availability of operational funds.
- An increased market value of land plots have been observed upon CCROs issuance.
- Ngara District PLUM Team outreach consultancy services. Five members of the Ngara PLUM team on different occasions were invited to conduct training of PLUM teams and facilitate land use planning establishment in two village of Kitongosima and Shinembo in Magu District Mwanza Region (June 2013) and two villages of Nyabusozi and Isambara in Biharamlo District (Sept 2014). In these villages, a total of 750 farm plots were demarcated, plotted and issued CCROs.
- As a result of the planning, some pasture improving SLM technologies were applied after enclosing two degraded village sites covering a total area of 52.5 hectares in Kirusha and Rusumo. The practices involved among others, reseeding with pasture legumes and palatable grass species (Figure 1), contour planting with Napier grass, boundary planting with *Ficus* spp. cuttings (Figure 2) and *Dodonea viscosa* (sticky hop bush). Also, grass strips, stone lines and storm-water diversion ditches for control of soil erosion along cattle tracks and paths were established. The initial results are promising. There is remarkable improvement in productivity, restoration of vegetation cover, recurrence of threatened grass species mainly *Cynodon* spp. and *Bucharia* spp. that were few in the baseline survey. Livestock keepers have become vigilant to take responsibility in monitoring dry season bushfires and imposing penalties to unauthorised livestock grazing.

Figure 1: Reseeding natural grassland with fodder and legume species, Rusumo, Ngara.

Figure 2: Boundary planting to create livestock enclosures.

Lessons learned

- Village participatory land use planning (VPLUP) has generated data that can be used as baseline and tool for planning future programmes.
- VPLUP enhances ownership of lands parcels and implementation of the community planned activities.
- VPLUP assists to build cooperative spirit among community members. This has facilitated formation of effective and functioning associations/ cooperatives movements/common interest groups per each land use type existing in a particular village.
- VPLUP enables the strengthening of focused extension service delivery mechanisms, which improve crop and livestock production, natural resource conservation and thus promote sustainable land management ethics/ practices in community mindsets.
- VPLUP has contributed towards improved resources utilization, poverty reduction and rural development. Diversified income generating activities ranging from beekeeping apiaries, zero-grazing and fodder production have started to utilize the vegetative resources available in conserved rangelands and natural forests in Kagera TAMP project sites of Rusumo and Kirusha villages.
- Land use planning is an important policy issue whereby local communities should be guided in a timely manner to apportion appropriate land parcels for various land uses that exist. This has to be done before the emergence of major land use conflicts in order to avoid unnecessary catastrophes.
- Village by-laws are a central component of the PLUP process because they give the land use plans a legal basis for enforcement. This enforcement component is essential because, inevitably, both villagers and outsiders may violate the provisions of the land use plans from time to time.

Figure 3: Project sign board publicizing SLM technologies to restore degraded grazing lands.

Issues and challenges encountered in village land use planning

Low attendance in public meetings

- The attendances in the village community meetings were not good in the early days of the project. These accounted between 30 to 45 percent in most of the villages. In total, four out of the original ten village meetings were postponed or scheduled for other days. Additional mobilization using local methods were utilized, such as drums. Good attendance is important for undertaking important decisions.

Competing needs for land use

- In Rusumo village, land areas were already allocated to various uses in the past and therefore no land was left for communal use and other important public utilities. This will automatically limit investments from newcomers. Even in the other nine villages, there are only small portions of land left as a land bank.

Corruption and lack of transparency

- Low awareness on land legislations and perceived corruption exist on the part of village leaders during land allocations, especially for new settlers. There is no adherence to good standards for land allocation as stipulated in the laws.
- Lack of and unavailability of land allocation records at all village levels. These include copies of minutes for village meetings and copies of allocation documents.
- High cost can be reduced by involving more villages in the process. Developing PVLUPs may not be of much help for a single isolated village basing on the fact that land and other natural resources are normally shared by adjacent and even distant communities. More impact would inevitably require involving more villages in planning and benefits sharing.

Recommendations

To address some of the challenges in the implementation of PVLUP based on lessons learned, the following are therefore recommended:

- Access to capital by villagers/ farmers is best facilitated when the Customary Certificates Right of Occupancy (CCRO) has been acquired.
- There is need for projects other than Kagera TAMP to integrate SLM issues to improve productivity and environmental management.
- It is not feasible to leave the administration of VLUM plans solely to village leaders, without close follow-ups. This requires a strong district intervention because of rampant corruption and low capacity at lower levels to administer the required legislations.

- The village land committees' capacity should be enhanced from time to time and tasked to manage all land allocation issues.
- Kagera River Basin communities should be regularly sensitized on the importance of participatory land use planning for sustainable management.
- The land use planning at national levels has to conduct cost-benefit analysis and environmental impact assessments to identify the feasibility of retaining some of the nature reserves and recommend how best to utilize the existing resources to contribute towards boosting the development of adjacent communities.
- Land suitability studies have to be done to show the potential and limitation of land resources for various uses. This information is important but is not available to assist decision makers and planners to select and put in place appropriate land uses in various parts of the Kagera Basin.

Soil erosion control: terraces, ditches and vegetative strips combined in Karambo and cattle track rehabilitation in Gatebe II micro-catchments, Rwanda

2.5

Author: Emmanuel Muligirwa

Affiliation: Kagera TAMP project staff

Soil is a living ecosystem, and is a farmer's most precious asset. A farmer's productive capacity is directly related to the health of his or her soil

Howard Warren Buffett

Summary

Karambo and Gatebe II micro-catchments are two of the project implementation areas, targeted due to the severity of land degradation. One is upstream in the Northern Province with predominantly mountainous terrain; and the latter is downstream in the Kagera River Basin in a low gradient hilly terrain bordering the Kagera National Park in the Eastern Province of Rwanda.

These sites are severely affected by soil erosion in the micro-catchments. This has affected the wider watershed and the Kagera River. Using a participatory catchment management approach the project led a community-based intervention which included constructing terraces in the Karambo project site; and rehabilitating cattle tracks in Gatebe II to halt and reverse the effects of erosion and restore the productive capacity of the soils. Rehabilitation was a community level activity realised through hoes, shovels and pick axes for the more rocky terrain.

Key words: soil erosion, fertility, bench terraces, cattle tracks, ditches.

Introduction

Karambo micro-catchment

The site is characterized by rocky soil types at the summit, with sandy loam soils across the steep hillsides. The soil is characteristically red rather than reddy brown, an indication of the level of degradation and reduction in humus content. With long term poor land management and agricultural practices, the area has been exposed to severe erosion resulting in low yields, increased runoff and sedimentation of the stream in the valley below. The sedimentation affected the quantity and quality of portable water available for community use. Through the engagement of the local community members, in 2012 Vi LIFE (a local service provider) identified the following as remedial measures for the identified priority land degradation issues:

- Construction of radical/bench and progressive terraces;
- Planting agroforestry trees along the contours as well as grass strips to strengthen the terraces.

Bench or radical terraces were constructed to control soil erosion by controlling runoff. The steep slopes were converted into a series of steps, with horizontal ledges (benches) and vertical walls (risers) between the ledges.

Gatebe II micro-catchment

The site experienced rapid influx of settlers and resultant human influence following refugee settlement in the de-gazetted Kagera National Park after 1994. The area experienced a rapid decline in soil fertility. This is attributed to land use conversion from savannah forest to crop land. With the increasing frequency of long droughts, the removal of vegetation cover and expanding cattle tracks, the land has been exposed to greater degradation, particularly rill and gully erosion. The proximity of the settlements and demand for fuelwood has also led to park encroachment. However the impacts of increased agricultural and livestock activities on ecosystem degradation was not immediate, but was registered much later as the pressures increased.

The diagnostic analysis undertaken by CSDGIS (2012) identified the following as some of the proposed remedial actions:

- Improving soil conservation measures including gully control technologies and establishment of demonstration plots for learning and capacity building;
- Reducing pressure on wood resources and vegetative rehabilitation through forest plantation in the buffer zone within the Kagera National Park;
- The planting of agroforestry species in crop land.

The project applied a participatory approach involving local communities and local NGOs as service providers. They were mandated to undertake interventions in response to the priorities as indicated by the catchments' local communities. The interventions included the following: construction of terraces and water trapping pits, incorporating vegetation strips; rehabilitation of the degraded cattle tracks and construction of infrastructure to check the runoff. This would further reduce soil erosion and halt gully creation.

The aim of the project was to modify the factors accelerating the erosion process by reducing the influence of poor cropping and land management practices. The interventions would also address slope steepness and effects on runoff and soil deposition in floodplains and water courses.

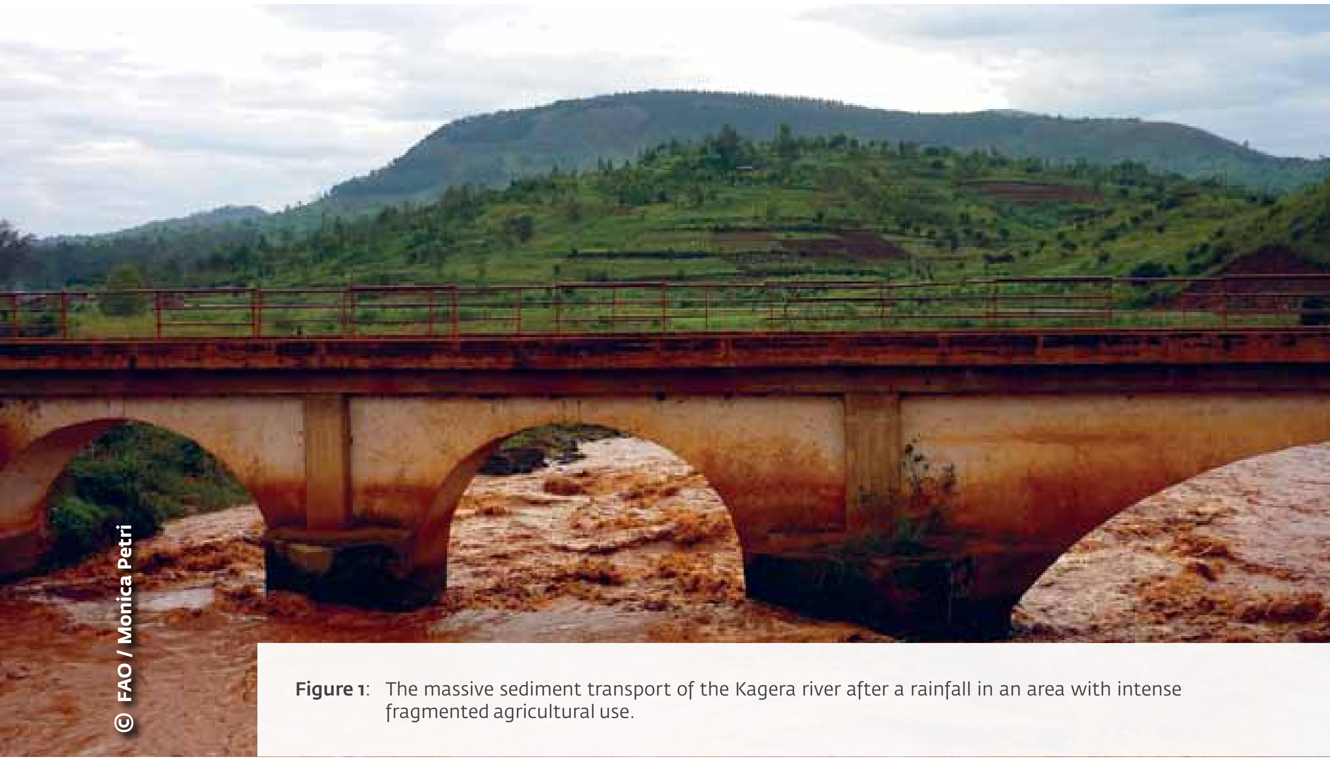

Figure 1: The massive sediment transport of the Kagera river after a rainfall in an area with intense fragmented agricultural use.

Project methodology and interventions

Through a participatory land degradation assessment of the micro-catchments with farmers, the project established priority issues and corresponding remedial measures to be implemented. The participation of local communities gave context and credence to the resultant list of proposed activities.

The community in Karambo identified and ranked the issues according to their perceived importance and also made representative sketch drawings of the environmental problems before and after the implementation of sustainable land management (SLM) approaches and technologies.

The resulting problem ranking was a compilation of local community members' perspectives of what their priority issues were (Figure 2). The community drawings (Figure 3 and 4) on the other hand was representative of the degraded state of their environment ("before" scenario); and the results of SLM implementation ("after" scenario). The adjacent hillsides to the stream at the valley bottom were illustrated as the top and bottom sections of the drawing, separated by the "Umurindi" river in the middle.

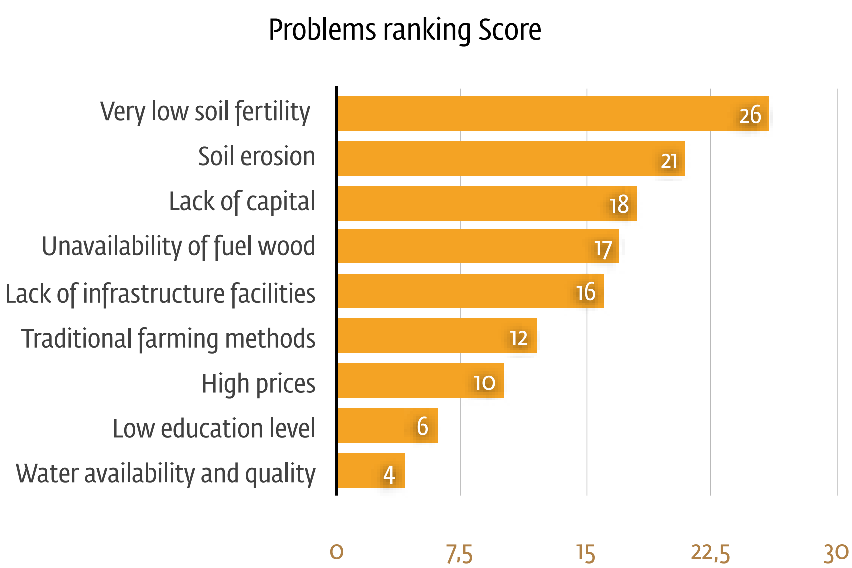

Figure 2: Problem ranking by the local community members in Karambo (Vi Life, 2012).

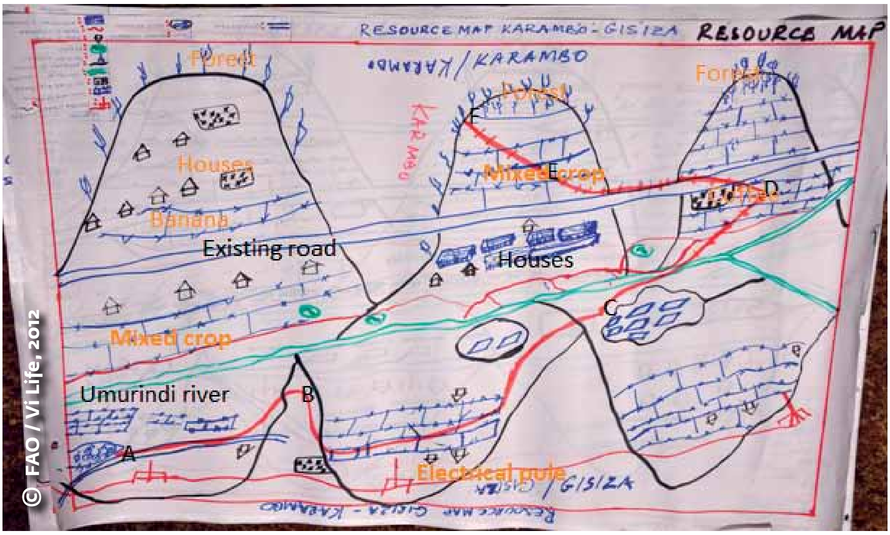

Figure 3: Local community members' representation of the baseline situation.

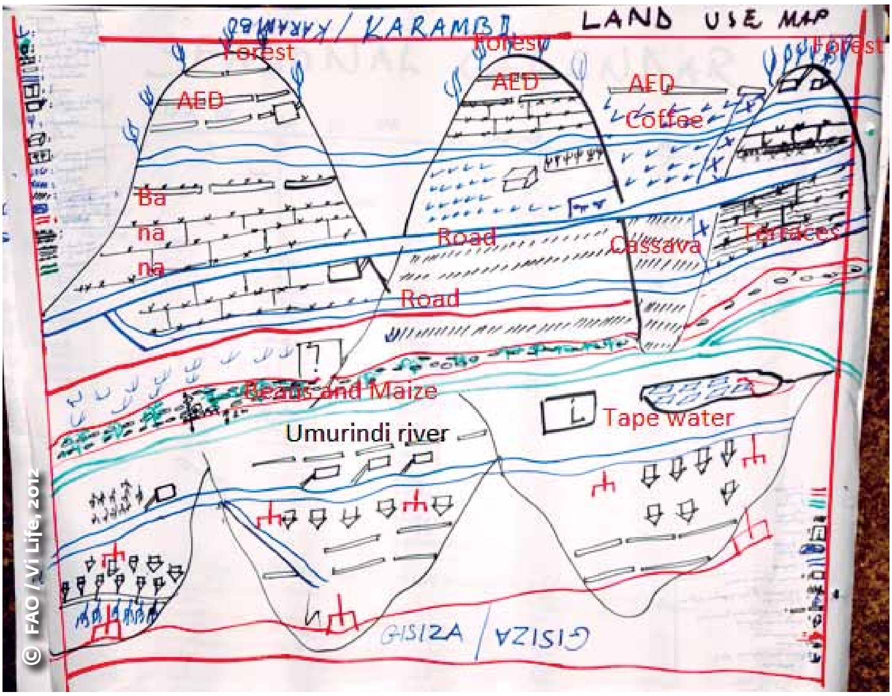

Figure 4: Local community members' representation of the micro-catchment after SLM interventions.

Terracing in Karambo micro-catchment agricultural hill slopes

Terraces were constructed to intercept and reduce rainfall runoff. They would also decrease the steepness of the hill sides and reduce soil erosion. In addition to erosion control, the bench terraces retained rain water allowing gradual percolation into the soil without structural damage. The risers and edges of the terraces were planted with Napier grass and *Calliandra* spp. for structural support, runoff control and as fodder for the FFS group's piggery unit (Figure 5). The terraces stored much runoff and released it at very low rates. By this, there was a significant reduction of the down-slope erosion and surface soil damage.

Figure 5: Bench terraces with Napier grass and water retention pits.

The grass strips (hedgerows) were intended to trap sediments and doubled fodder for livestock.

Ditches in Gatebe II micro-catchment cattle tracks

The rainfall infiltration rate on the exposed ground (tracks) had reduced over time due to the process of continued compaction by animal hooves. In some parts of the micro-catchment, this crusting of the soil contributed to the increasing run-off rate, sheet erosion which developed into rill and later gully erosion (Figure 6).

Figure 6: : Cattle track before intervention.

Figure 7: Cattle track after rehabilitation.

The expansion of cattle tracks in Gatebe II was stopped from transforming into gullies through the construction of water retaining and runoff controlling ditches. The ditches were constructed in parallel lines across the tracks and placed alternately from line to line, for effective run-off control (Figure 7).

Results

Terraces

Irish potatoes were previously not cultivated due to the terrain conditions - the slopes were steep and rocky and difficult to cultivate on. Following the intervention, the farmers were able to cultivate Irish potatoes for the first time in the catchment area. Table 1 illustrates the contribution of the terraces to Irish potato yields on three 500m² plots under different SLM and soil fertility management approaches during the September 2013-February 2013 planting season.

Plot No.	SLM Techniques Applied	Results
1	Terraces with fertilizer application and strip cropping	Yield of 1 504 kg (18 January 2013)
2	Terraces without fertilizer application and planting in the traditional commonly used random manner	Yield of 1 024 kg (25 January 2013)
3	No terraces, no fertilizer application and random planting (the control)	Yield of 600 kg (30 January 2013)

Table 1: Irish potato yields under different SLM technologies.

In addition to the contribution of terraces on the productivity of the slopes, the combination of bench terraces with ditches and vegetative strips yielded the following results:

- Enhanced agricultural production: the benches increased the arable and workable land through a slope reversal along the entire slope (5 hectares in area). Reduction in run-off facilitated the successful application of inputs, unlike in the past when the inputs were often washed-off down the steep slopes during rainy seasons. The terraces also promoted sustainable farming on the slopes.
- Risk reduction: the stabilising of the slopes and reduction in erosion has reduced the risks of landslides, subsequent crop and fertile top soil loss. With sustainable productivity it is anticipated that farmers will become more food secure.
- Protection of natural resources: the technologies contributed to the prevention of further land degradation, controlled runoff and increased water retention after the rains.

- Economically viable: the value addition investment to the land contributed to the increase of income generation activities for the farmers. Although the investment costs outweighed the returns in the first years, the increased degree in productivity over the years will pay-off on reduced investment in infrastructural maintenance.
- Crop diversification: the increase in yield per unit area on the bench terraces is promoting crop variety, rotation and the marketability of the various crops.
- Capacity enhancement of farmers: there is increased appreciation and adoption by local community members of the SLM technologies within and outside the FFS groups, thereby covering the wider catchment.

Cattle tracks

Observable environmental and landscape restoration has been achieved. Furthermore, the cattle tracks increased compliance of sustainable land use in the Kagera buffer zone - a restricted agricultural and livestock production zone in the catchment. The benefits of the anti-erosion infrastructure include:

- reduced sediment transfer;
- improved water infiltration which supports colonisation and regeneration of vegetative cover by indigenous plants; and
- halting in the formation of gullies.

Analysis (impacts, lessons learned and constraints)

Although terraces are reported to have a negligible influence on the crop yields, they have a major effect on sediment delivery at the slope level. Although the farmers appreciate the results, they still require assistance to scale-up and out the technologies and increase the wider micro-catchment community uptake. The major hindrance to this achievement is the cost of construction of bench terraces, which is estimated at 3 000 – 3 500 $ per hectare, depending on the terrain conditions, material and labour requirements.

The outcomes of the SLM interventions point to other areas to be considered in scaling-up and out of the objectives of the project:

- Mindsets: A farmers' knowledge gap analysis and a baseline survey before the SLM implementation is important. This will identify opportunities for more effective adoption and uptake of SLM applications.

- Skills level and capacities: it was observed that the farmers depended on knowledge transferred by the FFS facilitators and service provider field staff. These facilitators influenced the degree to which FFS groups take-up the SLM lessons from the study plots, hence there is need to regularly carry-out refresher training tailored to increase SLM technology adoption and uptake.

- Collective response: it is important for the farmers to understand their stake and role in the adoption and scale-up and out of SLM technologies and approaches. Some farmers still associate project interventions with financial assistance. Although they appreciate the knowledge enhancement received, they still prefer to obtain capital contributions for their agricultural activities. The beneficiaries should be guided in understanding the communal and wide-scale impact of soil erosion. They should also be guided to appreciate the potential of gaining shared benefits through concerted efforts to control erosion and enhance productivity.

- Costs of technologies: the initial cost of bench terrace construction is quite high and cannot be easily borne by the farmers. This limits the level of adoption and scaling-up, even though the impacts on agricultural productivity are evident and appreciated.

- Policy influence: the national policy on land consolidation ensures wider provision of extension services to farmers and delivery of subsidised inputs. Facilitating project beneficiaries in FFS groups set up to undertake SLM activities reduces the required initial investment costs, thus contributing to the adoption and scale-up and out of SLM technologies.

- District plans: harmonising project SLM interventions with district development plans accelerates the scale-up and out of appropriate SLM technologies and approaches. The district budget allocation for soil erosion control activities ensures wider implementation coverage and human resources. Districts in such cases effectively co-fund project interventions and undertake joint implementation of activities with a common SLM adoption goal.

Conclusion and recommendations

Although there are observable positive results in the implementation and adoption of SLM technologies at farm and slope levels, the following should be considered in enhancing the scaling-up and uptake of these applications.

- Terrace construction costs are quite expensive for the farmers to adopt such a technology. Such constructions should be restricted to areas where slow-forming progressive terraces or grass bunds would be less effective in soil erosion control.
- More radical / bench terraces should be constructed when they have the potential of improving farmers' livelihoods, increasing their resilience and production systems on steep slopes and protecting downstream infrastructure.
- In addition to combining terraces, water retention ditches and grass strips, approaches such as conservation tillage should be used between terraces to further reduce soil erosion and enhance soil functioning.
- The maintaining and repairing of the terraces should be handled by the farmers and should focus on sustaining soil and water management and hence productivity over time.
- Bench /radical terraces should be protected, especially in the first two years of their establishment. Risers should be planted with grasses or shrubs, which could be managed as fodder for livestock.

Stabilizing riverbanks using bamboo

the case of the Kayokwe-Waga-Ruvyironza watershed complex

2.6

Author: Léonidas Nzigiyimpa

Affiliation: Conservationist in charge of protected areas in southern Burundi

It is better to break a rule of grammar three times than to break that of nature just once

Carl von Linné (1907 – 1778)

Summary

Serious land degradation in Burundi and in the Kayokwe-Waga-Ruvyironza watershed (part of the Kagera Basin) has led to scarcity of natural resources and to food insecurity. This degradation is primarily caused by erosion, water pollution and loss of fertility. In an effort to remedy the situation, bamboo has been planted along a 37 km stretch of Kayokweone, Kayokwe, Waga and Ruvyironza Rivers. This initiative had positive ecological and economic effects. Communities have adopted this new technology which not only plays a role in protecting the environment but also contributes to diversifying sources of jobs and revenue.

Key words: bamboo, riverbank protection, soil erosion, buffer zone, ecological functions.

Introduction

Declining soil productivity due to land degradation has led to food insecurity and chronic malnutrition. The loss of productivity provided the impetus for farmers to use sustainable land management measures. These measures include: integrated watershed management; integrated crop, forestry and livestock system; community management of woodlands; planting along contour lines; use of improved cooking stoves; agroforestry; protection of buffer zones and stabilization of river banks using bamboo.

Bamboo are a group of flowering, perennial, evergreen plants which grow in the tropics and semi-tropics. Bamboo (Bambusa spp.) has hollow woody-walled upright stems with ringed joints and edible young shoots. Bamboos originate in tropical Asia and are some of the fastest-growing plants in the world. This taxon has two methods of reproduction: sexual reproduction characterized by dense but infrequent fruiting and vegetative reproduction (asexual).

The Kayokwe-Waga-Ruvyironza River complex is formed by two hills called the Nyakibari and Magamba. The Nyakibari Hill is situated in the municipality of Kayokwe, in Mwaro province, while the Magamba Hill is located in the municipality of Nyabihanga in the same province. This region records precipitation of between 1 300 and 1 400 mm and average temperatures of between 15 and 17 °C. The two hills are in the natural region of Kirimiro. The altitude at this site ranges from 1 590 to 1 650 meters.

The challenges facing the watershed (Figure 1) include the following: overgrazing – which causes soil condition modifications and massive erosion; land conflicts – due to demographic pressure; scarcity of land; accelerated degradation of natural resources; recurrent bushfires; uncontrolled quarry extraction and failure to restore open digs; poor agricultural practices (uncontrolled slash and burn farming, steep up-and-down slope cultivation); and low adoption rates of soil and water conservation practices.

Planting bamboo along the banks of watercourses by the Kagera TAMP aims to stabilize the banks and halt soil degradation. The planted bamboos also serve as an additional source of revenue for households. The species *Bambusa vulgaris* was selected because it shoots more easily than other species and grows very rapidly.

Figure 1: Satellite image of the Kayokwe-Waga-Ruvyironza area (source: Google Earth).

Methodology

Community-based strategy: The river bank stabilization initiative was the result of a concerted effort of managers who outlined a framework for dialogue with representatives of local communities, technical staff from the Provincial Directorate of Agriculture and Livestock (DPAE), forestry services, the territorial administration, community groups and organizations. This community-based strategy has enabled activities to be regularly fine-tuned while work is being undertaken to strengthen accompaniment by and involvement of partners and beneficiaries. The strategy makes it possible to make visits and inquiries as well as to allow for partners to express their views.

Delegating activities for producing and planting bamboo to the direct beneficiaries has strengthened participatory management and given greater accountability for the management of the entire technology package to the grassroots technical services and farmer field schools (FFSs).

Work related to nurseries and planting was carried out by following the high labour intensive (HIMO) approach during the forestry seasons 2012-2013 and 2013-2014.

Multiplication of Bambusa vulgaris: The multiplication technique for Bambusa vulgaris consists of cutting sufficiently mature stem containing several internodes. A clean hole is made in the middle of each central internode for a cutting with four to six internodes. Next, the prepared stem is placed in and covered with soil. Open internodes are carefully left uncovered (Figure 2). The cuttings are then watered twice every day to the level of the open holes in the internodes until green shoots appear. Adopting the technique of making openings in the internodes will be successful so long as watering is done regularly. The new shoots appear in less than two weeks and start to grow rapidly.

Figure 2: Prepared cutting and covering with soil up to the internodes.

Between 2012 and 2013, 76 000 bamboo plants were produced in a nursery by the Kagera TAMP in the Nyakibari valley in the municipality of Kayokwe (Figure 3: A and B). The rate of germination for *Bambusa vulgaris* was 86 percent. Such multiplication phase was a valuable experience for communities who came to learn the new technique of bamboo planting material preparation by cuttings. Previously, people used rhizomes which were dug up at great effort to start a new plantation. Besides degrading the environment, the former technique did not produce large new plantations partly because extracting the rhizomes is extremely difficult and partly because of inefficient transport - carried on men's heads over long distances.

Planting bamboo: The seedlings produced were transplanted along 37 km of the banks of the Kayokwe, Waga and Ruvyironza Rivers and planting at a spacing of between two to five meters, depending on the riverbank condition (Figure 3: C). This technique goes hand in hand with legal provisions of the water code which stipulates that a five meters buffer zone be left on each side of a watercourse. It is prohibited to conduct any farming activity within this zone. In addition, the participating communities benefited from more than 1 200 seedlings which were planted on their private property.

Figure 3: Bamboo multiplication [A. Preparation of cuttings, B. Watering, C. Digging of the planting holes and plantation, D. Young bamboo stands on the banks of the River Kayokwe].

Results

Beneficiaries: In total, eight FFSs and their 284 members directly benefitted of this activity. The beneficiaries include four FFSs in Nyakibari and four FFSs in Magamba. A total of $17 500 was invested in the project and 284 households benefited from cash revenues.

Strengthening capacities: Two hundred and eighty-four FFS members were trained in the field on multiplication techniques for bamboo. Of these, 60 percent were women and 40 percent were men. In addition, before the activities started, 80 representatives from grassroots administrative authorities and field technical services took part in a workshop to raise awareness about bamboo's ecological and economic importance.

Creation of a buffer zone: After planting the bamboo, farmers no longer cultivate crops up to the water's edge. They respect the bamboo plants and the buffer zone. This strip is now protected both by law and by local communities and provides habitat for riparian-specific plant and animal species.

Restoration of ecological functions: Planting bamboo stabilized riverbanks, contained rivers in spate through the plant's interlaced roots and reduced erosion. The plants also provide a more effective windbreak than a classic hedge (Figure 3: D) and contribute to oxygen renewal at a rate 35 percent higher than *Eucalyptus*[2] spp. Several species of birds have returned, finding it a suitable habitat to build their nests. Situated at the interface between land and water-based habitats, the restored buffer zone of the watercourses once more perform the valuable function of filtering and trapping sediment and dissolved pollutants transported by those sediments.

An available resource: The culms of the cultivated bamboo plants are used as fuel and construction materials. Bamboo's kilowatt hour (kWh) yield is 20 percent greater than that of resinous wood (see web links in footnote).

Bamboo also offers an excellent substitute for timber reducing the rate of cutting wood from over-exploited forests, grows without fertilizer or pesticides and can be harvested after an extremely short growth cycle of three to five years, compared with ten years for eucalyptus (see web links in footnote).

Increased revenues: Planted bamboo is an important source of revenue. The bamboo culms are cut at maturity and sold to processing units in Gitega and Bujumbura as well as to neighbours wanting to build fences or houses and for a wide range of other purposes. Each clump of bamboo produces an annual average of ten culms measuring four meters. After taking into account the cost of cultivating bamboo and commercializing its products, the anticipated net profit for communities involved will be $76 500 per year, starting in 2016.

2 French - www.expocreative.com/lebambou.html.
English - www.inbar.int/news-category/summits/ethiopia-bamboo-rattan-green-economy-summit/page/2/.

Analysis of impacts, lessons learned, constraints and solutions

Impact

Behaviour change: Local communities are now aware of the problems of land degradation, which is why they readily adopted this new innovative technology. Besides stabilizing riverbanks, a share of the bamboo seedlings was also planted on household farm plots to widen the benefits of the plants.

Improvement of community livelihoods: The production and sale of bamboo culms generates significant revenues for households. These are used to pay children's school fees, healthcare expenses and to meet basic needs, including increasing food security.

Job diversification: In order to make this activity sustainable, ten young people will soon be trained at a unit specialized in processing techniques to make bamboo products. After training, these young people will be supported to set-up their own small-scale unit to make bamboo products.

Synergy for consolidating results: A valuable synergy has developed around this initiative to promote bamboo as a tool for stabilizing riverbanks. The launch of the bamboo planting programme by the Kagera TAMP was marked by the Permanent Secretary at the Ministry of Agriculture and Livestock in Burundi, the FAO Representative, the Governor of the Province of Mwaro, the administrators of the municipalities of Mwaro and many farmer beneficiaries. The occasion signalled ownership of the scheme from the highest level down to the grassroots. This synergy has made it possible to use and mobilize human resources, which would otherwise have remained unavailable. To strengthen the dynamic that has developed around this resource, a study visit to Rwanda is now being prepared so that beneficiaries can learn more from the experience of organizing the bamboo sector.

Lessons learned

A major awareness-raising campaign will be needed to further explain the importance of protecting buffer zones of watercourses to increase the understanding of local communities and to ensure their contribution.

The protection of 37 km of the buffer zone for this watershed is not enough to have a large impact on reducing soil and water degradation. It will therefore be necessary to continue planting bamboo on both sides of the watercourses for a length of at least 200 km.

Constraints and solutions

Some of the young bamboo seedlings were eaten by goats soon after planting in 2012. To protect young plants a fence of small tressed branches was erected around each plant. The damaged plants were replaced.

Bamboo can behave like an invasive plant, because the rhizomes can run several meters underground before a new shoot appears. This issue is all the more important given that the watershed is located in an area with high population growth, where the smallest plot of land is precious. However, it is easy to contain bamboo: it is sufficient to dig a small trench 20 cm wide and 20 cm deep around the space where the bamboo is planted.

Recommendations

Training DPAE technical services and FFS members who are direct beneficiaries in multiplication techniques for bamboo and training young people in processing and commercialization techniques for bamboo products are important to ensure long-term future of the sector. The project or DPAE technical services should launch one or more small-scale processing unit(s) as quickly as possible for processing bamboo products.

Conclusions

Bamboo has proved to be an important alternative resource in an area where deforestation and water and soil degradation are major problems. This project has acquired credibility because it has integrated and acknowledged the participation and know-how of technical services, community associations and partners in the planning process, implementation and monitoring and evaluation. Indeed, Kagera TAMP has encouraged people to go beyond their hidden or potential capacities and become the main actors in finding solutions for their own problems rather than aid dependence. However, the planting of bamboo along both sides of watercourses will need to be continued over longer distances if the scheme is to achieve the desired effect – the sustainable conservation of water and soil as precursors to food security.

Figure 4: Bamboo are being watered.

Figure 5: Bamboo are growing.

Conclusion Theme 2

Lessons learned from catchment planning

2

Management of land resources in an integrated manner is one of the key challenges facing the four riparian countries (Burunda, Tanzania, Rwanda and Uganda) of the Kagera River Basin. As such, the objective of this theme was to present attempts made by the Kagera TAMP in combining the catchment management planning and local governance strategies to promote integrated land resources management. With varying degrees of success, each of the six case studies presented from the four countries demonstrate positive outcomes on the interventions implemented, as well as providing useful lessons for improving similar projects in the future.

While the general principles of catchment management planning and local governance were demonstrated in all cases presented, the specific Kagera TAMP interventions and processes in each country were defined based on their local context. In some cases, the planning and implementation of the interventions were defined within the broader framework of integrated watershed management approaches, while others were undertaken from a more technological-based perspective.

For example, in Burundi and Tanzania, a broad and structured framework for participatory integrated watershed management was used to characterize the target watersheds for interventions that addressed the linkages between land and water degradation and livelihoods. In both countries observable outcomes were registered in terms of increased water levels, improved food security, reduced conflicts and fire incidences, thus confirming already known benefits associated with integrated watershed management approaches. Key lessons learned include the need for an inclusive participation of all stakeholders in watershed management, capacity building at all levels and partnerships.

In Tanzania and Uganda, participatory village land use planning (PVLUP) was used as an entry point to catchment management planning. This has helped to facilitate integration of government-endorsed participatory land use planning strategies into the catchment management planning process. Through partnership and multi-stakeholder capacity building of local government officers and village community groups, sustainable village land use plans were developed in Tanzania with potential to reduce land conflict by as much as 75 percent. The project has demonstrated that participatory land use planning can successfully be integrated into the catchment planning process.

In Rwanda, a more technological-based perspective was undertaken. Construction of terracing with other complementary technologies like ditches and vegetative strips for soil erosion control was demonstrated with promising results. However, the scaling up are hindered by the high costs involved in the construction of terraces. Therefore, it is recommended that bench terraces (radical) should be used in a restrictive manner, and to rather focus attention on wide application of slow-forming progressive terraces or grassed bunds.

Finally, the stabilization of over 35 km river banks in Burundi using bamboo has proved to have positive outcomes. An observable reduction of soil erosion was registered, along with return of several species of birds that originally use the area as habitats. Farmers are expected to make a profit of about $76 500 starting in 2016 from the sale of bamboo products. However, more awareness campaigns are still needed to enhance the local understanding on the importance of bamboo as a conservation technology.

The present conclusions can also be used to inform scaling-up as follows.

Collection of data and increased knowledge

The integrated watershed planning activity was based in various knowledge creation processes. Activities started by analyzing land degradation root causes including population pressure, fragmentation of land, overexploitation, land tenure insecurity, differential access to resources and low knowledge base to mention some. Also, these studies allowed exploring existing sustainable land management practices and building on local knowledge and innovation. By documenting best practices, an examination of what can be replicated, improved, and further developed was also done. Thanks to all these assessments, the planning phase showed how best practices can be put across at a landscape scale in the most economically and socially suitable manner. Finally, documenting costs and benefits also support investment' prioritisation by different actors and donors.

Participatory planning and learning to support community awareness

Within the same watersheds, it is important to rely on existing farmers groups. As the project had created various experiential learning groups (namely the FFS) with different enterprise focus, the awareness raising related to the ongoing planning phase was supported from the ground. Beneficiaries were able to share on how they can benefit from restoring their ecosystems and achieving higher productivity. This finally allowed a more people centered planning process.

Diversification of practices in order to multiply planning benefits and focuses

The success of the watershed management is rooted on the multiplicity of opportunities that beneficiaries can access throughout the landscape. For that, the planning should focus on a whole range of practices to be used in the appropriate position of the watershed to generate enhanced overall agro-ecosystem productivity, including energy resources, feed for animals, and building materials. Such multiple benefits will mobilise farmers interest to invest by themselves on best practices and to sustain project lessons learned over the time.

Capacity development and institutional support

To be effective in improve planning and governance, capacity development needs to integrate a variety of beneficiaries and to focus on a wide set of skills, training levels, socio-economic abilities, technologies and geographical variables. Farmers and smallholders benefit by increased capacity to profit from legal support to certify private or communal ownership and to access small scale investment funds thanks to their new planning capacity. In summary, this capacity can be the foundation for an increased social construct and improved negotiation capacity with institutions and in conflict-solving processes. Decentralized government institutions benefit of a wider capacity to apply existing policies and by-laws and increase their formal capacity and their relationship with central level entities. Service providers and farmers might also gain a revenue by land planning capacity as they can be requested by peers to replicate trainings in other areas.

3

Agro-ecosystem management for multiple benefits (production, SLM, climate and biodiversity and ecosystem services)

Introduction

In contrast to intensive agriculture, the agro-ecosystem approach focuses not only on producing food but on delivering a range of ecosystem services as well, integrating the multiplicity of factors affecting crops, livestock, natural resources and livelihoods. Agro-ecosystems depend on natural environments from which productivity is enhanced in a sustainable way through a diverse and complex mix of practices and technologies. Farmers, pastoralists and forest users employ a diverse mix of livestock, fish, food, fodder and fiber crops, vegetables, rangeland and pasture species, fruit and fuelwood trees, medicinal plants and other natural products, to generate a range of benefits and meet their food and livelihoods needs. Through a broad-based, integrated process, the agro-ecosystem approach aims to address the full range of socioeconomic and biophysical constraints that users typically face. In the Kagera River Basin, for example, constraints are growing as a result of population pressure, intensification, unsuitable management practices and climate change. Managing risk and enhancing productivity through diversification and sustainable intensification is critical to securing and improving rural livelihoods. An integrated approach to improve livelihoods and the agro-ecosystems upon which they depend can overcome many of the shortcomings of conventional agriculture and deliver multi-functional interventions that are widely affordable, appropriate, applicable and adoptable.

The concept

The Kagera Transboundary Agro-ecosystem Management Project (TAMP) has applied the guiding principles of an ecosystem approach to optimise the biological, physical and human interactions with a view to effectively contribute to food security and the well-being of rural populations. Agro-ecosystems (see box on next page) are capable of providing a range of benefits well beyond the production of crops and livestock commodities, while reducing costs, and reducing risks. The project sought progress in social, institutional and organizational aspects, and promoted community-based, collaborative farming systems. Most importantly, it took advantage of interactions between indigenous technologies, local innovations and scientific advances, including adapted quality seeds, germplasm and agro-ecological principles for soil, water and pest management. Diversification and resilience were the underlying features for system sustainability, as well as trade-offs between intensification and natural resource conservation, and enhancing market linkages for socio-economic benefit.

What is an Agro-ecosystem?

An agro-ecosystem is defined as a "semi-natural or modified natural system managed by humans for food and agricultural production purposes". Agro-ecosystems are determined by three factors, which exhibit genetic, spatial and temporal variation, and by their interactions:

1. The abiotic or physical/ecological environment is described by the climate and weather, altitude and topography; soil quality and fertility; water supply/irrigation; vegetation or land use; and location/access.

2. The biological /genetic resources important for food and agriculture which can include the genotypes, cultivars and species of crops, trees, grassland, semi-domesticated and wild plants; genotypes, races and breeds of domesticated and wild animals and fish; as well as insects, arthropods, fungi, and micro-organisms, including those that may be beneficial and harmful.

3. The agricultural activities and decisions of farmers (including activities related to herding, forestry and fisheries) which are characterized by management practices and socio-cultural variables.

The management practices include type of cultivation, size of farm, technology and agronomic specifications and economic factors. The socio-cultural variables include population density/pressure, land tenure, knowledge systems and education, government services and policies. The activities and decisions of farmers, foresters, fishers and herders at field, farm and community levels, which modify and use the available resources to achieve certain production and management goals, depend on the agro-ecological and socio-economic context and are influenced by the decisions of policy makers and governments.

Source: FAO Terminology database www.fao.org/faoterm/en/.

Such an agro-ecosystems' approach sought a sound integration across key agriculture and environmental sectors and enhanced synergies between the various crop, forestry, livestock, rangeland and fishery components by strengthening connections between all actors, including across watershed, district, or transboundary level.

Effective partnerships were built among farmers, civil society, researchers, private sector, policy-makers and local communities. The sharing of information, research and development experiences led to raised awareness, understanding and a wider application of improved land resources management practices. This helped achieve more equitable, environmentally-friendly, and productive agricultural systems contributing to the sustained delivery of multiple ecosystem services. Emphasis was placed on required policy and institutional support to provid an enabling environment for wider adoption and sustainability.

To maintain a properly functioning agro-ecosystem, various technologies and approaches were combined in an ecological and socially acceptable way. For example, optimal crop rotation and crop diversity balance were targeted by taking into consideration ecological functions and farmers' preferences. Safeguarding and restoring soils was essential as the basis of production and agro-biodiversity, through increasing soil organic matter and protective vegetation cover, and living organisms including roots, through the use of various trees, grass and crop species and varieties (living roots). Sustainably managing large fauna (cattle) and ruminants in the system contributed to improve soil fertility (through application of manure) and led to increased resilience and food security (reliable and increased crop and livestock yields). Agro-silvo-pastoral practices (intentional combinations of trees with crops and livestock that involve intensive management of the interactions between the components) were instrumental. Well managed multipurpose tree and other leguminous species introduced by the project increased the overall (biomass) productivity, improved soil fertility, and soil and water conservation, influenced the micro-climate (shade and shelter from the sun and wind), increased carbon sequestration, etc. The aim was to simultaneously produce food, fodder, fuel and reduce bioenergy demand.

Finally, the integration of agro-ecosystem and livelihood approach presents multiple benefits as it "combine(s) vertical and horizontal integration" as described by van Ginkel *et al.*, (2013). The vertical integration implies an approach in which field, farm, landscape and region are nested to address contextual variation in drivers of adoption. The horizontal integration relates to working across disciplines and sectors (agriculture, forestry, markets, environment, water and energy) addressing policy and institutional requirements for innovation uptake across scales.

Six specific case studies are described under this theme that demonstrate viability and adoptability of the agro-ecosystem approach as an effective tool for sustainable, integrated land resources management:

Chapter 3.1 describes how agroforestry supports crop-livestock integration and is conducive to soil and water conservation in Rwanda. Participatory methods were implemented in collaboration with local service providers and diagnostic land use plans and small scale (private sector) enterprises were promoted. The case study highlights how agroforestry practices linked with innovative energy saving technologies both decrease woodland degradation and improve farm productivity. The agro-ecosystem gender balance and work equity is also positively impacted as cooking stoves and solar energy devices reduced the time required to collect firewood and the time for cooking.

Chapter 3.2 focuses on promoting both sustainable forest management and improved cooking stoves as one of the most effective natural resource management practices in Burundi. The extension and dissemination of improved cooking stoves should be seen as a complimentary strategy which enhances the impacts of initiatives aimed at combating land and agro-ecosystem degradation. In this case, the agro-ecosystem approach rehabilitates the environment and brings social benefits, such as income generation (e.g. local artisans skilled in making the improved cooking stoves), less time spent collecting wood, improved air quality and hence better health inside homes, fewer risks of burns for children and the satisfaction of being able to self-regulate resources.

Chapter 3.3 analyses the livelihood and environmental impacts of agroforestry in Tanzania. While protecting the land from erosion and retaining water, nutrients and organic matter on the hillsides, the activities increased community and farming systems' resilience to climate change impacts, increased carbon sequestration and reduced land use conflicts. Agroforestry practices provided farmers with both a source of nutritionally valued food and cash, and constituted feed for livestock whose products in turn generated cash, improved families' nutrition and also maintained farmland productivity through their manure.

Chapter 3.4 illustrates the importance of focusing on crop-livestock interactions for achieving soil erosion protection, soil fertility management and fodder and crop diversification and hence resilience to climate change and enhanced food security. This in synergy with the ongoing government livestock development programs in Rwanda increased crop and livestock productivity and contributed to environmental restoration.

Chapter 3.5 presents a case study from Burundi where crop-livestock integration through better feeding of animals led to an increase in manure production that was used to improve soil fertility and was the basis for agro-ecological intensification and increased agricultural productivity. The introduction of forage crops helped to restore protective vegetation and control erosion, while enhancing livestock nutrition and productivity. In addition, the small-scale manufacture of multi-nutrient feed blocks generated a source of revenue for farmers.

Chapter 3.6 shows how the agro-ecosystem approach applied by the project in Uganda contributed to carbon sequestration and yield benefits through a variety of sustainable land management (soil, crop and livestock management) technologies and approaches.

Reducing woodland degradation and restoring agro-ecosystems

3.1

through agroforestry, landscape management and energy conserving technologies in Rwanda

Author: Jean Marie Vianney Rukundo

Affiliation: Kagera TAMP project staff

> *"Trees are really still our heroes in that they are working across our needs for water, our need for carbon and for the needs of local people. Moving towards landscapes will help us move towards sustainability..."*

Mary Barton-Dock, Former Director of the Environment and Climate Change Department, World Bank

Summary

The Kagera TAMP project helped communities to address woodland degradation through promoting agroforestry practices within the agricultural system for multiple uses. Such practices were shown to provide mulch for coffee, stakes for beans, timber and construction materials, firewood, as well as perennial vegetation for livestock fodder and soil and water conservation. Agroforestry backed up by the promotion of improved cooking stoves to reduce energy demand, has shown to contribute to the restoration of trees in the landscape and to the improvement of community livelihood.

Key words: agroforestry, participatory methods, FFS, demonstration fields, soil and water conservation, crop-livestock, small-scale energy production.

Introduction

Most of the catchments within Kagera River Basin, particularly in Rwanda, are characterized by high population growth which puts increasing pressure on natural resources such as woodlands and forests. The growing rural and urban population are increasing demand for fuelwood and charcoal for cooking, timber for construction purposes and mulching material for coffee and banana plantations. This has led to over-exploitation and degradation of woodlands and forests but also loss of trees and woody biomass in the agricultural landscapes. The majority of the rural households depend on locally-gathered fuelwood for home energy, and they still prepare their food using traditional stoves, which require large amounts of firewood and are very inefficient - more than 80 percent of the energy generated is lost! Furthermore, coffee is a main cash crop in some areas (e.g. Ryamanywa catchment) which requires the application of mulching materials for soil protection and moisture conservation. Farmers, therefore, cut a lot of foliage from trees and grasses from woodlands to satisfy the demand for mulch. In addition, farmers cut small trees to use as bean stakes, reducing rates of natural regeneration. All of these activities have degraded the tree and woodland resources, reducing the protective vegetation cover and share of perennial species which, in turn, has contributed to an increased risk of erosion and landslides and reduced resilience to extreme weather events.

Addressing woodland degradation through promoting agroforestry practices, in combination with the promotion of improved cooking stoves to reduce energy demand, contributed to the agro-ecosystem services restoration and community livelihood in target catchments in Rwanda. Farmers were trained in sustainable land management (SLM) practices, improved cooking stove installation and tree nursery establishment and management.

Objective

This chapter documents the key results and experiences related to the reduction in tree and woodland degradation through agroforestry and landscape management practices in three catchments. The key interventions undertaken were:

- Preparation and implementation of community land-use and management plans;
- Promotion of agroforestry practices and establishment of tree nurseries that supplied tree seedlings to the communities in the catchments;
- Training of farmers in sustainable land management practices including creation of soil and water conservation structures such as anti-erosion ditches and water trapping pits in selected sites in the catchment and stabilisation of terrace raisers with grasses;
- Promotion of sustainable energy supply and energy saving devices among community members.

Approach and Methodologies

Participatory rural appraisal and catchment mapping

At the start of the project, a Participatory Rural Appraisal (PRA) land-livelihood diagnostic exercise to assess and map the natural resources within the target catchment was undertaken. The diagnostic and analysis of findings were facilitated by Vi Agroforestry staff (service provider) and involved all project stakeholders in the area (e.g. local community leaders, farmer representatives, agronomists from both sectors and district and environmental officers). Biophysical and socio-economic information in the catchments was collected, analysed and sketched by the community members. The sketches were later redrawn using geographical information systems (GIS) software to obtain accurate, easily-managed and stored maps showing major land use units as a basis for planning. Problem identification and ranking was carried-out, from which detailed community management plans for the three catchments were developed, covering a total of 258 hectares with 470 households (Table 1).

Catchment name	Catchment area (ha)	Woodland area (ha)	Number of households/people
Ryamanywa	96.9	18.0	279/655
Karambo	66.5	12.6	104/452
Nyarurembo	94.6	5.4	87/325
Total	**258.0**	**36.0**	**470/1 332**

Table 1: Key characteristics of the three target catchments in Rwanda.

Community capacity building through trainings

In the 3 target catchments in Rwanda some 240 farmers were trained in specific SLM practices: construction of soil and water conservation structures; agronomic practices; intercropping and rotations; agroforestry techniques, planting of woodlots, and protecting or planting trees on field borders or on the contour for fodder, fuelwood and carbon sequestration; soil organic matter management and mulch for soil fertility management. These practices aimed at enhancing resilience to drought and extreme weather events, helping adapt to and mitigate climate change and also as energy saving technologies.

120 interested farmers were also organised in groups and trained in tree nursery management including: tree nursery bed establishment and management; selecting picking and transplanting germinated seeds into polythene bags; site selection; planning and record keeping for nurseries; as well as concepts and principles of stem grafting.

Finally, farmers were trained to use improved stoves that reduce deforestation and increase energy use efficiency. The training courses went hand-in-hand with provision of implements to support community members. For example, after training 12 lead farmers (seven females and five males) on improved stove installation, 186 improved stoves were distributed to community members in the catchments (manufactured locally with quality clay using a certified model by Ministry of Infrastructure and Bilem Innovation).

Demonstration

One approach for restoring degraded land and vegetation cover was the planting of trees and grasses on the risers and crops on level terraces constructed by farmers. These were used as demonstration plots for study tours with funding and technical support of the project.

Community based nurseries

Ordinarily, tree nurseries are mainly established and managed by external actors and therefore the local population do not feel involved and lack a sense of ownership of the tree seedlings. In addition, availability of tree seedling often does not coincide with the planting periods due to late delivery. Late planting period leads to very low survival rates and farmers do not generate benefits from laborious tree planting. To rectify this situation, the project adopted the approach of supporting the establishment of community-based tree nurseries in every catchment.

Results and Analysis

Tree nurseries

A total of 120 farmers were trained in tree nursery establishment and management. This resulted in the establishment of four community nurseries, leading to the production and planting of 63 572 trees of different species (Table 2).

Species Sites	*Grevillea*	*Calliandra*	*Leucaena*	*Alnus*	*Spathodea*	*Cassia*	*Filao*
Nyarurembo	11 051	7 697	6 454	1 598	280	150	1 600
Ryamanya	2 356	9 950	3 840	2 242	225	200	1 600
Karambo	4 951	3 304	3 304	804	201		1 765
Total	**18 358**	**20 951**	**13 598**	**4 644**	**706**	**350**	**4 965**

Table 2: Trees planted per catchment area in Rwanda.

Figure 1: Ntibarikure with his home nursery, Karambo microcatchment.

One of the outcomes of the training was that farmers themselves gained practical skills to manage tree nurseries and some of them have since established tree nurseries as a business enterprise. For example, Mr. Jean Damascene Ntibarikure (Figure 1), one of the farmers, said "I have started with training in nursery management and now I can make money from tree seedling production activities along with supporting my neighbours to easily get seedlings".

Another outcome is the establishment of different agroforestry practices in the catchment such as woodlots, trees on field boundaries and on soil conservation structures (e.g. planting on terrace risers).

Soil conservation structures: training and construction

A total of 240 farmers were trained in the establishment and management of soil and water conservation (SWC) structures stabilised with grasses and fodder trees. As a result, they have led their peers to construct various SWC structures with project support (Table 3). David Ruhumuriza, a farmer living in Karambo microcatchment area confirmed an additional result, "The improvement in fodder availability has positively increased cattle milk production (from an average of two to ten litres per cow per day)". This has also reduced the time for children to collect fodder grasses from woodland (see Figure 2).


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Figure 2: Use of improved fodder production.

Sites/ Results	Karambo	Ryamanywa	Nyarurembo	TOTAL
Anti-erosion ditches (km)	6	18.5	4.3	14.8
Bench/Radical terraces (ha)	5	0	0.8	5.8
Water trapping pits (#)	13	13	6	29
Terrace risers/banks stabilized with grasses (km)	10.32	0	3.7	14.02
Tree nurseries (#)	2	2	1	5

Table 3: Soil conservation structures.

The key outcome of these SWC structures has been the reduction of sediment laden run-off water from the sloping land in the catchments, increased availability of livestock fodder harvested from the vegetation planted on terraces, some water trapping pits enhancing water conservation, as well as reduced degradation of vegetation and biomass in woodlands where farmers and their children used to collect grass to feed their animals.

Energy conservation technologies

A total of 12 lead farmers (seven females and five males) were trained in improved cooking stoves (ICSs) installation and 107 improved stoves named "*Canarumwe*" (which use firewood) as well as 93 solar devices were distributed to farmers within catchment areas (Table 4).

Catchment name	hh with ICS	hh with solar devices
Ryamanywa	27	20
Karambo	63	50
Nyarurembo	23	23
Total	**107**	**93**

Table 4: Energy conserving technologies in households as promoted in target catchments.

Women greatly appreciated the promotion of improved cooking stoves, particularly the reduction in the quantity of firewood needed to cook food - from 3 814 kg/hh/year using a traditional stove to 1 716 kg/hh/year of firewood for the improved stove. If all the 470 community hhs converted to ICSs, firewood demand could be reduced from 1 792 698 to 806 714 kg per year – a saving of nearly 1 000 tonnes per year. Assuming 1 hectar of forest produces 20 tonnes of dry firewood per year, the 470 hhs would need to harvest from only 40.3

hectares using ICSs compared to 89.6 hectares using traditional stoves. The use of improved stoves would reduce deforestation pressure by 55 percent.

To conclude, this intervention has reduced the time spent cooking and collecting firewood and it has contributed to woodland conservation by reducing the amount of wood harvested for fuel, which was among the key factors contributing to woodland degradation.

Lessons Learned

1. Positive change in the landscape is not possible without the commitment of land users. When interventions engage the people in identifying response measures and demonstrate that men and women farmers are capable of participating, there is likely to be success.

2. The introduction of agroforestry practices and energy saving technologies can both decrease woodland degradation and improve farm productivity (labour saving).

3. The energy saving technologies – cooking stoves and solar energy devices - has reduced the time required to collect firewood and the time for cooking, enabling women to spend more time in productive task, child raising and contributing to school attendance by children.

4. The partnership approach (local government, technical facilitators and local community) must be promoted as key players support each other, pooling resources, doing complementary roles and forming a collaborative relationship.

Conclusion, Recommendations and Way Forward

Farmers were suffering from the effects of a serious shortage of firewood in the different micro-catchments which has led them to readily adopt agroforestry practices and improved cooking stoves. Farmers have also learnt tree nursery establishment and management as well as sustainable land management practices. The production of trees will sustain the environmental protection and, in case of leguminous trees, will increase soil fertility. SLM interventions have modified substantially the production system and impacted crop and livestock production by decreasing erosion, improving soil water retention and increasing fodder production. The use of improved stoves will make agroforestry production efforts more sustainable as the community socio-economical dimensions have also been impacted by reducing women working time and allowing them to orientate their effort to other tasks. The results of these interventions are very encouraging and the localities where these interventions have been implemented will serve as demonstration sites for farmers from other areas.

The project interventions should be scaled out so that more farmers can be reached and involved. In addition, more technologies for energy saving, such as improved charcoal making, should be promoted. There is a strong need to increase the cost-sharing approach for all technologies, a prerequisite for enhanced community ownership and sustainability of project interventions. More field learning sites and knowledge sharing avenues should also be encouraged. In addition, farmer/enterprise groups could be set-up and linked, first with Bilem Innovation to identify suitable clay in the area, and with credit providers, to set-up stove production units expanding the local supply of improved stoves for wider uptake and sustainability.

Promotion of improved cooking stoves by the Kagera TAMP project to strengthen community livelihoods

3.2

Author: Cyrille Mbonihankuye

Affiliation: Fruits and Vegetables Programme, Institute of Agronomic Sciences of Burundi (ISABU), Burundi

Summary

This chapter presents the impact of the introduction of improved cooking stoves on the lives of farmer field school (FFS) members during implementation of the Kagera River Transboundary Agro-ecosystem Management Project (Kagera TAMP). Training and awareness-raising was carried-out for FFS members on the importance of improved cooking stoves for the environment in general, and to reduce land degradation in the Kagera watersheds. This activity has given local communities the capacity to protect the environment, since the promotion of improved cooking stoves as part of the project has contributed to a significant decline in the rate of deforestation. The various training and awareness-raising sessions attended by FFS members as part of the project on the impact of improved cooking stoves on air quality in the home has had a particularly beneficial effect on people's health. The training sessions involved building two types of improved cooking stoves, one made of clay and the other of bricks. A total of 36 FFSs averaging 25 to 30 members each have installed these improved cooking stoves in their respective households.

Key words: improved cooking stoves, natural resources, watersheds, environment.

Introduction

In Burundi, wood and lignocellulose[1] biomass supply more than 96 percent of the country's domestic energy; and fuel wood alone accounts for 7 percent of the volume of timber consumed at national level.

For this reason, demand for wood is very high and is increasing with population growth. However, supply is unable to keep pace; on the contrary, it is declining. The imbalance between supply and demand for fuelwood is having a negative effect on the environment, as well as on energy and food security.

The environmental impacts of increased deforestation and loss of protective vegetation cover include greater erosion caused by rainwater runoff, flooding of low-lying land, crop destruction, subsidence of river banks and reduction in river water quality due to sedimentation.

Food security impacts include collection and use of crop residues as a source of household energy instead of leaving them to act as natural fertilizer for the soil or to feed livestock which in turn provide manure. Meanwhile, the rising cost of fuelwood has made it increasingly unaffordable for most poor members of the rural communities across Burundi. Poor rural households are thus no longer able to cook beans because of the long cooking time, although this is a cheap and protein-rich food that can be readily grown in association with cereals or as a sole crop.

Given the extremely high rate of population growth, the precarious energy situation in Burundi and in the wider Kagera Basin is a cause for concern. The already low and annually declining level of forest and non-forest tree cover and the prevalent and massive use of wood by households and by brick and tile-making factories, poses a threat to the ecological balance. Family members, especially women, are forced to travel long distances to collect firewood which reduces time in productive and reproductive/nurturing tasks. The traditional three-stone cooking stoves used by most people in Burundi are open stoves that only make use of 15 percent of the wood they burn; the rest is lost in smoke and heat. This is also a source of indoor air pollution with repercussions on human health, due to toxic particles contained in the smoke, including carbon monoxide.

1 Lignocellulose includes: virgin biomass (all naturally occurring terrestrial plants such as trees, bushes and grass) and waste biomass (by-products of various industrial sectors such as agricultural products (maize stover, straws, etc.).

Given the precarious nature of the region's energy situation, the Kagera project resolved to disseminate improved cooking stoves. The improved cooking stoves allow users to make savings on the amount of firewood used, in varying percentages according to the models and the way in which they are used. The general principle is to optimize the energy yield by building a closed stove, so as to concentrate the heat around the cooking pot.

This paper presents the impact of improved cooking stoves on the fight against land and agro-ecosystem degradation and efforts to improve the livelihoods of FFS members taking part in the Kagera TAMP.

Training methodology

An improved cooking stove is a piece of domestic equipment for which studies confirm the energy savings compared with the traditional three-stone cooking stoves that are widely used by rural communities. The dissemination of improved cooking stoves by the project in target watersheds in the Kagera Basin sought to:

- Promote the sound use and management of forest resources by the rural community;
- Contribute to safeguarding of forestry and agroforestry resources by reducing deforestation;
- Reverse land degradation in the Kagera watersheds.

The training focus is twofold. First, the capacity for construction and use of improved cooking stoves is developed to reduce the quantity of wood used for meal preparation allowing trees and shrubs to be maintained in sufficient quantities near homes, as the improved stoves can use dead twigs and branches. Second, the practices of coppicing or selective felling to maintain tree growth for future generations is also included in training to help ensure there is a sustainable supply of fuel wood without denuding the landscape. The capacity to use new stoves also brings many social advantages, such as revenue generation (e.g. local artisans skilled in making the improved cooking stoves), less time spent collecting wood, improved air quality and hence better health inside homes, reduced risks of burns for children and the satisfaction of being able to self-regulate resources and reduce greenhouse gas emissions.

To tackle the precarious nature of the region's energy situation, the Kagera TAMP project organized training of trainer (ToT) sessions on techniques for building and using improved cooking stoves, so as to promote fuelwood saving technologies. A total of 90 trainers, made up of farmer field school (FFS) representatives involved in sustainable land management (SLM), FFS facilitators and local chiefs from the Provinces of Gitega, Karusi and Kirundo took part in the training initiative in July 2012 and May 2013.

The training was implemented in two phases: indoor theory-based training during the first day (Figure 1) and practical training (Figure 2) in households during the second day.

Figure 1: Theory-based training on the construction and importance of improved cooking stoves.

Figure 2: Practical training in the building of improved cooking stoves made of clay.

The training involved building two different types of improved firewood cooking stove, one type made of clay and the other made of bricks (Figure 3 left and right). Both these types of cooking stove are closed stoves, with a single opening. They heat up very quickly and retain their heat, unlike the three stone traditional cooking stoves, which allows the flame and heat to escape from three openings,

Figure 3: Construction of improved cooking stove made of bricks (left) and a double stove of clay (right).

wasting energy in the process. The improved cooking stoves are made of locally available materials, namely earth (subsoil), a spray of water, fine ash, clay, green grass and small bricks. Mixing the earth with water and all the other materials produces a solid paste with which the improved cooking stove is then built (Figure 4).

Figure 4: Practical training in using improved cooking stoves made of clay.

Results

By late 2014, a total of 1 145 households had installed improved cooking stoves and more have expressed an interest in learning the technology. The practical work was carried-out by all the FFS members in all the watersheds being developed by the Kagera TAMP in Burundi. It should be noted that all the FFS members who have been trained now have improved cooking stoves in their homes and are working to make the technology available to other members of their local communities. Community members who are not members of FFS involved in the project have requested training to build improved cooking stoves. As a result, some members of 36 FFSs have installed improved cooking stoves in their respective households. A facilitator from the TWUNGURANUBUMENYI group was called on by FVS AMADE (an NGO resulting from the merging of *Famille pour Vaincre le Sida* – FVS – and *Association Mondiale des Amis de l'Enfance – AMADE Mondial*) to train trainers of associations to which it is linked in the municipality of Bukirasazi. A total of 20 trainers drawn from three associations took part in that training initiative.

The advantages of improved cooking stoves

The new stoves are made of locally available materials and use considerably less wood during cooking (generally 50 percent of what had been required with traditional stoves); thereby promoting household development, since the time and the money that was previously used to collect and buy firewood is now used for household development. They also reduce cooking time and hence greenhouse gas emissions; help to reduce deforestation and protect the environment; are easy to build; and they improve food security, since people who had ceased to cook beans can now cook them again. The use of improved cooking stoves also makes it possible to reduce air pollution and risk of burns and negative impacts on human health. The use of improved cooking stoves should be accompanied by training in tree and forest management to promote protection of naturally-seeded tree seedlings, coppicing and selective felling for the regeneration of woody biomass and to encourage biodiversity through bee keeping and sustainable harvesting of non-wood forest products.

Constraints and lessons learned from improved cooking stoves

Promoting improved cooking stoves is one of the most effective natural resource management practices. Given that more than 95 percent of Burundi's energy needs are met by fuelwood and that 76 percent of the fuelwood is consumed in rural areas, the environmental impacts are very significant on agro-ecosystems and watersheds. The extension and dissemination of improved cooking stoves should be seen as a complimentary strategy which enhances the impacts of initiatives aimed at combating land and agro-ecosystem degradation. These can only be effective if consumption of wood is strictly limited to that which can be sustainably regenerated by rural families. The use of improved cooking stoves compared to the use of traditional ones shows that a massive difference can be made by up-scaling them.

For women, already overburdened with work in the fields and at home, going back and forth to look for fuelwood is an extra chore. The use of an improved cooking stove can help to lighten the task of searching for fuelwood and enable women to save time, which can then be spent on other activities for household development.

The use of improved cooking stoves contributes to savings in wood energy, thereby limiting wastage of forest resources. The annual consumption of fuelwood per household of 1.22 m^3 can be reduced by 50 percent by improved cooking stoves, a saving of 0.61 m^3 /year. Multiplied by the 1 145 households which benefited from the TAMP initiative in Burundi, that means saving 58 hectares of forest each year, which is a significant contribution to the natural resource conservation. This practice also reduces the use of crop residues for cooking, making them available for composting or for feed for animals instead, thus contributing to soil fertility restoration.

The only constraints cited was the fragility of improved stoves made of clay and need for some reinforcing materials. Particularly, users have been advised to take care while cooking in order to avoid water falling on the stoves. Also, in some areas there is limited access to clay to repair improved cooking stoves, as and when needed, or for use in training other members of the community who seek assistance from those who are already trained to help them build a stove in their own households.

Conclusions and recommendations

There are promising results for the use of improved cooking stoves. A survey of beneficiaries of these stoves revealed that the following benefits have been realised:

- The quantity of fuelwood used by improved stoves has been reduced by 50 percent compared to traditional stoves. Beneficiary families say they have made monthly savings of about 8 000 FBu ($5.10 equivalent).
- Cooking times have been reduced, thus beans which take a long time to cook can be reintroduced into the diet with nutritional benefits and the time saved can be used for food production or other activities.
- Indoor air pollution has declined significantly, which will contribute to reducing respiratory diseases and improving women's and children's health.
- Offences linked to illegal wood collection, which are regular occurrences in municipal and national forests, have substantially declined.

The wide-scale dissemination of improved cooking stoves in rural and urban households is recommended as it makes a considerable contribution to reducing land and ecosystem degradation.

Household members should be empowered to be able to build an improved cooking stove by themselves and repair it as necessary or have access to trained artisans at an affordable price.

Impacts of agroforestry in enhancing and promoting sustainable land management

3.3

in Missenyi, Karagwe and Kyerwa Districts in the Kagera Region, Tanzania

Authors: Grace Rwegasila Eustace, Clement Mtui, Wambura Pesha

Affiliation: Vi Agroforestry, Tanzania

Summary

Within the Tanzania Kagera TAMP activities, various agroforestry practices combining crops, livestock and tree species provided a way to enhance and promote sustainable land management, restoring degraded lands, enhancing productivity, ensuring sustainable use of biodiversity, and contributing to climate change adaptation, as well as mitigation. Through Farmer Field Schools (FFS) the project catalyzed tree-based technologies. Also, practices that demonstrated to be beneficial both in terms of income and land restoration were replicated in learning / demonstration sites for diffusion to farmers. These sites showed how to integrate and upscale the various technologies to improve crop yields and provide other benefits on farmers' fields. This paper describes the positive livelihood and environmental impacts of an agro-ecosystem approach focusing on the importance of agroforestry practices.

Key words: agroforestry, FFS, demonstration plots, ecosystem services, income generating activities.

Introduction

Agroforestry is described as a land use system where trees are grown in association with agricultural crops, pasture or livestock and there are usually both ecological and economic interactions between components of the system (Liniger and Critchley, 2007). It is an alternative approach to single purpose land use, based on the deliberate integration of trees and / or shrubs with crops and / or livestock. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land use systems. Wild and farmed agro-biodiversity in agroforestry systems are typically higher than in conventional agricultural systems; where "wild" includes wildlife species (plant, animal, microbial) and beneficial associated species such as soil biota, beneficial predators and pollinators, while "farmed" means intentionally selected plant and animal species. With two or more interacting plant species in a given land area, a more complex habitat is created that can support a wider variety of birds, insects, and other animals, while also reducing the risk of serious pest and disease outbreaks.

Sustainable land management (SLM) practices are those that sustain productivity while helping farmers to adapt to the impacts of climate change and achieve increased environmental resilience in different climate or agro-ecological zones (Wekesa and Jonson, 2014). SLM practices are essential for: i) ensuring agricultural productivity in the short-, medium- and long-term; ii) protecting and enhancing the productive capacity of cropland, forest land and grazing land including uplands, slopes and valley bottom lands; and iii) potentially reversing land degradation.

Agriculture production in the Kagera Region in northwest Tanzania has been seriously declining over recent decades due to land degradation and inadequate investment. Farmers are still depending on the traditional cultivation system known as *ekibanja*, whereby bananas are grown together with coffee. Local people are highly dependent on these crops for both food (bananas) and cash earning (bananas and coffee). The introduction of SLM practices under the Kagera TAMP was highly welcomed by the community to tackle problems of land degradation, deforestation, biodiversity loss, weak governance and conflicts over natural resources. Agroforestry was one of the interventions used by the project to address the challenge of land degradation in farms.

The target group was small-scale farmers, with a focus on gender issues and vulnerable groups within the community. The implementation process involved different stakeholders in the five Districts of Kyerwa, Karagwe, Ngara, Missenyi and Bukoba. The district councils played a role of coordination, while extension staff within the districts played a role of site facilitation. Other stakeholders were the "service providers", including Vi Agroforestry Tanzania (Missenyi, Karagwe and Kyerwa), Tanganyika Christian Refugee Service (TCRS) – Ngara, Relief for Development Society (REDESO) – Ngara and Kolping Socoiety (Karagwe and Bukoba).

Methodology

Agroforestry has been adopted by the Kagera TAMP project to rehabilitate degraded land, using agroforestry practices to restore and more sustainably manage the land through implementation of: i) farmer field schools; ii) demonstrations of successful SLM technologies; iii) income generating activities.

Farmer field school approach

The farmer field school (FFS) approach let the farmers choose the appropriate agroforestry practices and use them to address different agricultural production challenges in their farms. The challenges addressed include low soil fertility, soil erosion and low soil moisture holding capacity. The main test crop, banana, was selected by the participating communities as it has the highest value in the Kagera Region. Banana serves as the staple food as well as a cash crop. Due to land degradation and serious diseases, its production in terms of quantity and quality has been progressively declining. Farmers selected banana in order to learn how they could improve their land management to increase banana production, thus enhancing their food and livelihood security.

Some of the agroforestry practices the project catalyzed were field borders tree planting, intercropping, fruit orchards, manure application (collected from livestock within the farm), use of cover crops and stabilizing contour structures by planting nitrogen fixing trees or shrubs that could also be used for mulch to provide nutrients and conserve moisture. The practices were applied to newly established farms for comparison with the existing farms and to improve them. The project supported the participating community by providing agroforestry seeds, tree cuttings, fruit seeds and grafted fruit seedlings of mango and avocado. A combination of measures were used to obtain planting materials. For some trees like *Ficus* spp., cuttings were prepared by the communities and planted. For *Cedrella odorata* and *Maesopsis* spp., farmer groups working with the project established nurseries to raise seedlings. For some trees like eucalyptus, seedlings were bought from commercial nurseries as these were not mostly advocated by the project but many farmers wanted them.

Demonstrations of successful SLM technologies

Practices that demonstrated to be beneficial in terms of income and restoring degraded land in the FFS were replicated in one learning / demonstration site per catchment for diffusion to farmers who were not part of the FFS group. These

Figure 1: Kagera TAMP demonstration site.

sites showed how to integrate and upscale the various technologies to improve crop yields and provide other benefits on farmers' fields.

At Kibingo ward in Murongo, the Kagera TAMP FFS group established a demonstration site along the steep slope. The site demonstrated the technologies of contour farming combining physical and biological measures for soil erosion control and water harvesting, notably contour bunds, terraces, hedgerows, mulching, cover crops, manure application and tree planting (Figure 1). Various crops were planted and the harvests were compared to their conventional farm practices. Following establishment, the site has received visits from various other farmer groups / individuals for learning purposes and visitors have expressed their excitement in discovering how agriculture activities can be carried-out sustainably on steep slopes.

Richard Daudi one of the FFS members confirmed the benefits of the demonstration site as:

> “*Improved environmental condition within the farm, increased crop productivity for domestic use and for sale, gained knowledge transformed to their existing farms.*”

Income generating activities

There is poverty and low income among the community due to their dependence on banana and coffee to earn cash. The production of these crops has been progressively declining in recent years due to land degradation and emergence of specific diseases, notably banana *Xanthomonas* wilt (BXW) and coffee wilt disease. The Kagera TAMP created awareness in the community on the proper use of available resources that can lead to generating additional revenue. FFS group members were facilitated on the establishment of micro-enterprises for farm based income generation. The activities selected and implemented by FFS members were tree nursery establishment, beekeeping, poultry keeping, goat keeping and vegetable gardens. The participants earned money by selling different products and used it to purchase different foodstuffs, enhancing families' diets, paying school fees, also to support better management of their farm (buying mulching materials and farm inputs, and hiring labour for the construction of sustainable land management structures).

Results of applying agroforestry practices

Agroforestry practices demonstrated to have positive impacts to address the challenges of land degradation in a range of micro climates (e.g. from high rainfall zones to drought prone areas in the cattle corridor). Agroforestry systems were advantageous compared to conventional separation of crop and forest enterprises, as they offer increased productivity, economic benefits and diversity in the ecological goods and services provision. Apart from trees planted under agroforestry systems, the Kagera TAMP supported land users to plant a number of valuable tree species in different areas for the ecosystem services they provide. Trees such as *Maesopsis eminii*, *Markhamia lutea*, *Ficus* species and *Erythrina abisinica* were planted around water sources to benefit from and protect the water source and maintain a humid microclimate. Other species such as *Cedrella odorata*, *Acrocarpus flaxinifolius* and *Eucalyptus* spp. were planted on open areas like hill tops and palatable leguminous species were planted in grazing land to contribute to the restoration of pasture quality.

District	Microcatchment	No. of trees planted
Missenyi	Minziro	14 700
Kyerwa	Murongo I and II	6 000
	Kihanga/Katera	5 000
Karagwe	Bujuruga	5 548
Total		**31 248**

Table 1: Trees planted under Kagera TAMP project (2010-2014) in Kagera Region, Tanzania.

The beneficial results of the agroforestry practices introduced to land users as part of the Kagera TAMP included a range of livelihood and environmental impacts:

Livelihood impacts of integrated agroforestry or agro-pastoral practices in the Kagera region

- Agroforestry practices provide farmers with both a source of food and cash. For increased food security in the household, a wider variety of food crops are encouraged in each farm (e.g. peas, beans, maize, banana, cassava and others) for domestic use and sale of the surplus alongside selected tree species.

- The trees on the farmland provide a continuous supply of fuelwood for cooking – as they grow, farmers cut small branches.

- Species such as *Calliandra calothyrsus*, *Cajanus cajan* and *Tithonia diversifolia* provide fodder for livestock as well as fuelwood for domestic use. The seeds of *Cajanus cajan* (pigeon pea) are also a valuable short season food crop.

- Livestock and livestock products have indispensable roles in generating cash, improving families' nutrition and also maintaining the productivity of the farmland through their manure. Farmers are now improving their households' nutritional status by providing eggs, meat, honey and milk for home consumption.

- Farmers are also improving their families' nutritional status by the consumption of fruits and vegetables from their farms. Participating farmers have already harvested fruits like passion fruit, pawpaw and pineapple. In the near future, they expect to harvest mangoes and avocadoes. The vegetables preferred by the farmers are tomatoes, cabbage and onions, which are produced in large quantities for both domestic use and for sale.

- Before the introduction of agroforestry practices, the indigenous species used to produce a bunch of 10-20 bananas weighing 20 kg. The introduction of improved varieties and consequent reduced losses due to disease control increased yields to 40-50 kg per bunch – after the application of agroforestry and improved soil management, yields rose to large bunches of over 70 kg.

- If leguminous species are integrated with crops, their foliage can be used as mulch and falling leaves provide a litter layer reducing weed growth and the cost of weeding and enhancing moisture retention.

Environmental impacts

Agroforestry interventions protect the land from erosion and retain water, nutrients and organic matter (carbon sequestration) on the hillsides, contributing to adaptation and increasing the resilience of communities and their farming systems to the impacts of climate change. Main environmental impacts included:

- Hedgerows in field borders and strip/alley cropping planted along contours make the hillsides more stable. *Calliandra*, pigeon pea and *Tithonia* strengthen the contour bounds and contribute to soil erosion control and provided foliage for incorporation in the soil as a green manure to restore the soil organic matter content.

- *Pennisetum purpureum* also known as Elephant grass or Uganda grass and Guatamala grass (*Tripsacum andersonii*) planted along contour lines as fodder crops also reduce runoff, control soil erosion and conserve water to reduce the impact of droughts.

- Falling leaves and the cutting of foliage from leguminous species provides mulch which enhances soil organic matter and nitrogen content, restoring soil biological activity and enabling it to store more soil moisture.

- Stabilization of soil by tree roots is reducing soil erosion and enhancing water infiltration. Tree roots are also able to tap nutrients from deep in the soil profile, transferring these into their leaves. When these leaves drop and decompose, they form organic matter and add nutrients to the topsoil, where it is available to crops with shallower roots.

- Most of the favoured leguminous species used in agroforestry contribute to nutrient cycling through associations with *Rhizobia* bacteria on the root hairs, which enable them to fix nitrogen from the air to enhance soil fertility.

- Agroforestry increases both above- and below-ground carbon sequestration in woody biomass and soil organic matter. In time, matured trees will produce timber.

- Trees on the farm act as a wind break by reducing the speed of wind, hence protecting crops from being damaged by storms. They also provide shade for people, animal and crops.

Lessons learned due to application of agroforestry

The combinations of agroforestry practices (both vegetative and agronomic) through Kagera TAMP activities addressed the challenges of land degradation by enhancing the productivity and sustainability of farming. The participatory activities with FFS groups and local communities improved the existing indigenous knowledge about agroforestry and opened the minds of the communities to not only depend on banana and coffee, but to combine other beneficial enterprises.

Women benefited most from the agroforestry activities, as they can now obtain enough diverse foods, fruits, vegetables and animal products, fuelwood and other products within their farms, thus enhancing household food security and nutritional status – especially of children. Agroforestry practices have also reduced the time women and children spend on routine labour for weeding and fetching firewood.

Challenges encountered during Kagera TAMP implementation

Although the agroforestry practices introduced by the Kagera TAMP have led to many benefits in the community, many of the practices initially required intensive use of labour, in contrast to the traditional banana-coffee farming system. As a result, only farmers who were reasonably well-off have applied the practices in their farms.

More efforts are needed for adaptation to extreme weather events through ensuring the use of drought resilient species on drier hillslopes, planting tree seedlings right at the start of the rainy season and conserving any rainwater through small water harvesting pits with added manure and mulch for moisture retention.

Most of the villages in the microcatchments have no land use plan, which can lead to land use conflicts, especially between farmers and herders. Existing village by-laws related to environmental management are not being adhered due to weak enforcement by village leaders. Also, a recent problem causing conflict is returning community members from the towns, which are given community grazing land by village leaders to plant trees such as *Eucalyptus* spp. and *Pinus* spp. as a private investment thus reducing the communal land area for grazing.

Due to the tedious nature related to many of the tested SLM practices, the community depended on the project for support to finance the additional labour required to implement the SWC technologies. Nonetheless, alternatives which require less additional labour were also tested, such as natural regeneration of pastures including tree species, the use of ties in retention ditches to store water and planting agroforestry species downslope of contour bunds and retention ditches on progressive or bench terraces for optimising water conservation.

Recommendations for upscaling and follow-up

Kagera TAMP has done good ground work, awakening the community on the importance of sustainable land management and implementation of various policies related to land management. This needs to be sustained and scaled-up, so that the next generation will find a good environment in which to live. The following recommendations are made for up-scaling:

- Villages must be supported to develop and update land use plans to minimize land conflicts and promote sustainable land management and relevant by-laws should be validated and strongly adhered to by community members.
- For the project actions to be sustainable, the capacity of community members should always be enhanced to build a sense of ownership of the SLM practices so that they contribute in terms of labour and available materials.
- Village and/or community by-laws should be strongly enforced and fines should be collected from those who are held / found responsible for any destruction or theft.
- Knowledge on agroforestry practices should be updated through refresher training of extension staff and service providers – also awareness raising of decision makers as well as the community.
- Practices that enhance adaptation to climate change (higher temperatures; more frequent and intense extreme weather events) need to be prioritised through rigorous assessments of the costs and benefits and reasons for success or failure of each SLM practice with the stakeholders. WOCAT tools[1] were used for this purpose, to assess and document technologies and approaches and to select best practices for scaling-up. They need to be used more widely and the results carefully analysed for informing scaling-up strategies.

1 See theme 4 of this booklet, chapter 4.1.

Conclusions

Kagera TAMP focused on alleviating land degradation, also enhancing land productivity and livelihoods. Most of the land degradation in the area is caused by unsuitable (unsustainable) farming methods, deforestation, over-grazing, uncontrolled bush fires and grassland burning, encroachment of water sources for agricultural activities and allocating farmland for expanding settlements. To address these issues, a range of appropriate restorative practices have been identified, including the use of soil and water conservation structures like contours and terraces, soil fertility restoration through mulching and manure application, use of cover crops and planting of leguminous shrubs and trees, planting of trees for fruits and fodder, regeneration of trees, shrubs and grasses through area enclosure, use of fire breaks for the control of bush fires and grassland burning.

The Kagera TAMP has demonstrated conclusively that an agro-ecosystem approach including various soil and water conservation and agroforestry practices which combine crops, livestock and tree species provide a way to enhance and promote sustainable land management, restoring degraded lands, enhancing productivity, increasing sustainable use of biodiversity, and contributing to climate change adaptation, as well as mitigation.

Enriching soils in the Kagera Basin, Rwanda

3.4

through soil erosion control structures (bench terraces), fodder production, manure management and efficient fertiliser use

Authors: Desire M. Kagabo ≠, Celestin P. Ndayisaba ±

Affiliation: ≠ = International Center for Tropical Agriculture (CIAT), Rwanda
± = Rwanda Agriculture Board (RAB)

Summary

A range of sustainable land management (SLM) technologies were introduced to groups of farmers working together through Farmer Field Schools (FFS) in the Karambo micro-cathment located in Rulindo District in Northern Rwanda and in the Gashari micro-catchment located in Kayumbu Sector, Kamonyi District in Southern Rwanda. Agro-environmental management through combined practices and technologies proved to increase crop and livestock productivity (Irish potato, cassava, maize, beans and fodder crops) restore environment through soil conservation and fertility management.

Key words: soil erosion, terracing, soil fertility management, fodder, manure.

Introduction

Rwanda's landscapes suffer from severely degraded soils and vegetation, consequences of human activities, especially through farming of steep slopes. About 91 percent of the population is in the rural sector and mostly depending on agriculture. Although the national average is 400 persons per square kilometre (all land) there are today more than 746 people per square kilometre of arable land (CCA Rwanda, 2015). Population growth of over 2.7 percent per year has significantly reduced the size of farms to an average of 0.7 hectares per household. Furthermore, these small plots are mainly located on unstable steep slopes, which are continuously under cultivation. This chronic disequilibrium between population and land, coupled with inappropriate agricultural practices, have negatively impacted on the stock of natural resources in the last four decades (Kagabo *et al.*, 2013) and on ecosystem functioning.

Sustainable land management practices, such as terracing and mulching, coupled with good crop management practices provide solutions to control soil erosion, reverse the decline of soil fertility and boost crop production. Terracing creates level strips of land separated by risers/banks which are generally protected with perennial vegetation. The level strips intercept runoff and allow it to percolate into soils, increasing soil moisture content, and contributing to recharge of groundwater, which is especially important when dry spells occur. Fodder, trees and shrubs planted on the risers stabilize the terraces and supply fodder for livestock, contributing to increased production of manure, which can be applied to soils to increase soil organic matter and plant nutrients. Additionally, mulching protects the soils and is decomposed by soil organisms, contributing to soil organic matter. The levelled land on terraces, mulching and enhanced soil organic matter helps retain applied fertilizers to feed crops instead of being washed or leached away. These different practices complement each other to increase both crop and livestock production at household level and livelihoods. For households without livestock, the selling of fodder may contribute to household income.

Beans, maize, cassava and Irish potatoes are the focus of crop intensification efforts by the Ministry of Agriculture (MINAGRI) of Rwanda (Kathirezan, 2011). Their intensification pathway lies in the use of improved crop varieties and management practices such as use of mineral fertilizers coupled with organic manure, pest and disease management. There is a need to assess how terraces, mulching, fodder grasses, agroforestry trees and shrubs, as well as manure and mineral NPK (nitrogen, phosphorus, and potassium) fertilizer applications affect the yields of these priority crops and provide co-benefits in the context of Rulindo and Kamonyi Districts of Rwanda.

Methodology

Two micro-catchments were selected. The first micro-catchment is Karambo located in Murambi Sector, Rulindo District in the Northern Province of Rwanda and the second micro-catchment is Gashari located in Kayumbu Sector, Kamonyi District in the Southern Province of Rwanda. The farmer field school (FFS) approach was used as one of the ways of addressing the land degradation issues. Through the FFS approach, agro-ecosystem analysis (AESA) and a range of sustainable land management (SLM) technologies were introduced to groups of farmers working together in a participatory manner.

Through the FFS study plots in Kamonyi and Rulindo, the farmers aimed to determine: (i) the effect of bench terraces on fodder and manure production; and (ii) the effect of terraces, mulching, manure and mineral fertilizer application on cassava and Irish potato yields.

Participatory Research Approach

Prior to this study, a baseline study was conducted to understand the socio-economic situation of farmers in the study area. Data for this paper were derived from two farmer field schools (FFSs). The first FFS group included 30 members (19 women and 11 men) in Karambo, Rulindo District and the second group of 32 members (20 women and 12 men) in Gashari, Kamonyi District. Trials on SLM techniques for two different crops during the 2013A[1] season (i.e. September 2012 – February 2013) were conducted in the study plots.

The main focus of the FFS groups was to improve yields of the Irish potato crop, cassava, maize and beans through the application of SLM technologies. In both Karambo and Gashari, the groups tested soil fertility improvement methods and soil erosion control techniques on a plot that had no history of successful Irish potato cultivation. The plot had been considered difficult to till and not conducive for Irish potato growth. In Karambo, the FFS group focused on growing high yielding cassava varieties and the group undertook trials on soil fertility improvement, soil erosion control and soil moisture conservation techniques by using manure and mulch.

1 In Rwanda, agricultural season A starts in September and ends in December of the same calendar year, agricultural season B starts in March and ends in May of the same calendar year, and agricultural season C starts in June and ends in August of the same calendar year.

Cassava plots were squares of five meters and the improved plant spacing was one meter on the line and between lines. Four treatments were considered:

1. traditional farm practice combined with manure;
2. mulch only;
3. manure and mulch;
4. NPK + manure + mulch.

The traditional farm practice consists of planting cassava with irregular spacing between cuttings without the addition of any soil amendments. In this study, the plot with traditional farm practice treatment received the same number of cuttings as in other treatments (i.e. 25 cuttings planted per plot). Socio-economic and crop data were collected before and after the establishment of the bench terraces. Crop yields were recorded before and after treatments. Furthermore, the livestock [tropical livestock unit (TLU) which is equivalent to 250 kg of animal weight] and fodder were assessed before and after field experimentations in all sites. Assessments were also conducted in both sites on inputs such as manure, improved seeds and on fodder production. Continuous monitoring of manure production and its use in the sites was conducted by FFS facilitators and to record harvested fodder from field borders, bench terrace risers and elsewhere in the area, using data recording forms.

Results and Discussions

Land allocation and manure application to crops

Common bean is the most important crop in Rulindo. Beans are grown by a larger number of farmers (Figure 1A), are allocated a bigger portion of land (Figure 1B), and receive a larger share of manure produced per household (Figure 1C) than any other crop.

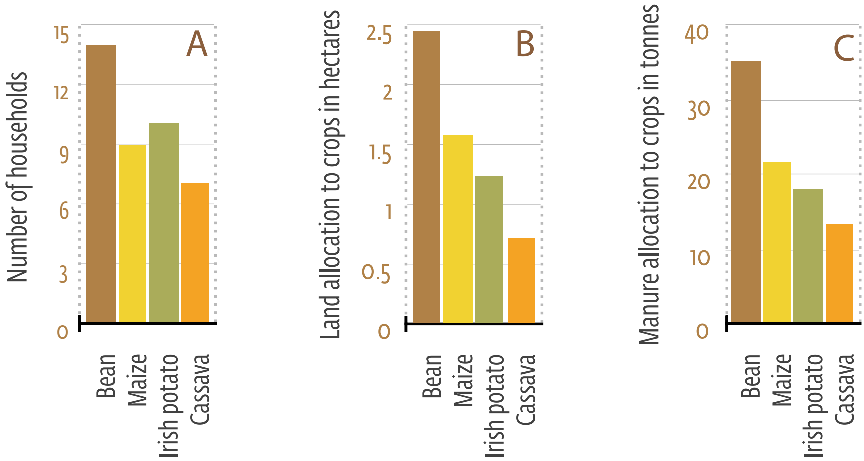

Figure 1: Number of households growing beans, Irish potato, maize and cassava (Figure 1A), size of land allocated to each crop (Figure 1B) and quantity of manure applied to each crop (Figure 1C) in Rulindo District, Rwanda.

Common bean is the most important crop not only in the Northern Province of Rwanda but also across the whole country, occupying a larger portion of cultivated land in the country than any other crop (Bizoza, 2011, Kathiresan, 2011). This is because beans are eaten almost every day by most Rwandans and all meals contain bean as a main food through the year. As a result, Rwanda has the highest bean consumption per capita worldwide (Katherine *et al.*, 2014). Bean is consumed as green leaves (*umushogoro*), green pods before maturity, fresh bean and dry bean (Woomer *et al.*, 2004). Bean is planted as a sole crop or in intercrops with maize, banana, and cassava. Generally in Rulindo District, beans occupied 59 percent of cropped land followed by maize and Irish potatoes.

Livestock are important for providing manure on farm and most farm-households in Rulindo have some small animals such as goats, sheep, pigs, rabbits and poultry (Rulindo District, 2013b). There is a governmental program called One Cow per Poor Family which promotes stall fed cows. Due to this program, on average in 2013 the number of cows/bulls that are stall fed increased up to 25 percent. The One Cow per Poor Family policy together with zero-grazing policy enhances manure production per household.

Figure 2: Crop diversification among 17 observed households in Rulindo in 2013A season,

Cropping diversification is common in Rwanda as well as in East Africa. It consists of growing more than one crop on the same land either intercropped or grown one following another (Waha *et al.*, 2013). This kind of cropping system reduces the risk of complete crop failure, benefits the subsequent crop in rotation as it may contribute to increased soil nitrogen through biological nitrogen fixation (Giller, 2001), or phosphorus through deep pumping of minerals by deep rooted crops, combats erosion through providing shade to the soil, and decreases disease pressure to crops (Waha *et al.*, 2013). It is also liked as it allows householders to diversify and thus better balance their diets through home produced commodities (Woomer *et al.*, 2004).

In this case study, all the seventeen households observed had more than one crop per season despite the smallness of their lands (Figure 2), and as shown in Figure 1A, most of households grow bean.

Effects of bench terraces on fodder production

Making terraces requires planting both grasses and agroforestry trees and shrubs to stabilize risers or banks. By doing so, the fodder production is also increased proportionally with the number of bench terraces made (Figure 3).

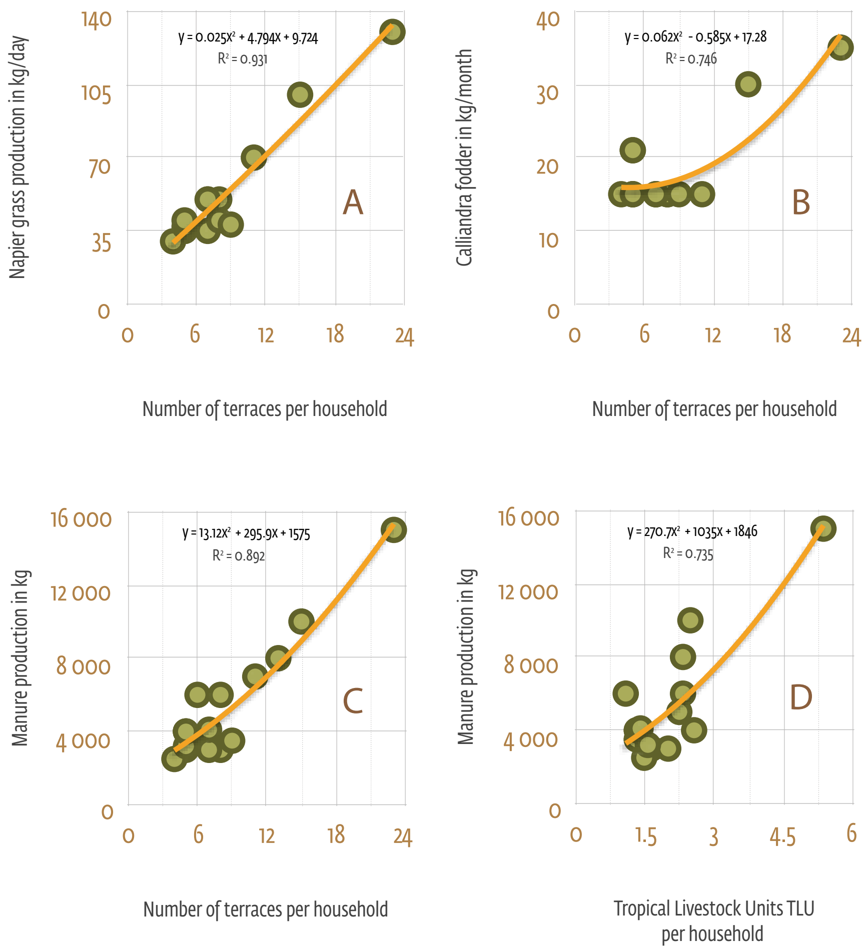

Figure 3: Correlation between the number of bench terraces per household and Napier grass production per household (A), *Calliandra* fodder production per household (B), and manure production per household (C). Manure production is also positively and strongly correlated with the number of Tropical Livestock Units (TLU) per household (D). [TLU is equivalent to 250 kg of animal weight.]

The effect of bench terraces on fodder production is presented in Figure 4. Farmers used to produce very small amounts of Napier grass before terraces were made. After the terraces were established, the production increased five to eight fold (35-130kg/day per hh). *Calliandra* was a new shrub used with terracing, and the production is still low (15-30 kg/month per hh) but expected to increase once the plants are mature. For households with cattle or other livestock, making terraces may mean a significant increase in milk, meat and manure production. Figure 3 C and D show that manure production is positively correlated to the number of terraces per household as well as the number of TLU a household possesses. For poor families without livestock, the increment in fodder production induced by bench terraces may lead to more income as fodder is easily sold to livestock farmers.

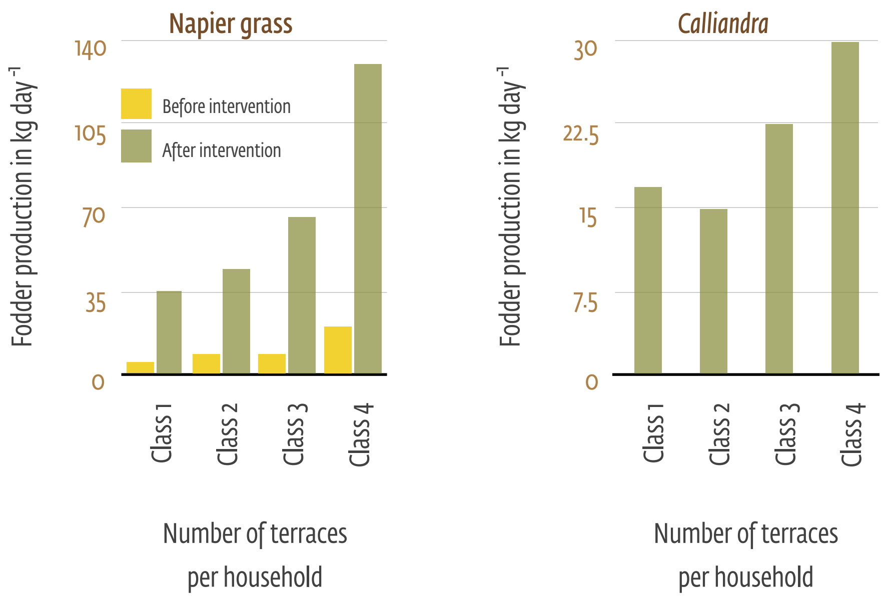

Figure 4: Fodder production per number of terraces per household in sample of 17 farmers in Rulindo[2] in 2013A. [The number of terraces per household was grouped in classes: Class 1 households having 1 to 5 terraces, class 2, 6 to 10 terraces, class 3, 11 to 15 terraces, and class 4, 21 to 25 terraces. The class of 16 to 20 was not found. The length of a terrace varied between 20 and 25m.] reflecting farm field size.

Fodder grasses and trees are planted to stabilize terrace banks or risers, leading to increased fodder production per household. As the number of terraces increases, this scenario leads to feeding livestock with enough or luxurious quantities of fodder, producing larger quantities of urine, dung and litter in the stall and providing more and better quality manure which is returned to crops. When livestock units are many, the quantity of manure is increased for soil fertility restoration. On the contrary, livestock keepers will have to source both fodder and litter from their lands or outside when their home production is not sufficient. The national policy of zero-grazing and stall feeding of animals

2 The number of terraces has been grouped in five categories and a mean per class was used. The Napier grass production is given per day whereas Calliandra production is given per month as the production per day is small.

helps in increasing manure production per household and enhancing livestock productivity.

Effects of mulch and NPK on cassava yields

Planting cassava to a spacing of one by one meters combined with manure and mulch significantly improved cassava root storage by four fold. By combining the spacing, manure, mulch and NPK, cassava root storage increased by six fold (P =0.002) (Figure 5).

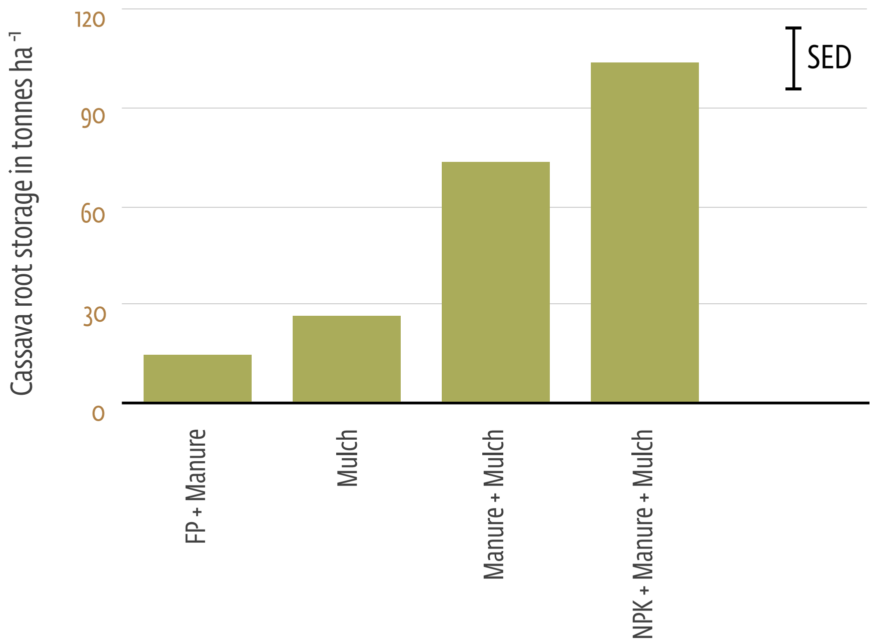

Figure 5: Cassava root storage (tonnes ha^{-1}) observed in 2014 A season at Rulindo, Rwanda. [SED: standard error difference, FP: farmer practice]

Positive effects of mulching on crop production are well-established, attributed to higher soil moisture content, higher availability of phosphorus and potassium and reduced weed density on mulched plots than non-mulched. Additionally, good cassava row arrangement, and the application of NPK fertilizer increased cassava yields in Eastern Democratic Republic of Congo as reported by Pypers *et al*., (2011 and 2012). Application of mulch led to some improvement in yields of cassava in the Kagera TAMP FFS site in Rulindo. Mulching helps to conserve soil moisture longer than bare soils, especially when water is a limiting factor, limits the weed growth, release nutrients as it decays, protects the soil from rain water erosion, etc., hence boosting cassava root storage. There is evidence that farmers from Rulindo should move from their current practice of planting cassava without any regular spacing and manure application to planting in rows, applying mulch and manure, and NPK mineral fertilizer.

Effects of bench terraces and NPK on Irish potato yields

Figure 6 shows that applying 30 tonnes per hectare of fresh manure on terraces significantly increased yield (P = 0.008) of Irish potato as compared to the application of 30 tonnes of fresh manure combined 300 kg of NPK per hectar on soils without soil conservation measures (without terrace or planting grasses on contour line).

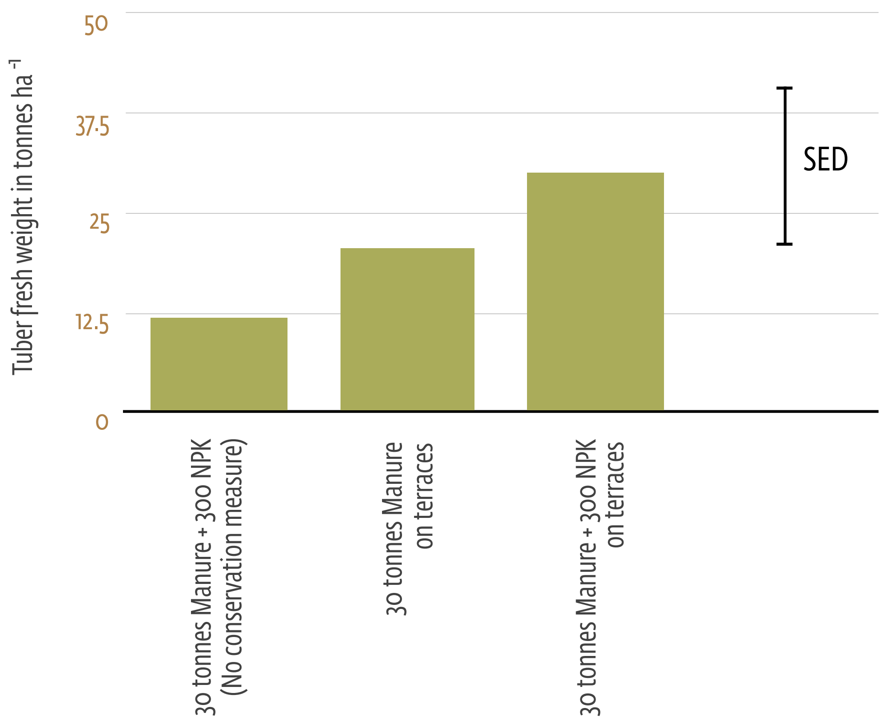

Figure 6: Response of Irish potatoes to bench terraces, manure, and NPK fertilizer application at Rulindo District in 2013A season.

Irrespective to manure and inorganic fertiliser application, potato yields from bench terraces and on soils without conservation measures significantly differed (Figure 6). The average potato yield from plots without soil conservation measures is 12 tonnes per hectare far below that of 30 tonnes per hectare obtained on bench terraces (Figures 6 and 7).

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Figure 7: Harvested field of Irish potato on bench terraces in Karambo micro-catchment, Rulindo District.

Our results corroborate results from Umuhinzi, 2014, and Rural Sector Support Project, 2014. Improvements in Irish potato yield due to terraces have also been reported in Nyanza District – reportedly tripling the yield (Umuhinzi, 2014). In Karongi District, application of manure (30 tonnes per hectare) and NPK (300 kg per hectare) is reported to have increased yields of Irish potato from 3 tonnes to 15 tonnes per hectare, a fivefold increase (Rural Sector Support Project, 2014).

The benefits due to terraces are associated with their ability to reduce rainwater runoff and soil loss. Terraces are able to reduce rainwater runoff and soil loss by 87 and 95 percent, respectively (Chow *et al*., 2010). Halting runoff loss is beneficial especially as increasing weather variability and climate change is augmenting the frequency of rainfall scarcity and severe drought spells – boosting the resilience of production to the impacts of climate change. The reduced runoff allows water to infiltrate and be retained as soil water for uptake as needed by the crop, leading to enhanced production. Additionally, a soil which is lost through erosion by rain splash and runoff is the top soil – the layer of more fertile soil. Reducing soil loss through terracing of steep slopes will maintain the fertile soil in place. Adding enough manure and mineral fertilizer to the level strips generated by terraces ensures the effective use of these resources as they are not washed down slope. Furthermore, high yields observed on terraces in this study are evidence that engineering works were well accomplished, which is not always the case. Care is needed to avoid sloping land vulnerable to landslide and to ensure topsoil is carefully set aside and replaced on bench terraces (level land between risers) during construction for plant growth. Nonetheless, costs of construction (and maintenance) also need to be taken into account.

Conclusions and recommendations

This study of the activities of farmer field school (FFS) groups supported by Kagera TAMP facilitators and technical staff looked at the impacts and benefits associated with the sustainable land management practices in Rulindo and Kamonyi Districts, Rwanda. Growing fodder species on terrace risers increased the fodder production per household per day by five to eight fold compared to before terracing. Fodder and manure production per household increases with the number of terraces a household has (R^2 = 0.931 and 0.892 respectively) and 86 percent of sampled farmers get fodder from terraces. Other SLM practices such as mulching coupled with manure and NPK fertilizer application increased the yields of cassava almost by seven fold. Planting Irish potatoes on terraces with the application of manure and NPK increased the yield three fold compared to yields without terraces with same rates of manure and NPK fertilizer.

The Government of Rwanda (and others wishing to benefit from these findings) is therefore encouraged to increase the investment in sustainable land management practices (such as the small terraces shown in Figure 7) that require investments beyond individual farmer's reach. Farmers, as beneficiaries of terraces, should be encouraged to plant as much fodder grass and agroforestry trees and shrubs as possible, as this contributes to increased manure production for sustainable soil fertility management. Additionally, farmers are encouraged to apply some mineral fertilizers to their crops in addition to the use of manure as losses down-slope are minimized by terraces. However, there is a need to replenish nutrients that are removed with the harvest. As much as farmers can, it is advisable to apply mulch, manure and NPK in their cassava plantations and shift to even plant spacing to optimise plant growth.

Farm diversification, agroecological intensification and agrobiodiversity

for enhanced resilience and sustainability

3.5

Author: Elias Minani

Affiliation: Animal Production Programme, Institute of Agronomic Sciences of Burundi (ISABU), Burundi

Summary

Crop and livestock integration provides the ideal formula for increasing agricultural productivity, promoting sound natural resource management and improving livelihoods for rural communities in the Province of Mwaro in Burundi. Crop and livestock integration activities undertaken in the province by Kagera TAMP diversified the farming activities and showed improvements in soil fertility, restored vegetation and increased agricultural productivity, which in turn enhanced farmers' well-being.

Crop-livestock integration, through better feeding of animals, led to an increase in manure production from 3.2 to 11.8 tonnes by adult head of cattle per year. This was used to improve soil fertility and was the basis for agroecological intensification and increased agricultural productivity. The introduction of forage crops helped to restore protective vegetation and control erosion, while enhancing livestock nutrition and productivity. In addition, the small-scale manufacture of multi-nutrient feed blocks generated a source of revenue for farmers households or local artisans.

Crop-livestock integration provides multiple benefits and is the best way forward for prosperous and sustainable agriculture.

Key words: integrated management, crop-livestock.

Introduction

Crop and livestock farming is a way of life for communities living in rural areas around the Kagera River. However, as a result of demographic pressure coupled with climate change, natural resources and ecosystems – especially soils and vegetation – have been degraded due to land fragmentation and unsustainable crop and livestock intensification (Ministère de l'Agriculture et de l'Elevage, 2009).

The aim of the Transboundary Agro-ecosystem Management Project for the Kagera River Basin (Kagera TAMP) is to combat land degradation and ensure its productive and sustainable use. In particular in the lower reaches of the Kagera River in Mwaro province in Burundi, crop-livestock integration was introduced through a participatory approach as means to address soil fertility depletion and enhance livestock health and productivity. Growing fodder crops for the animals to improve their health and to use the animal manure for replenishing soil organic matter played a crucial role in maintaining soil health and the integrity of agro-ecosystems. Properly managed crop and livestock integration is an effective method for improving productivity while sustaining natural resources addressing the challenges of achieving improved food security, higher household revenues and climate change mitigation.

Methodology

The crop-livestock integration was piloted in the region of Mugamba in Mwaro Province, which suffers from the range of constraints commonly found in the Kagera Basin, including land fragmentation and soil infertility. In particular, Mugamba Region has an annual erratic rainfall of between 1500 mm and 2000 mm (most of which falls in the months of November and March) and acidic soils, due to weathering, leaching and loss of soil organic matter (Gouvernement du Burundi, 2012). The soils are classified as marginal land, unsuited to either agriculture or livestock keeping. However, livestock keeping is prevalent and consequently overgrazed lands have been seriously degraded. Available land is limited and the already poor soils are further depleted of nutrients due to grazing pressures and periodic burning which result in loss of the protective vegetation.

A participatory approach was adopted, using farmer field schools (FFS). Awareness-raising sessions were organized for project partners, including farmers, extension staff and administrative officials. Theory-based training sessions were supplemented by practical sessions in the field in order to strengthen communities' technical and organizational capacities for introducing forage crops and effective zero-grazing techniques, planting fodder hedges along contour lines across the watershed and launching the small-scale manufacture of multi-nutritional feed blocks to enhance livestock health and generate income for the local artisans.

Results Obtained

Increased soil cover and erosion control

Following training sessions on introducing forage crops and stabilising watersheds by planting fodder hedges, more than 21 km of fodder hedges were planted as anti-erosion strips to stabilize slopes, minimise down-slope erosion and supply forage for livestock. Also 4.63 hectares of forage crops were planted on farmers' plots.

Knowledge transfer to farmer partners and local communities

The project helped strengthening capacities for crop and livestock integration through both practical and theory-based training. A total of four theory-based and four practical training sessions were held on the themes of forage crop management, making multi-nutrient feed blocks, milk hygiene and sound livestock management. In total, 257 farmers attended the training sessions and various types of extension material were produced for farmers and field technicians use (two posters, three brochures and two factsheets) in French. These are available for wide use by service providers, and can be translated in English for use accross the Basin.

Small-scale manufacture of multinutrional feed blocks

A total of 33 farmers were trained in making multi-nutrient feed blocks and during the project a total of 3 100 kg of such feed blocks was sold (Figure 1). The ingredients used can be found locally (calcium, bonemeal, *Calliandra* flour, rice bran, molasses, urea and cooking salt). This activity is still continuing, beyond the start-up funding offered by the project.

Figure 1: Small-scale manufacture of multinutrient feed blocks at the Nyakirwa FFS.

A laboratory analysis revealed that the nutritional value of the locally-produced multi-nutrient feed blocks was very high compared with that of manufactured imported feed blocks. The local feed blocks are less expensive (900 FBu per kg compared with 2 700 FBu per kg for a manufactured imported feed block), more nutritious and more palatable.

The FFS members have been invited on a number of occasions to provide training in making multi-nutrient feed blocks to other farmer groups or FFS members who were not directly involved in the project.

Reduced erosion and improved soil fertility through increased vegetation cover and manure production

Anti-erosion hedges planted along contours by FFS members following training by the project are helping to reduce topsoil erosion of the over-grazed hilly landscape, where the soils are acidic and have a high aluminic toxicity (Figure 2).

Figure 2: Integrating forage crops, food crops and erosion control .

Zero-grazing and compost production

To further boost soil fertility and reduce degradation, the project is promoting zero-grazing. Compared with the traditional free-range livestock system, zero-grazing livestock keeping results in a significant increase in manure production. Manure output averages 11.8 tonnes by adult animal per year, compared with 3.2 tonnes by adult animal per year under the traditional system (Gaboryaheze, 1993).

From the cowshed, the manure and litter cannot be directly applied to the fields, as it would be firstly transferred and left mineralizing for two to three months on composting pit. The mineralised manure is then transported in baskets to the field where it is to be used and applied directly to the seedbed (see chapter 4.1. on compost making).

Some reports from elsewhere identify that there are challenges in taking the manure to the fields and spreading it. However, in this area, it is reported that:

> *"Really there is no challenge of labour because to get manure is a good bargain in the rural communities such as in Mwaro Province."*

The increased availability of manure for farms has improved the fertility of fields and reportedly is leading to an increase in crop productivity.

Importantly, zero-grazing has also enabled plant cover to be regenerated on pasturelands. If burning will also be controlled pastureland are expected to gradually replenish soil organic matter through growth and decomposition of above and below ground plant material.

Associations and the gender dimension

In order to promote the adoption of techniques and facilitate their dissemination, the participatory farmer field schools (FFS) approach was used (Figure 3).

Figure 3: FFS members inspect the biomass production of the new forage variety.

This involved 257 farmers organising themselves in four groups or associations which became the direct partner-beneficiaries of the project. Those involved were:

- Abavudukanakivi Association: 33 members (12 men and 21 women)
- Twiyunguruze Association: 54 members (21 men and 33 women)

- Komezubucuti Association: 12 members (four men and eight women)
- Nyakibari Association: 158 members (63 men and 95 women) organised in five FFS groups

In addition to the direct benefits of raising awareness and skills in SLM, membership of the FFS associations was also seen to increase social cohesion through the sharing of a common interest. This is generally seen as a way of preventing social conflict or neighbourhood disputes, which should have lasting benefits beyond the project's lifespan.

It was observed that women were highly active in project implementation. In the associations involved, the level of women's participation is an average of 62.5 percent.

Young people also took part in various activities, taking the place of their parents. In some cases, this was to avoid the absence of the parent when he/she had another family activity or commitment. Furthermore, and encouragingly, some young people were pleased to replace their parents to participate in the project activities. This is a good way to familiarize the young people and to support them to become committed to SLM and integrated crop livestock production. It should contribute to preventing the migration of young people out of rural areas.

An example of crop and livestock integration benefits

A female farmer association member describes the impact of crop and livestock integration:

> *The crop and livestock integration through zero-grazing of cattle has helped to reduce the number of animals on pastureland. The planting of forage crops along contour lines, integrating them with food crops has enabled me to use this technique (Figure 4). With zero-grazing my livestock are producing more manure which I use to improve the soils on my farm. Because I had feed I was given a cow by the Government. This was in recognition of her being a role model for improved agriculture.*

Figure 4: The female farmer describes the advantages of forage crops for her livestock.

This farmer is now also an approved producer of seed potatoes, an activity which earns her extra revenue, on top of the income she receives by selling milk.

As regards food security, the farmer says she has milk all year round since she adopted zero-grazing (this was not the case when her cows were free-ranging). Milk production has also increased, in terms of daily supply and a longer lactation period.

Through the use of manure to feed the soil, production of food crops now exceeds her needs, so much so that she is selling the surplus at market, especially maize and potatoes.

Conclusions and Recommendations

A summary assessment of the project's impact in terms of take-up leaves no doubt as to the sustainability of the results achieved. Crop-livestock integration is a system-based strategy for improved production and sustainable natural resource management and it represents an effective path towards food security. For this reason, it is important to support producers in the process of transforming extensive practices into a more agroecologically intensive system, based on crop-livestock integration.

Faced with problems of scant amounts of land, soil infertility and the need to improve livestock management, farmers have been quick to learn the principles of ecological agriculture that are possible through crop-livestock integration.

However, given the pressure related to lack of investment and inadequate technological knowledge, a number of recommendations can be made based on this experience:

- Strengthen the concept of a solidarity chain to restock local livestock. There is a government program to give a dairy cow to farmers who have planted enough grasses and fodder to practise zero-grazing system. The project has contributed by increasing the capacity of the farmers to respond to the government program on promoting stall fed cattle through training on increasing the availability of fodder and forage. The farmers who receive a cow from the government are then requested to give the first-born female calf to another farmer who has planted also enough grasses and fodder to practise the zero-grazing system;
- Encourage the formation of associations in rural communities to facilitate works of common interest at microcatchment levels;
- Facilitate access to i) seeds and planting material for fodder and forage crops, agroforestry seedlings for increasing tree-cover and restoring soil productivity and providing materials for stall building (e.g. *Calliandra* spp. and *Grevillea robusta*) and also ii) inputs (e.g. making multinutrient mineral blocks) and iii) some equipment such as storage facilities for the range of related different agriculture activities;
- Support income generating activities.

Outcomes and impacts of the adoption of sustainable land management technologies on carbon sequestration

in two micro-catchments in Mbarara District, Uganda

3.6

Author: Dennis Babaasa

Affiliation: Institute of Tropical Forest Conservation, Mbarara University of Science and Technology, Uganda

Summary

The change in carbon-balance due to the adoption of sustainable land management (SLM) technologies by farmers was estimated for Kabingo and Rubagano micro-catchments in the Uganda part of the Kagera River Basin using the Ex-Ante Carbon-balance Tool (EX-ACT)[1]. Adoption of SLM technologies showed an overall carbon sequestration benefit of 16 tonnes of carbon dioxide equivalent (tCO_2e) per hectare per year in Kabingo and 17 tCO_2e per hectare per year in Rubagano micro-catchment, a significant contribution to climate change mitigation. Tree planting was the most important carbon sink the strongest determinant of carbon-stock (responsible for over 95 percent of the carbon-balance). Restoration of soil organic matter through establishment of trenches and infiltration ditches contributed to soil erosion control, enhanced water retention, biomass production and crop yield, and hence carbon sequestration, increased crop yields and contributed other benefits such as control of soil erosion. It is recommended that those SLM practices that lead to climate change mitigation as well as increased agricultural production and food security should be prioritised for SLM up-scaling in the wider landscape.

Key words: mitigation, carbon balance, ex-act.

1 www.fao.org/tc/exact/ex-act-home/en/.

Introduction

Globally, agriculture is a major contributor of greenhouse gases (GHGs) to the atmosphere. The GHGs and associated global warming are largely responsible for the increasing weather variability, frequency of extreme events such as droughts, floods, storms and longer term climate change. However, some agricultural practices that are known to stimulate the accumulation of carbon stocks provide opportunities for climate change mitigation and adaptation (FAO, 2001 and 2013d). Carbon sequestration is very important for agriculture in terms of increased soil organic matter, which impacts on soil properties (texture, clay content and mineralogy as well as acidity), crop production, income and below ground biodiversity. Accumulation of carbon stocks above ground also has a positive impact on biomass production in crop, grazing and woodlands for multiple uses, as well as on the environment in terms of carbon sequestration and air quality. This function, although rather abstract for farmers when promoting sustainable land management (SLM) practices, is extremely important given that climate change negatively impacts on agricultural production. The potential for agriculture to mitigate climate change is regarded as being very high and most cost-effective when compared to non-agriculture sectors like energy (Smith *et al.*, 2008). SLM technologies that contribute to climate adaptation and mitigation as a co-benefit are also more likely to result in improved livelihoods and food security for vulnerable people (FAO 2013d). Agricultural extension services and farmers need to prioritise the adoption of those SLM practices with higher benefits in climate change mitigation and adaptation, as well as food security and rural development.

Objectives

The main goal of this appraisal was to determine the impacts of the adoption of SLM technologies on carbon rate of stocks and stock changes in two Kagera River Basin micro-catchments in Uganda. Specifically, this chapter provides:

i. An assessment of the overall impact of adoption of SLM technologies on carbon sequestration and/or emissions;

ii. A comparison of the different SLM technologies in emitting and/or sequestering carbon.

Methods

Study area

Kabingo and Rubagano micro-catchments are located in Mbarara District, south-west Uganda. The Kagera TAMP project conducted a participatory diagnostic of land and livelihoods showing that the micro-catchments were experiencing major environmental changes, largely resulting from land degradation as a result of the increase in human population and the resultant expansion of agricultural activities into marginal and environmentally sensitive areas like steep slopes. Loss of vegetation cover, soil erosion and general environmental degradation accounted for the trend of decreasing agricultural productivity, increasing poverty and household food insecurity. Thus, the watersheds were in dire need of interventions and plans for more sustainable utilization of land, vegetation and water resources (use of LADA Local Manual).

Through a participatory process, a number of SLM technologies were introduced and adopted by the farmers in the target micro-catchments. The Kagera TAMP progress reports show that these two catchments had the highest number of SLM practices and adopters compared to other micro-catchments in the Uganda part of the Kagera River Basin. It is on this basis that the two catchments were selected for carbon-balance assessment. Data on land use in each micro-catchment was derived from progress reports and discussions with the field extension worker in those areas where change was observed due to project implementation between the project start (2010) and end (2014).

Carbon-balance estimation

The Ex-Ante carbon-balance tool (EX-ACT) Version 5.1.1 Tier One Edition, developed by FAO (2013e), was used to estimate the carbon-balance. Carbon-balance is the net balance from all GHGs expressed in carbon dioxide equivalents that were emitted or sequestered without and with the SLM technologies. The carbon-balance for each SLM activity is calculated and then summed-up for all the SLM practices adopted by farmers in the catchment to determine whether the net result of the project activities was a carbon source or sink. The balance was divided by the land total area, to estimate the tonnes of carbon dioxide equivalent emitted/sequestered per hectare per year (tCO_2e).

Results

SLM technologies adopted

Table 1 shows the SLM technologies introduced by Kagera TAMP and adopted by farmers in Kabingo and Rubagano micro-catchments. With the exception of mulching in Kabingo, the rest of the technologies were applied in both micro-catchments. The Kagera TAMP baseline data shows that none of these SLM technologies were in use in the two micro-catchments before the project started working in the areas in 2010. The SLM technologies were also assigned in terms of carbon-balance main impact area and the EX-ACT modules used. The land areas under SLM technology in Table 1 are relatively small because only sites where SLM practices were initially applied when the project started are included, so that they had been in place for at least two years and their impacts (e.g. improved soil fertility and production) were already visible. However, the same impacts are anticipated in the other sites in the micro-catchments and other catchments in Uganda, since they have comparable land degradation problems and similar interventions have been introduced. Changes in use of fuel wood when using energy saving stoves has not been quantitatively assessed, because the majority of the households have adopted them recently. Much of the tree planting has been done on heavily degraded areas like on steep slopes which have been the hotspots for erosion and where the soils are too shallow and rocky for crop growing so growth is slow.

SLM Technology	Carbon-balance main impact area	EX-ACT module	Quantity	
			Kabingo	Rubagano
Energy saving stoves	Reduced emissions of carbon dioxide per energy produced	Investments (introduction of energy saving technologies)	0.392 tonnes fuelwood/year/ household	0.392 tonnes fuelwood/year/ household
Goat shelters	Reduced emissions of methane and nitrous oxide per production volumes	Livestock (increased animal production)	18 goats	24 goats
Trenches	Carbon sequestration	Crop production (improved cropland management)	4.2 ha	9.2 ha
Tree planting	Carbon sequestration	Land use change (restoration of degraded land)	5.3 ha	12.3 ha
Infiltration ditches	Carbon sequestration	Crop production (improved cropland management)	1 ha	2.5 ha
Mulch	Carbon sequestration	Crop production (no till/residue management)	0.5 ha	-

Table 1: SLM technologies adopted by farmers in Kabingo and Rubagano micro-catchments, Uganda, and their project related EX-ACT modules *(Kagera TAMP unpublished monitoring assessment data August 2014)*.

EX-ACT carbon-balance

The calculations of the overall gross carbon emissions and/or sequestration were made assuming that they will be at equilibrium over a 20 year period. The results in Table 2 indicate that the project created a net sink, with the carbon sequestered being 1 795 tCO_2e and 4 204 tCO_2e for Kabingo and Rubagano respectively. This was equivalent to the estimated potential increase in net carbon sequestration of 339 tCO_2e per hectare in Kabingo and 342 tCO_2e per hectare in Rubagano over the full duration of the analysis (20 years) or estimated actual 16.9 tCO_2e per hectare per year in Kabingo and 17.1 tCO_2e per hectare per year in Rubagano.

Component of the project	Carbon Balance	
	Kabingo	Rubagano
Land use change		
Other (tree planting)	-793	-1 840
Agriculture		
Annual	-113	-240
Perennial	-951	-2 207
Grassland and Livestock		
Livestock (emissions)	62	0
Inputs & Investments		
Fuelwood	0	0
Total	**-1 795**	**-4 204**
Per hectare	**-339**	**-342**
Per hectare per year	**-16.9**	**-17.1**

Table 2: EX-ACT carbon-balance for SLM technologies adopted by farmers in Kabingo and Rubagano micro-catchments, Uganda.

The carbon-balance was differentiated according to EX-ACT software modules. The main components leading to carbon sequestration was the establishment of agroforestry systems on former degraded land that lead to the attainment of a higher reference soil carbon stock from land use change (Kabingo 793 tCO_2e and Rubagano 1 840 tCO_2e) as well as to changes in mainly biomass as well as additional soil carbon impacts due to the established new tree cover (Kabingo 951 tCO_2e and Rubagano 2 207 tCO_2e). Tree planting was therefore the most important carbon sink and at the same time, the strongest determinant of carbon-balance responsible for over 95 percent of the carbon-balance. The carbon losses and sources of GHG emissions were from the keeping of zero-grazing goats. Overall, SLM technology adoption contributed to carbon sequestration and specific SLM technologies that had a higher carbon sequestering benefits should be prioritized when up-scaling the technologies in the wider landscape.

Impacts

One of the most tangible and easily seen results of carbon sequestration was the improvement in yields of several crops that are grown in Rubagano micro-catchment (Table 3). This could be attributed to the changes in cropland management that led to more soil organic matter and hence higher carbon sequestration and soil fertility. The changes in land management and land use have also reduced soil erosion and associated loss of soil organic carbon. Although surface runoff of rainwater still occurs, the volumes of lost water is much lower and relatively clear of soil particles. With such changes in agricultural practices, the challenges of water quality can also be met. Once the changes have taken place over large areas, the frequency and severity of floods will also decrease.

Main crops	Average productivity (yield/ha)	
	Previous (2010/2011)	Current (2013/2014)
Bananas	621 bunches	694 bunches
Beans	122.5 kg	191 kg
Cassava	160.6 kg	271.4 kg
Coffee	576 kg	653.8 kg
Irish potatoes	6.5 bags	9 bags
Maize	120.4 kg	191.5 kg
Sorghum	165.7 kg	213.7 kg
Sweet potatoes	3.6 bags	5.2 bags

Table 3: Changes in yield of crops in Rubagano micro-catchment, Uganda (*Kagera TAMP unpublished monitorin assessment data August 2014*).

Lessons Learned

Farmers always recognize the importance of an SLM technology when it results in material benefits for the farm-household. In order to achieve the carbon sequestration which contributes to global environmental benefits (climate change adaptation and mitigation, supporting and restoring biodiversity and other e.g. air and water quality), those agricultural practices that also ensure enhanced crop and livestock production as well as food security need to be promoted.

Challenge

Kagera TAMP has been running for four years. This is a very short time for the project to ensure institutional strengthening of farmers associations, especially the farmer field schools, and up-scaling of sustainable land-use management practices. More time is required to accomplish them, as that will be when the full, wider environmental restoration and carbon sequestration objectives of the project can be wholly achieved.

Conclusions and recommendations

Based on the analysis, it is recommended that those SLM practices that lead to climate change mitigation as well as increased agricultural production and food security should be prioritised for SLM up-scaling in the wider landscape. The analysis of the Ex-Ante carbon-balance results shows that the SLM project piloted practices have a significant mitigation potential over 20 years, thereby participating in the global effort to lower anthropogenic emission and tackle climate change. The study reflects the agro-ecological mitigation co-benefits on incrementing SLM and watershed level intervention, pointing out potential synergies.

Sustainability can be achieved providing that the project steering committee members and district authorities promote the successful SLM planning and management practices through extension services and further projects and programmes such as LVEMP and NBI.

Conclusion Theme 3

3

Recommendations for multiple benefits scaling up through and agro-ecosystem management approach

As per the title of the project, Transboundary Agro-ecosystems Management Project, the Kagera TAMP activities, including these reported in other chapters of this booklet, were developed in recognition of the need for a deeply integrated agro-ecosystem approach. The case studies elaborate the importance and multiple benefits of integrated approaches based on ecological, economic and social dimensions, using four criteria for sustainability: namely productivity, resilience, stability and equity. Such case studies aimed to address and manage interactions between soil and other components of the agro-ecosystem. These include soil–plant-water–pest-predator interactions in the rhizosphere; soil-plant-livestock-atmospheric interactions through organic matter and nutrient management; natural resources conservation and enhanced productivity through sustainable intensification. These conclusions can be used to inform scaling-up as follows.

Diversification of practices in order to increase ecosystem services provision and livelihood

The success of agro-ecosystem management is rooted in the multiplicity of opportunities that beneficiaries can access throughout the landscape and how SLM practices can contribute to the growth of income generating activities. Crops, livestock, forest, trees, fruits, vegetables and other ecosystem services can be managed together through a combination of practices in the appropriate geographical position in the micro-catchment / watershed. Enabling land users to enhance agro-ecosystem productivity and improve ecosystem services provision and thereby to improve their livelihoods and to sustain project impacts building on the knowledge and lessons learned over the space and time.

Farmers to farmer services

Farmers can be supported to operate as FFS facilitators or peer to peer service providers, with the win-win result of increasing their revenues through increasing knowledge and awareness about the advantages of agro-ecosystem approaches. Farmers and enterprise groups could be linked with the private sector and credit providers to act as trainers, or as skilled artisans for the dissemination of proven local technologies acting as skilled human resources for promoting wider uptake and sustainability. Also, farmers can be empowered to develop and promote appropriate technologies locally.

Capacity development

Capacity development needs to include the multiple vertical and horizontal agro-ecosystem dimensions. So, it has to be scale-independent and to include multi-sector concerns. Capacity should be built on a sense of ownership of the proposed sustainable land management practices, so that stakeholders are willing to contribute in terms of labour and available materials and can introduce endogenous knowledge to further fine-tune technologies. Finally, more field learning sites (various experiential learning groups with different enterprise focus) and demonstration fields (for wider awareness raising activities) should be made available. In order to increase spontaneous adoption of practices that are more labour-intensive, deepened awareness raising is required and innovative knowledge sharing avenues should be encouraged as well as incentive measures.

Payments for ecosystem services

Studies conducted by the project demonstrated that a combination of participatory monitoring, use of new sources of data and modelling, and the installation of some automated equipment can be usefully combined to inform and track the implementation of SLM practices. This can support payment for Watershed Services (PWS) schemes by demonstrating benefits on hydrological services downstream that could justify reimbursing SLM actions undertaken upstream (see box in the next page). In such cases, the engagement of local and downstream water users in the development of a monitoring network may increase acceptance of new technologies, enhance confidence in results, and improve stakeholder knowledge of the actual and wider potential hydrological benefits of SLM. Within Kagera TAMP activities in Rwanda, the monitoring provided some evidence that soil and water conservation measures can for average rainfall events contribute to runoff capture, erosion control and rainwater harvesting. While modelling and scenario analysis suggests that the combination of in-situ and ex-situ technologies can significantly reduce erosion and runoff even for relatively large rainfall events.

Importance of monitoring in the scaling up of watershed services incentives in Rwanda

Incentives or Payment for Environmental Services (PES) schemes, in regards to watersheds services, involve downstream water users paying or encouraging upstream famers to protect and/or restore such hydrological services. Such Payment for Watershed Services (PWS) should be conditional of a measurable increase in the watershed services provided (Engel *et al*., 2008; Wunder, 2015). However, in the absence of hydrological monitoring, it is difficult for PWS schemes to both detect changes in hydrology with any confidence and to attribute any changes to the SLM practices implemented (Asquith *et al*., 2008). As a result, the monitoring of most PWS schemes is based on compliance, rather than evidence that SLM practices have had a positive impact (Smith *et al*., 2013; Ponette-Gonzalez *et al*., 2014; Porras *et al*., 2013). In other words, as long as upstream land users implement the SLM required by the PWS agreement then they are paid, even if there is no indication that the expected improvements in watershed services have materialised, which places the risks of a PES scheme primarily on the buyers for watershed services. Therefore, for a PWS scheme to be robust and fair and achieve the principle of conditionality hydrological monitoring is important.

In the East Africa region, many proposed PWS schemes have not made it past the design phase, and for those that have, hydrological monitoring of the impacts has generally been limited. Fisher *et al*. (2010) reviewed the feasibility of watershed PWS schemes in the Rufiji and Pangani Basins in Tanzania and found that a lack of hydrological data hindered the successful development of schemes. To support a PWS scheme in the Lake Naivasha Basin in Kenya, which aimed to encourage the adoption of SLM techniques by smallholder farmers, four river gauges were installed and on-farm monitoring carried out. However the data collected has yet to provide any evidence that SLM has resulted in hydrological benefits (Chiramba *et al*., 2012). A PWS scheme was successfully established in a small subcatchment of the Ruvu Basin located in the Uluguru Mountains in Tanzania; but, despite the installation of a hydrometric network, no improvement in watershed services was recorded, in part due to the small area to which SLM was applied (Lopa *et al*., 2012). These examples illustrate the difficulty of successfully developing a PES scheme

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in which payments are conditional on measured improvements in watershed services. For a PWS scheme to work there needs to be a shared perception, by upstream farmers and downstream water users, both of the watershed services provided by a catchment and of the actions necessary to restore/protect these services (Jeanes *et al*., 2006). If developed successfully, PES schemes can provide a framework both for the funding and implementation of SLM and for monitoring its hydrological impacts.

Figure 1: Agricultural expansion onto steep slopes, forest degradation and erosion in the Marebe catchment, Rwanda.

The establishment of a baseline that encapsulates the hydrological variability of a catchment is the foundation upon which a PWS scheme should ideally be developed (Smith *et al*., 2013). A robust baseline allows the additionality of a PWS scheme to be estimated by calculating the net positive impact of interventions relative to the situation where they were not implemented (Porras *et al*., 2013). More accurate estimation of additionality (and potential negative externalities) also makes it easier to assess the financial feasibility of a scheme, and in particular whether the benefits gained by downstream users are worth the payments they made. However, many PWS schemes do not undertake hydrological monitoring due to the cost and the limited amount of time often available to establish a baseline prior to any interventions (Ponette-Gonzalez *et al*., 2014).

The Kagera TAMP undertook a study whose primary aim was to quantify and evaluate the hydrological impacts of SLM on a small catchment in Rwanda. This was achieved primarily through the establishment of a participatory monitoring network, the acquisition of relevant secondary information from open-access databases and the application of a hydrological model and scenario building. In addition, the role that local participation could play in the monitoring was investigated and the possibility explored of upscaling SLM and hydrological monitoring to the wider meso-scale catchment, potentially through the development of a PWS scheme.

Findings and main suggestions to scale up of Payment for Watershed Services are listed below:

- The hydrological monitoring and scenario analysis carried out by this Kagera TAMP study provided insights into the hydrology of the catchment and allowed an assessment to be made of the current and potential impacts of SLM. Results showed that the discharge of the catchment responds rapidly to rainfall and appears to be related closely to surface water/groundwater interactions and connectivity. Turbidity response to rainfall was generally slower and apparent anticlockwise hysteresis effects suggested that erosion was widespread across the catchment during rainfall events. This and other observations support the conclusion that, in recent years, land use change, land degradation and erosion have significantly altered the hydrology of the catchment. In particular, increased hydrological connectivity, caused in part by the expanded gully and footpath networks, allows runoff and sediment to be conveyed more quickly to the stream network.

- The monitoring provided some evidence that ex-situ rain water harvesting structures can combat the present soil water erosion problem by reducing runoff for smaller rainfall events, while modelling and scenario analysis suggests that the combination of in-situ and ex-situ technologies can significantly reduce erosion and runoff even for relatively large rainfall events.

- For PES schemes aimed at protecting hydrological services, the engagement of local and downstream water users in the development of a monitoring network may increase their confidence in results and their belief that investments in SLM are worthwhile (Le Tellier *et al*., 2009). For any SLM

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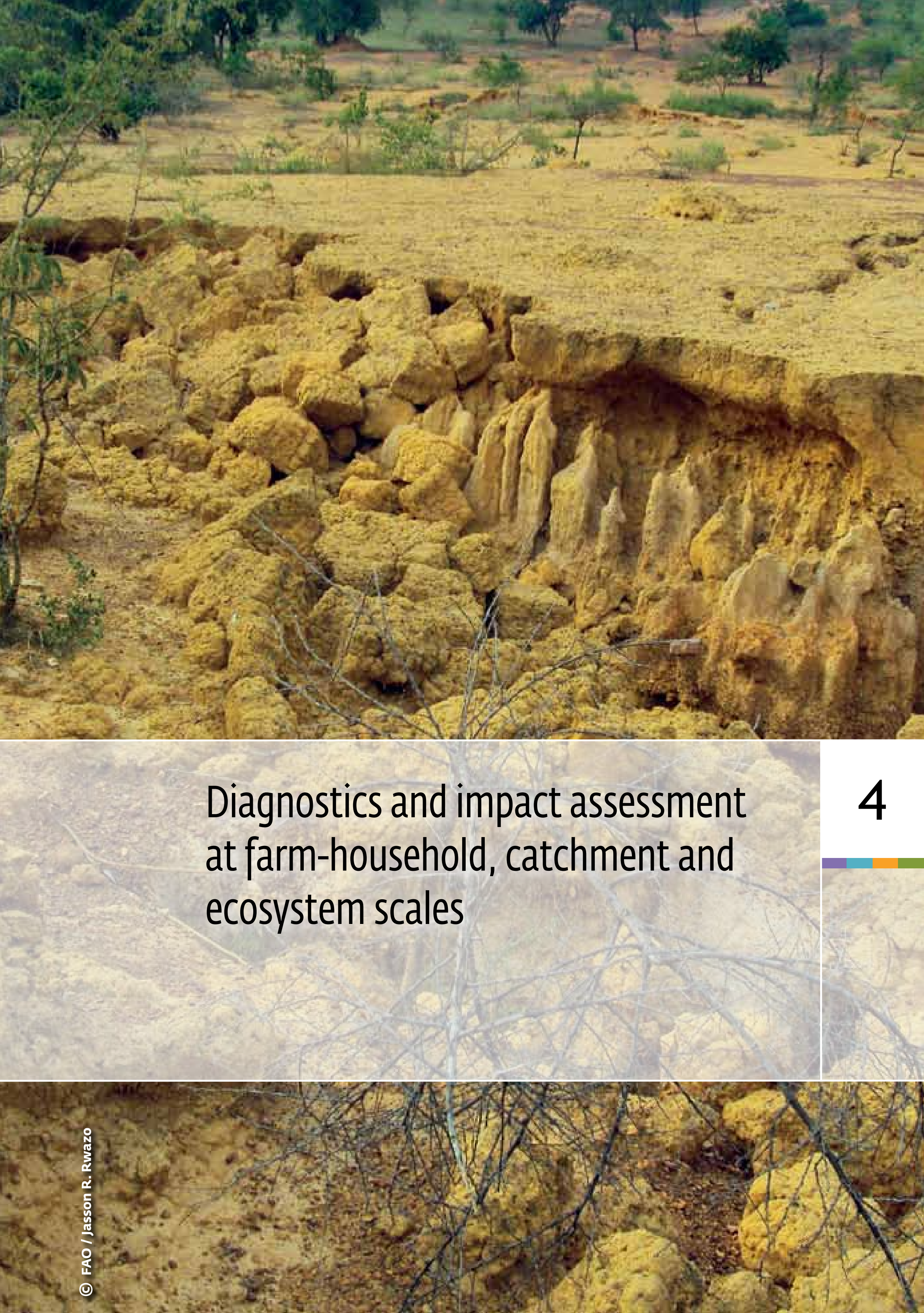
work to be successful, local acceptance of the SLM interventions and trust between key stakeholders is essential (Nyssen *et al*., 2007; Fisher *et al*., 2010; Bond and Meyers, 2010). Acceptance can be encouraged by involving the local community in monitoring, and increasing their knowledge of the hydrological benefits of SLM.

- Overall, a combination of participatory monitoring, use of new sources of data and modelling, and the installation of some automated equipment looks to be the best way to inform and track the implementation of SLM across the entire Yanze catchment in Rwanda and in other areas of the Kagera Basin.

Figure 2: SLM activities in the Karambo catchment, Rwanda.

Source: Batchelor, J., Birori, M., 2016. Assessing the hydrological Impacts of Sustainable Land Management in the Kagera Basin. A case study of the Marebe catchment, Rwanda. Kagera TAMP project report.



4

Diagnostics and impact assessment at farm-household, catchment and ecosystem scales

Introduction

The present theme describes how a variety of tools and methods were used to assess and quantify the nature, extent, severity and impacts of land degradation and sustainable land management on Kagera agro-ecosystems, from the micro-catchment to river basin level. It also presents how the project developed local, national, and international (transboundary) capacity to analyze, design, and plan assessment systems and to derive appropriate conclusions that guided interventions on the ground in an adaptive manner. A number of proven methodological frameworks and tools were applied which provided flexibility and accommodated the country and local circumstances where assessments were undertaken. Procedures made ample use of participatory rural appraisals, expert assessment, field measurements, but also involved remote sensing and GIS modelling as appropriate. Finally, the section describes how data have been transferred to local and national institutions and will therefore be available to inform future studies and interventions.

In this section, the five chapters present the findings that deal with diagnosis of land degradation and existing SLM practices including impacts at farm-household, catchment and ecosystem levels.

Chapter 4.1 describes how the LADA methodology for local assessment - LADA Local (FAO, 2011b) was used to characterize land degradation processes, their causes and impacts in Kyazi micro-catchment, Missenyi District, in the Kagera Region of Tanzania. It enabled local actors to assess the extent to which land resources (soil, vegetation, and water) and landscapes/ecosystems are being conserved or improved by sustainable land management (SLM) practices. The chapter presents the guiding principles that should be adhered to for successful implementation of LADA Local tools for assessing land degradation and SLM. Indigenous technical knowledge was given weight and used in a balanced and complementary way with scientific knowledge. Finally, policy implications and challenges encountered during LADA Local application are also described.

Chapter 4.2 presents an empirical assessment of land degradation and technologies for improved land management in selected districts where the Kagera TAMP was implemented in Uganda. The assessment was carried-out by adapting the WOCAT Questionnaire for Mapping Land Degradation and Sustainable Land Management (FAO-WOCAT, 2011) and using the adapted questionnaire to facilitate discussions with community based organisations (CBOs) leading to implementation of SLM in the micro-catchments. Determinants and causes of land degradation, conservation technologies used in the selected micro-catchments and their effectiveness, and limitations to use of different conservation technologies are presented in this chapter.

Chapter 4.3 presents a case study of one of the SLM technologies piloted in Tanzania to improve SLM. A cost-benefit analysis of contour bunds stabilized with lemon grass, pineapples, farmyard manure and grass mulch in banana farming was carried-out. To assess whether the technology was profitable or not, a comparison between the situation "with" and "without" the SLM technology, including the costs and benefits accruing, were enumerated for both establishment and maintenance of the technology and a cost benefit ratio was computed. Costs and benefits have been shown to play a central role in adoption of SLM technologies. Liniger *et al*., (2011) recommended that investments in SLM should aim at both short-term (rapid) and long-term (sustained) paybacks. Thus inputs for both initial establishment and continued maintenance need to be compared with benefits.

Chapter 4.4 deals with the impact of sustainable land management technologies on food security and livelihoods in Uganda. The impacts of the SLM interventions implemented by the Kagera TAMP were evaluated through a performance and outcome assessment for which primary data was collected from beneficiary households, members of farmer field schools and key informants in the target micro-catchments in the six project districts in Uganda. The findings of the interviews with the primary SLM beneficiaries and project records were used to assign the livelihood benefits in terms of the five major livelihood capitals (physical, human, natural, financial and social) that have accrued to the beneficiaries.

Chapter 4.5 describes the participatory multi-sector process which was adopted in the Kagera TAMP to assess and map land degradation and sustainable land management for the entire basin (FAO-WOCAT, 2011 and FAO, 2011c). The resulting data and maps were used to inform the project intervention strategy, to identify best practices for SLM in the region for scaling-up and to guide effective and responsive interventions at various scales. SLM implementation at farm and catchment levels, was guided by field assessment of SLM performance and impacts and by analysis of barriers and constraints to wider uptake. Results also inform policy making, planning and budgetary allocations by the concerned technical sectors at district and transboundary levels and serve as a baseline for more integrated landscape management approaches.

Finally, **chapter 4.6** analyses the project monitoring and evaluation systems. It lists the project results highlighting the type and scope of SLM adoption and scale-up that has taken place in the project area as a direct result of improvements initiated by Kagera TAMP. Also, SLM provides a large set of diverse environmental benefits, between which change mitigation benefits. Thus, the second part of the chapter focuses on the estimation of the GHG through the Kagera TAMP activities.

Experiences and lessons learnt in application of LADA methodological approach and tools for local level assessment

4.1

The case of Kyazi micro catchment Missenyi District in Tanzania

Author: **Allan I. Bubelwa‡, Fidelis B. Kahiura***

Affiliation: ‡ *Multidisciplinary Sustainable Land Management team of Missenyi District*

* *Kagera TAMP project staff*

Summary

The Kagera River Basin is experiencing rampant and unsustainable use of its land resources – including physical, biological and chemical degradation. To analyse land degradation and to identify sustainable land management practices, the LADA Local Assessment (LADA Local) method was applied in the Kyazi microcatchment in Tanzania. LADA Local is a standard methodological approach and tool-kit used for the assessment of human and natural induced land degradation processes, their causes and impacts at local scale in collaboration with ground-based stakeholders and indigenous communities. The approach is also used to assess the extent to which land resources (soil, vegetation, and water) and landscapes/ecosystems are being conserved or improved by sustainable land management (SLM) practices[1].

This article describes the outcome of the analysis, the recommendations gathered at the watershed level and the lessons learned, including their policy implications.

1 Detailed information about LADA Local is available at the following link: www.fao.org/nr/kagera/tools-and-methods/lada-local-level-assessment-manuals/en/.

The indigenous innovations were recorded also in the WOCAT online database for sustainable land management technologies and approaches[2].

Key words: assessment, LADA, WOCAT, causes, impacts, SLM.

Introduction

The Kyazi microcatchment is located in Kitobo ward, Kiziba division, Missenyi District in the Kagera Region of Tanzania. Kyazi microcatchment discharges its water into Ngono River which is a tributary of the Kagera River. The microcatchment is therefore part of a nested series of catchments which form the Kagera River drainage basin.

The livelihood and well-being of the vast majority of the population in Kyazi village depends almost entirely on the land resources within their community territory including agriculture, livestock keeping, forestry, fisheries, stone and sand mining, brick making, etc.

Despite this high dependency on land, Kyazi like other microcatchments within the Kagera River Basin was experiencing rampant unsustainable use of its land resources - including physical, biological and chemical degradation.

The cause of widespread land degradation was largely due to absence of effective, concrete and site-specific agro-ecosystem-based sustainable land management (SLM) plans. The reason behind this situation was the lack of participatory SLM analysis and planning skills among the local rural development facilitators and advisors. In the Tanzania context, it was found that even though the rural development advisors were frequently being trained on participatory rural appraisal, the trainings were largely not action based and, thus, there was still bias towards conventional methods of SLM planning, characterized by passive participation of beneficiary communities/land users. The result was unsound and ineffective SLM plans, typified by insufficient land user ownership, commitment and self-help initiatives as well as lack of strategic vision and uncoordinated sectoral interventions.

2 Detailed information about WOCAT is available at the following link: www.wocat.net/.

The statement below was made by one of the land users during the Kyazi catchment characterization exercise. Mr. Kabandwa, an elder, sounds skeptical but reflects a true sad reality.

Swahili: *"Kabla ya mafunzo haya wataalam walikuja na mambo yao na walitushirikisha kwa kutupa mambo yao hawakupenda kutumia muda kujifunza kwa nini tunafanya kama tunavyo fanya."*

English: *"Before LADA training, development advisors used to come with pre-conceived intuitions and were biased towards a passive type of participation. They didn't spend enough time to learn about the logic behind our actions."*

This undesirable situation confirmed the need for the development of a resource pool of rural development advisors with participatory SLM analysis and planning skills, who could play the pivotal role of facilitating community assessment of land degradation processes and the development of demand-driven, site-specific, long-term, productive and environmentally sound SLM plans.

Recognising that the problems experienced in Kyazi microcatchment were common to other microcatchments within the Kagera River Basin, the Kagera TAMP organized an action-based LADA Local training workshop for rural development advisers of various background from all TAMP implementing districts in Uganda and Tanzania in 2012. The training was conducted in Bukoba rural district (see Box 1).

In the case of Tanzania, the training resulted in the emergence of a pool of 20 district-level facilitators competent in the application of LADA methodology and tools for participatory land resources assessment and SLaM planning. Five of these facilitators were from Missenyi District Council, where the Kyazi microcatchment is located.

Having set in place a resource pool of five facilitators competent in the application of LADA Local (FAO, 2011b), in July 2012 Missenyi District Council, supported by Kagera TAMP, embarked on application of LADA Local analytical techniques in characterization of the Kyazi microcatchment. LADA Local was used in assessing land degradation processes, their causes and impacts. The process involved collaboration and active participation of the land users/communities and local stakeholders. The focus was on both socio-economic (human) and bio-physically (natural) induced land degradation processes. LADA Local was also used in uncovering the extent to which land resources (soil, vegetation, water and animal) and landscapes/ecosystems were being conserved/improved by the successful SLM practices (indigenous or scientific) found existing on the ground.

Methodological approach and tools

LADA Local (FAO, 2011b) involved application of participatory analytical tools, outline questionnaire and questioning skills to stimulate community participatory dialogues. During the process, questionnaires and analytical tools were adapted to the local context and terminologies. The tools were applied to assess biophysical and human tools largely applied were those about physical interactions and schematic idealization used in the identification and uncovering of unknown or partially know facts and experiences about existing degradation problems and the extent of use of existing indigenous/traditional knowledge, and successful land resource and landscapes/ecosystem management techniques.

The guiding principles adhered to included:

- Attitude and behavioural changes among facilitators (IIED, 1996); through purposeful and candid use of the knowledge sharing square (see Box 1 for details); and respect of the dos and the don'ts (that is what SLM development advisors are supposed to do or not to do while facilitating grassroots LADA participatory dialogues).
- Giving weight to land users' indigenous technical knowledge and use it in a balanced and complementary way the scientific knowledge. Handing over the stick was a fundamental rule insisted on among facilitators where the Kyazi communities were empowered to take the leading role/the driver's seat in the SLM analysis and planning process. The photographs in Figure 1 illustrate part of LADA participatory dialogue using community territorial mapping and transect walk. Community territorial mapping and a transect walk used in combination with questioning skills partly uncovered useful information concerning the existing land degradation processes, their causes and impacts - and furthermore revealed the extent to which land resources and landscapes/ecosystems were being conserved and managed.

KNOWLEDGE SHARING	LAND USERS KNOW	LAND USERS DON'T KNOW
SLM ADVISORS KNOW	land users know/SLM advisors know	land users don't know/SLM advisors know
SLM ADVISORS DON'T KNOW	land users know/SLM advisors don't know	land users don't know/SLM advisors don't know

In this square both indigenous and scientific SLM knowledge base are combined in a balanced and complementary manner.

In this square development agents should strive to enable the local community to understand the principle and logic behind a particular scientific SLM measures.

In this square development agents need to empty their head by at least 60 percent and leave a space to accommodate new ideas and learn the logic behind successful indigenous or traditional SLM knowledge.

In this square development agent and local community jointly embark on a client oriented research to find out appropriate SLM solution (this is a researchable issue).

Box 1: Knowledge sharing square.

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Figure 1: Application of LADA Local method.

(Left: land users undergoing LADA participatory dialogue using community territorial mapping; Centre: development of a schematic map of Kyazi village territorial map drawn using locally available materials; Right: physical analysis of the land resources and landscape using transect walk across Kyazi microcatchment.)

Figure 2: Gully erosion identified through LADA microcatchment characterization.

Outcomes from the application of LADA Local method

The application of LADA Local significantly contributed to the characterization of the Kyazi microcatchment, as well as in the identification and understanding of land degradation processes, SLM uptake, their causes and drivers (see Figure 2). All the results were amalgamated and shaped into the Kyazi community participatory SLM plan. The developed plan opened opportunities for testing, demonstrating and up-scaling of various site-specific SLM technologies and thus forms the basis of the ongoing SLM interventions in Kyazi microcatchment.

The LADA Local analysis process resulted in the emergence of the currently widely and broadly used community integrated catchment ecosystem approach, which comprises three major alternative SLM approaches: SLM farmer field schools (SLM-FFS); SLM demos; SML income generating activities.

The community integrated catchment ecosystem approach which started from the LADA Local approach has contributed to increasing stakeholders' capacity and knowledge for promoting and replicating integrated agro-ecosystem management at all levels (i.e. village, ward and district levels).

Through use of the developed community participatory SLM plan, land users and the community in Kyazi village were able to identify and mobilize existing SLM resources and to search and negotiate for external support from various sources including the Kagera TAMP, Missenyi District Council (co-funding support), SCC-Vi Agroforestry, the KOLPIN Society and World Vision.

As an example, through the plan the community negotiated with Kagera TAMP to obtain external resources and was supported with 8 000 000 TZS ($4 706) to undertake varios agro-ecosystem based watershed level activities. This included running three SLM farmer field schools, two SLM demonstrations (soil moisture conservation; pasture improvement), two community related activities (water source rehabilitation; degraded pastures restoration) and 20 SLM income generating activities (five bee-keeping and 15 goat SLM-related income generating projects).

Implementation of Kyazi SLM community participatory plan opened and paved a way to a range of ecological, production, socio-cultural and economic benefits, which are proving various benefits. These included increased use of environmentally friendly agricultural practices; declining incidence of uncontrolled fire burning; boosted law enforcement against land degradation (e.g. against pollution of the water sources and destructive stone and sand mining); use and rapid expansion of crop-livestock integration and conservation of pasture in the Ngono riverbank ecosystem.

Besides describing the land degradation status, the LADA Local analysis also contributed in bringing to light previously unknown facts about the extent and use of indigenous and traditional knowledge in conservation/improvement of land resources. The LADA Local assessment uncovered and highlighted successful SLM practices for documentation through WOCAT (Figure 3). It is through LADA Local that SLM specialists working in collaboration with the community in Kyazi village came across the improved *Kibanja* farming system (see Glossary for definition), exemplifying a distinctive traditional improvement of the banana land use system. The WOCAT Technologies and Approaches (QT and QA questionnaires, WOCAT, 2008a and 2008b) framework was used to evaluate and document the *Kibanja* farming system and the results were entered into the WOCAT global database for wider sharing and use. In reality, land users used the technology as a customary practice inherited from elders but were unaware of the principle

Figure 3: Traditional water retention forms part of the successful *Kibanja* farming system.

behind it as a sustainable land use practice. LADA Local assisted in enabling farmer understanding of the deeper insight about the technology.

Application of LADA-WOCAT also enabled the assessment and understanding of existing analytical and facilitation gaps and SLM training needs within the village/ward and at district levels. Based on the identified gaps and needs assessments, a SLM training program was developed and district and field extension officers then benefited from a series of process phased, action-based SLM capacity building trainings. Training included various SLM practices; SLM farmer field school; the application of QT and QA documentation; principles of payment for ecosystems services (PES); integrated policy and legislation training; natural resource conflict resolution; the use of land use system mapping (LUS, FAO 2011c) and of the Questionnaire for Mapping (QM) land degradation and sustainable land management (FAO-WOCAT, 2011).

LADA Local assessment policy implications

LADA Local level assessment opened-up opportunities for documentation, dissemination and advocacy (DDA process) of the so-called "core" and "sensitive" SLM issues. Details of the key land degradation issues and recommendations for SLM revealed through application of LADA Local (see Box 2) were forwarded through various fora to policy makers as part and parcel of SLM lobbying and advocacy.

> In Kyazi microcatchment, through LADA Local analysis, it was revealed that pasture establishment in areas where livestock keepers keep a large number of stock is a bit complicated because its practicability relies on assurance in terms of ownership and availability of adequate grazing and water resources for the community and transient livestock herds, needing the attention of policy makers. Having realized this, livestock keepers in Kyazi village forwarded this issue to the Honourable Member of Parliament representing their Constituency (Nkenge) for consideration and inclusion in the on-going national constitutional reform which is currently taking place in Tanzania.

Box 2: Policy issues for a microcatchment highlighted by LADA Local.

Furthermore information gathered through LADA Local community participatory dialogues were partly used by experts outsourced by the Kagera TAMP to identify and develop technical and policy recommendations for promoting and sustaining SLM in the Kagera Region and Tanzania as a whole.

Challenges encountered during LADA Local application

- Failure of some SLM facilitators, especially at the field level, to adhere to the basic principles of PRA in terms of attitude and behaviour, awareness of the differential knowledge of land users and advisers, and do's and dont's of facilitation. To some extent, this impaired maximum sharing of experience and knowledge about SLM.
- Lack of flexibility among some facilitators, characterized by the mechanical use of LADA Local tools and questionnaires for data extraction rather than learning and identifying opportunities for present and future SLM

collaboration and improvements. In other words, some facilitators were largely problem focused and not opportunity focused. This created difficulties in helping communities/land users to design appropriate and functional SLM interventions.

- Generally the WOCAT tool are very useful, but the bulkiness of the QT questionnaire is discouraging to facilitators and potential beneficiaries alike. Some sections are too demanding and not easy to complete at local level (e.g. on the spot quantification of ecological and cultural benefits). To some extent QT was considered by some practitioners (WOCATEERS) as not user friendly.

Recommendations

- LADA Local application should be preceded by thorough and intensive training of SLM facilitators on the basic principles and tools of participation (i.e. using tools attitude and behavioural changes – the ABCs of PRA, the knowledge square for awareness of differential knowledge of land users and advisers and the do's and the don'ts of facilitation) – with periodic refresher courses. Otherwise, poorly prepared application may lead to unintended and undesirable results.
- Effective application of LADA Local requires facilitators to have a technical background in SLM but also to be capable and flexible in their approach in applying LADA Local as an analytical tool. The mind set of development advisers at the field and district level should be oriented and focused towards the existing opportunities and obstacles to sustainable land management, rather than being biased to problem focus.

During 2016 the WOCAT SLM technologies (QT) and approaches (QA) questionnaires are being streamlined as user-friendly, on- line tools for SLM practitioners and reporting on SLM best practices by country Parties to the UNCCD Convention to Combat Desertification.

The new Global Database is available at: https://qcat.wocat.net/.

Conclusion

LADA Local is a useful methodological approach and tool. With LADA Local, land users working in collaboration with development advisers can analyze land degradation process, their causes and impacts and furthermore uncover the extent to which land resources and their local landscapes/ecosystems are being conserved. In a holistic manner, the findings can be shaped into a workable community microcatchment-specific SLM plan. LADA Local furthermore uncovers salient issues for SLM policy formulation and for designing people-centered SLM capacity building programs.

Scaling-up and mainstreaming of LADA Local analytical skills to staff in the lower and higher levels of local governments is therefore recommended for maximum performance in SLM.

Assessment of land degradation and technologies for improved land management

4.2

The determinants of land degradation in selected districts in Uganda

Author: **Benard Onzima, Bernard Mwesigwa, Wilson Bamwerinde**

Affiliation: Kagera TAMP project staff

Summary

In order to assess the level of degradation in the microcatchments before the start of the project interventions and to assess the impact of the conservation and management approaches and technologies to be promoted by the project, the jointly developed LADA-WOCAT tools and methods (FAO, 2011a; WOCAT, 2008a and 2008b) were used. Soil erosion due to accelerated runoff was found to be the most widespread cause of land degradation. Other processes of soil and vegetation degradation were also prevalent and the effectiveness of the project supported soil and water conservation techniques depended on the location in the landscape. The most adapted technology combinations were chosen based on slope, altitude and land use.

Key words: LADA, WOCAT, assessment, soil erosion, causes, impacts, SLM, effectiveness.

Background

In order to assess the extent of land degradation in selected microcatchments and the conservation approaches being used, the LADA-WOCAT (2011) methodology was used to facilitate discussions with leaders of the community based organisations (CBOs) leading implementation of SLM in the microcatchments. The objective of this was to gauge the level of degradation in the microcatchments before the start of the project (baseline) and to assess the impact of the conservation approaches and technologies promoted by the project in managing the land resources.

First a land use map was prepared through analysis of available remote sensing imaging and key informant (KI) interviews with leaders of the CBOs that piloted SLM approaches in the project districts in Uganda. The analysis and mapping revealed that 50 percent of the land was used for a mixture of crops and livestock (see Figure 1 prepared within activities described in chapter 4.5). The rest of the land was under exclusive crop or grazing land with smaller areas of swamp and forest.

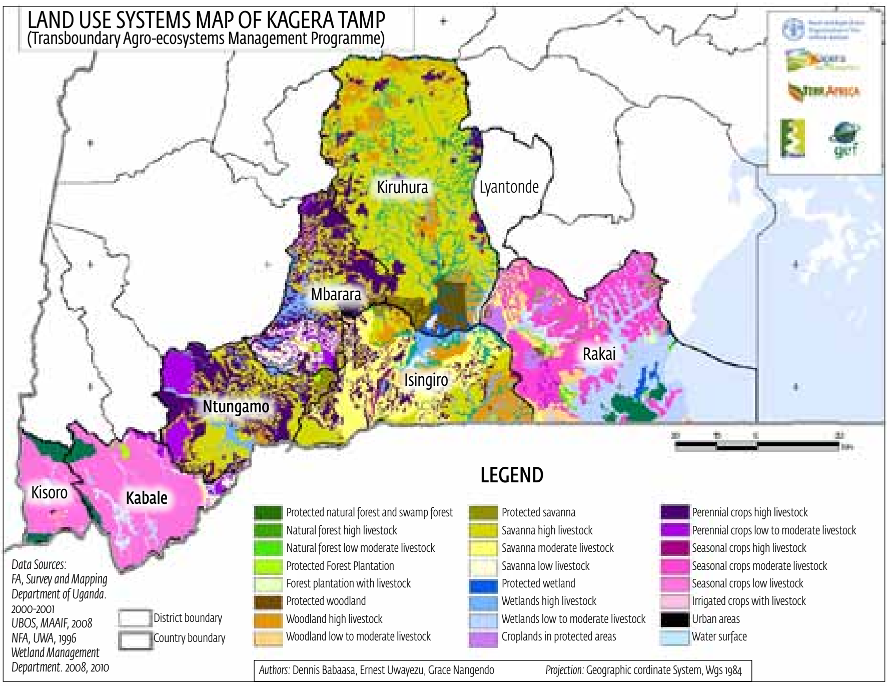

Figure 1: Land use systems in the project districts in Uganda.

Methodology

The LADA-WOCAT (2011) Questionnaire for Mapping Land Degradation and Sustainable Land Management (SLM) was adapted and used to facilitate discussions. Classifications and definitions from the manual for the Local Level Assessment (FAO, 2011b) of Land Degradation and SLM were also used. Key informant interviews with leaders of the CBOs that piloted SLM approaches in the project districts were the main source of information on the ground. After compiling the data in computer format, simple statistics were computed to analyse the root and map based land degradation and SLM knowledge.

Determinants and causes of land degradation

Degradation can have direct and indirect causes. Based on the participatory application of the land-livelihood diagnostic outlined in the manual for the Local Level Assessment (FAO, 2011b), key informant (KI) interviews revealed that the main direct cause of degradation was deforestation and removal of natural vegetation. Improper management of annual, perennial (e.g. grass), shrub and tree crops, and improper soil management, overgrazing and natural causes were the other main direct causes of land degradation.

Direct causes of land degradation	% of KIs (n=9)
Improper management of annual, perennial, shrub and tree crops	67
Deforestation and removal of natural vegetation	78
Improper management of the soil	33
Natural causes	33
Over-exploitation of vegetation for domestic use	22
Overgrazing	33
Urbanization and infrastructure development	11

Table 1: Direct causes of land degradation.

Erosion by water was reported as the most widespread type of land degradation. This was exacerbated and accelerated in many areas by the factors shown in Table 2.

CAUSE	% of households (n=710)
Over cultivation	27
Over grazing	20
Mono-cropping	17
Bush burning	12
Deforestation	12
Lack of retention ditches	5
Hilly area cultivation	4
Soil exhaustion	3

Table 2: Direct causes of erosion.

Besides poor cropping practices leading to soil nutrient mining, compaction and acidification, livestock was also an important cause of degradation. Trampling of the ground adjacent to water bodies exposes the soil, rendering it susceptible to erosion. Also the combination of dry season fires with trampling by cattle lead to soil compaction and reduced porosity, aeration and infiltration, predisposing the microcatchments to intense run-off and hence soil erosion.

Numerous tracks created by cattle moving in a single file towards watering points are also eroded and develop into gullies (shown in Figure 2). The volume of top soil carried to the water bodies from fields and along these gullies contribute to the silting process. Nearly all artificial water reservoirs are silted-up in this way. The cumulative effect of such soil deposited at the edge of the swamp could be a gradual but progressive drying up of the swamp edge. Some silt eventually gets to the lake Victoria and could contribute to a reduction in its depth and reduced water quality affecting aquatic life and human health. This is clearly depicted in Figure 2.

The leading indirect causes (driving forces) of degradation were limited education, awareness and knowledge of conservation technologies and population pressure. This implies that increased awareness and knowledge of conservation approaches and technologies and lower population growth, which depends on getting people out of poverty, are essential for reversing the trend of degradation.

With support from the Kagera TAMP, a range of soil and water conservation techniques have been adopted by the households in the microcatchments to address the teething problem of accelerated rainwater runoff and soil erosion as

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Figure 2: Soil erosion along a foot/cattle trail that runs vertically from a steep hill down to the water point in Rubagano microcatchment, Mbarara District.

shown in Table 3. Manure application, mulching and agroforestry were the most widely used techniques for rehabilitating degraded land and water resources rather than only controlling erosion.

TECHNIQUE	% of hhs using technique (n = 710)
manure application/composting	19
mulching	17
agroforestry	10
grass strips	9
mixed cropping	7
level ditches / pits	7
terraces	6
digging trenches	6
retention ditches / dams	3
rotational grazing	3
contour cultivation	3
graded ditches / waterways	3
conservation agriculture	2

Table 3: Erosion control techniques adopted.

The rate of degradation (the trend over a recent period of time) was thought to be decreasing in general by most of the KIs in the target catchments. Forty-three percent and 29 percent of KIs thought degradation was moderately and rapidly decreasing respectively (Table 4). Only 14 percent of KIs were of the view that degradation (especially erosion by wind and water) were increasing at a moderate rate. The different perceptions were discussed to enhance understanding and reasoning (degradation types, causes, extent, severity etc.).

RATE OF DEGRADATION	% of KIs (n=9)
slowly decreasing degradation	14
moderately decreasing degradation	43
rapidly decreasing degradation	29
moderately increasing degradation	14

Table 4: Rate of degradation.

Conservation technologies and their effectiveness

In order to reverse the degradation trends and to restore the degraded lands, a diversity of conservation technologies were used by farmers in the microcatchments. The main technologies adopted were digging trenches to reduce the speed and volume of runoff (Figures 3 and 4) and planting trees on the contour across steep slopes to stabilise the soils and to reduce the risk of soil erosion by running water. Mulching (Figure 5), manure application (Figure 6), stone lines (Figure 7) and use of grass strips were also popular.

Figure 3: A trench of about three feet deep and two feet wide constructed along the contour in Kanyakwanzi, Kabale District.

Figure 4: Water harvesting trench in a banana plantation in Rwerazi microcatchment in Ntungamo District.

Figure 5: Mulched garden of vegetables near Rurongo stream in Rurongo microcatchment, Isingiro District.

Figure 6: Manure application for soil nutrient improvement in Rwerazi microcatchment, Ntungamo District.

Figure 7: Stone lines in a coffee – *ficus* intercrop in Katongero microcatchment, Rakai District.

The preferred technologies were those considered effective in reducing or preventing degradation, especially erosion by water. They are observed to prevent or reduce degradation rates to a higher degree compared with other technologies. These widely used erosion control technologies (Table 2) were considered "moderately effective" to "very highly effective" as indicated in Figure 8.

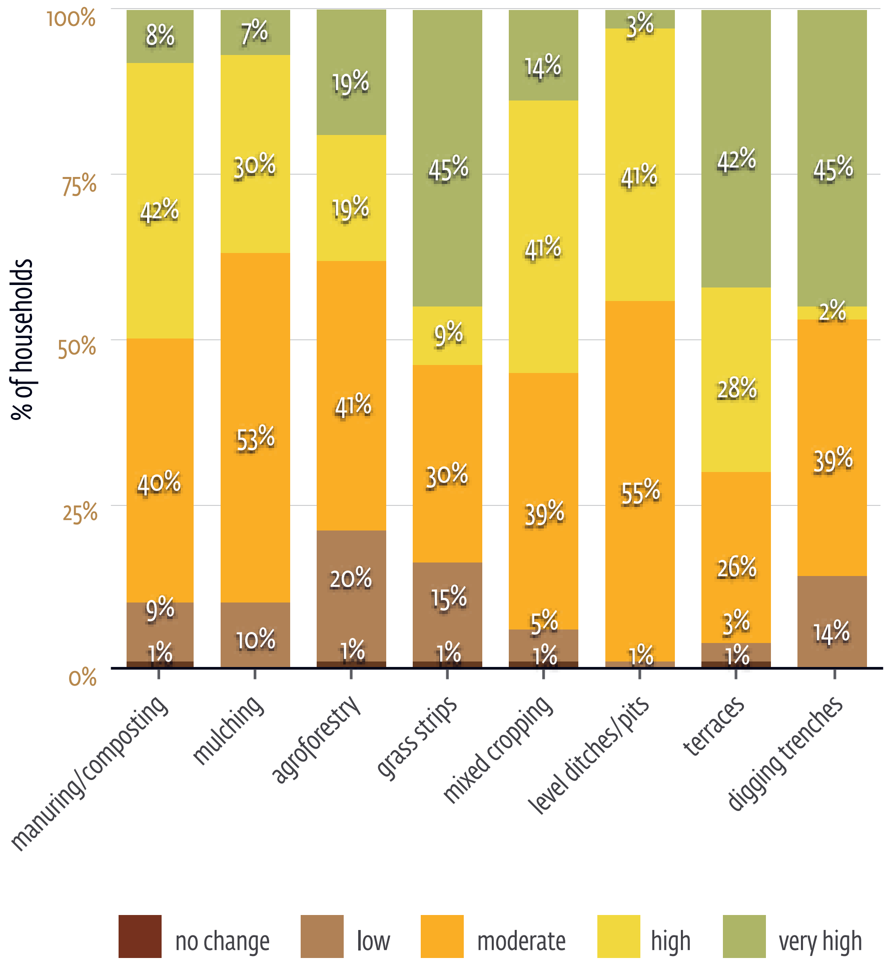

Figure 8: Effectiveness of main erosion control techniques used by farm households.

The effectiveness of erosion control techniques, however, seems to be dependent on the location of the plot in the landscape. Steep slopes, which are difficult to work, are planted with trees in the microcatchments. Similarly, grass bunds are not used in isolation but together with contour bunds for greater effectiveness. These technology combinations are illustrated in Figure 9.

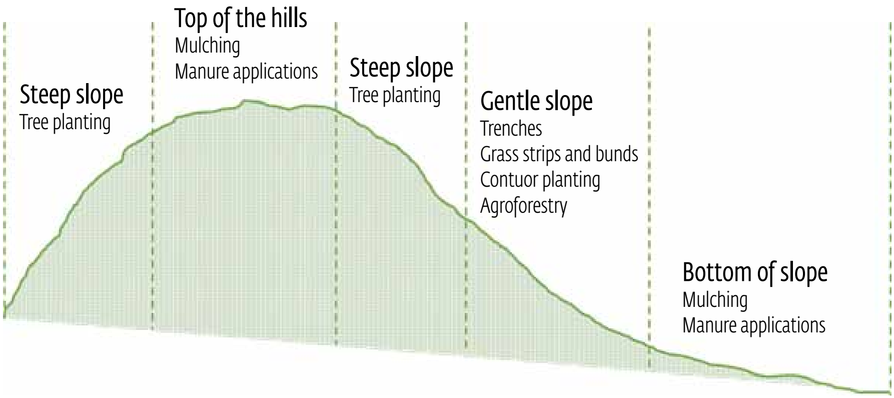

Figure 9: Combinations of SLM technologies along slopes.

Limitations to use of conservation technologies

Trenches (retention ditches)

Availability of labour to fully utilize conservation techniques seems to be the most limiting factor preventing farmers from expanding usage of some conservation techniques. For instance, construction of trenches is expensive in terms of man-hours consumed, while trenches need to be de-silted periodically for them to remain effective in controlling erosion. Usage of trees on the other hand is less labour intensive as the main labour requirement is mainly for planting, after which they become more or less self-sustaining, with minimum effort required.

Manuring

Households without livestock make limited use of manure compared to households with livestock. Mixed farming therefore seems to be an important precursor for manuring of fields and restoring soil fertility and land productivity.

Mulching

A large cash requirement to establish or utilize some conservation techniques is one of the major limitations in the microcatchments. Mulching materials are often not easily available, as most of the land is cultivated and crop residues are used for food or fodder when harvested. Further, some of the available materials such as banana leaves are not the most suitable for mulching. Supplies of perennial grasses, which could be used for mulching, are largely no longer available as they are used for livestock forage or fodder.

Agroforestry

Access to seedlings of various tree species, especially the fodder trees such as *Calliandra* spp. and *Gliricidia* spp. is limited. Establishment of permanent community nurseries could help alleviate this challenge as was done in other Kagera microcatchments. These community nurseries could adopt an approach that is not completely profit based but rather one where a nominal fee is charged for seedlings to guarantee sustainability. This would require government support / subsidies.

Conclusions

In conclusion, the assessment informed about types, causes and impact of land degradation, and guided the project intervention strategy. In addition, it helped identify SLM effectiveness at the slope or landscape level and advise practitioners about effective and responsive interventions at various scales.

Technically, assessment results clarified that adoption of SLM technologies is largely dependent on the availability of labour to establish structures (especially for physical SWC structures). This, in turn, depends on the socio-economic status of the households since the ability to hire labour is a function of income of the households.

Furthermore, trends observed in the micro-catchments where the Kagera TAMP worked suggest that farm households are more likely to use SLM techniques when they see direct benefits accruing to those practicing them ("seeing-is-believing" for some farmers). Similarly, SLM technologies that have direct and immediate socio-economic benefits are more readily adopted than those that take longer for benefits to be realised or generated.

Finally, the analysis of effectiveness of practices combination along land gradients confirmed that there is need to combine SLM technologies for maximum impact. Different land use situations require different techniques. For instance, very steep slopes may require planting of trees and grasses for stabilization while trenches and grass bunds are effective for protecting cultivated gentler slopes.

Cost-benefit analysis of contour bunds

stabilized with lemon grass, pineapples, farmyard manure and grass mulch in banana farming in Tanzania

4.3

Authors: Godfrey Baraba*, Allan Bubelwa*, Bertha Munyaga¥

Affiliation: * *Kagera TAMP project staff*
¥ *Executive Director's Office of the Bukoba District, Tanzania*

Summary

A cost-benefit analysis of contour bunds stabilised with lemon grass and pineapples grown with the application of farmyard manure and grass mulch to restore degraded banana fields was undertaken in Tanzania. The study indicated that a traditionally managed banana field has a positive payback and will break-even in the short term but use of technology is more profitable in the long term. This research showed wider SLM benefits, production and economic, socio-cultural and ecological benefits, revealing that the improved practices supersede the traditional management in various aspects.

Key words: cost-benefit analysis, contour bunds, bananas.

Introduction

The intensive degradation experienced in the Kagera River Basin led the Kagera TAMP project to introduce the SLM technology of contour bunds, stabilised with lemon grass and pineapples grown with the addition of farmyard manure and grass mulch applied to restore degraded banana fields in sloping lands in Tanzania.

A case study was conducted to assess the benefits of the technologies introduced by Kagera TAMP vis-à-vis the costs involved, in order to evaluate the practicability of wider application of the technologies. In this case study, the situation "with" technology has been compared with the "without" technology situation, where land users continue to practice traditional methods on similar banana fields. A complimentary analysis of changes in quality of land resources and socio-cultural and ecological benefits are also considered as a basis on which to draw conclusions.

The objective of this study is to assess the impacts of the technology on mitigation and prevention of land degradation by suggesting the most cost effective approach.

Methodology

As stated in Gittinger (1982), to assess whether the technology is profitable or not, a comparison is needed between the situation with and without the SLM technology, including the costs and benefits. The following formula is used: benefit cost ratio = total revenues ÷ total costs. The profitability of a technology is given if the net present value is greater than one.

Participatory observations of the application of the SLM technology (Figure 1) and interviews were the methods used in this case study. This involved multidisciplinary SLM teams visiting land users to collect overview costs, changes in production, agro-ecological and social-cultural aspects both on-site and off-site. The information obtained was uploaded to the WOCAT data base[1]. The data was processed using the WOCAT database to produce two four-page summaries of situations (one "with" and one "without" the SLM technology). [These can be viewed at www.wocat.net/en/knowledge-base.html.] Assessment of current inputs and output prices was done through discussion with SLM expert and land users followed by compilation of the data into the four pages summary. Assessment of costs and benefits of agricultural production (i.e. labour costs, agriculture inputs costs and crop yield) were made and presented in a tabular form. Assessment of ecological and social cultural factors were also carried-out using enumeration and these are accompanied with narrative to compliment the profitability analysis.

1 www.wocat.net.

Figure 1: The fully established technology (top); during technology establishment (middle); without technology (bottom) .

Results

The analysis of the results showed that the establishment costs for "with" technology situation is $ 1 403.79 per hectare compared with the establishment costs for the "without" technology situation of $ 109.3 per hectare (Table 1).

Measures	Activity	Inputs	With technology	Without technology
Agronomic	To supply hand hoes, machete, kihosho, sickle and spades	tools	12.35	12.35
Vegetative	To plant lemon grass and pineapples	labour	17.65	
	To dig holes and mix farmyard manure	labour	96.04	40.00
	To supply planting materials	lemon seedlings	15.69	
		pineapple suckers	7.84	
	To plant banana suckers	banana suckers	240.10	47.94
		labour	48.02	9.01
		farmyard manure	864.35	
Structural	To demarcate the contour level using A-frame	labour	8.82	
	To dig and cultivate the soils from the ditch	labour	35.29	
	To spread the excavated soil along the ditches, on the upper side	labour	52.94	
	To supply A-frames	A frame	4.71	
	To supply spades	spade	-	
TOTAL			1 403.79	109.3

Table 1: With and without technology situations for establishment cost ($/ha).

The maintenance costs (per hectare per year) for the "with" technology situation were $ 922.8 compared to maintenance for "without" technology situation of $ 340.89 (Table 2).

The maintenance costs would be similar "with" and "without" the improved technology if labour costs for mulching could be reduced through producing material on farm in field borders or on contour bunds.

Measures	Activity	Inputs	With technology	Without technology
Agronomic	To weed the entire field	labour	44.12	88.24
	To remove dry leaves and desucker bananas	labour	35.29	17.65
	To apply mulch	labour	44.12	
	To plant beans	labour	52.94	176.47
	To avail grass mulch	grass mulch	540.44	
	To supply beans seeds	seeds	117.65	23.53
Vegetative	To harvest farm products	labour	70.59	35.00
Structural	To clean the ditches	labour	17.65	
TOTAL			922.80	340.89

Table 2: With and without technology situations for maintenance costs ($/ha/yr).

The returns from the technology per hectare were substantial at $ 3 824 compared to "without" technology situation which accrued $ 1 883 (Table 3).

Product	unit	Quantity with technology	Quantity without technology	Price ($)	Value with technology	Value without technology
Banana	tonnes	7.0	4.0	118.0	824	471
Lemon grass	tonnes	2.0		176.5	353	-
Pineapples	tonnes	1.0		294.0	294	-
Beans	tonnes	5.0	3.0	470.6	2 353	1 412
TOTAL					3 824	1 883

Table 3: With and without technology situations for returns ($/ha).

Figure 2: A natural landscape in Tanzania.

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To calculate benefit cost ratio, the gross revenues was divided by total costs. The result for "with" technology situation in the short term is calculated at 0.64 compared to the "without" situation calculated at 3.69 (Table 4).

	With technology	Without technology
Gross revenues	3 823.53	1 882.35
Establishment costs	1 403.79	60.29
Maintenance costs	922.79	340.89
Net return	1 496.94	1 481.17
Benefit cost ratio	0.64	3.69

Table 4: Cost benefits ratio for with and without technology situations ($/ha).

A calculation over several years would show a much more interesting financial result and indicate how many years to payback the investment (establishment) costs.

The farmers should seek ways to adapt the combination of practices to optimise profitability (reduce direct costs and increase monetary benefits). Moreover, it is important to consider other social, cultural and environmental benefits. Considering wider benefits, enumeration showed that the "with" technology situation provide multiple accumulative benefits, scoring 82 percent compared with 18 percent by the "without" technology situation (Table 5). Only the number of benefits were scored, not their relative importance or value.

	Sustainable land management benefits	PREFERENTIAL SCORING		Comments
		Without technology	With technology	
Production and socio-economic benefits				
1	Increased crop yield	0	1	In the situation with technology, bananas as a test crop have increased in size (bunch) as well as numbers (palm and finger).
2	Increased farm income	0	1	Planting lemon grass and pineapples under the with technology alternative diversified sources of income.
3	Decreased workload	1	0	Application of farm yard manures and grass mulch increased the workload.
4	Reduced risk of production failure	0	1	The reduced moisture stress, improve soil nutrient levels and reduced soil erosion achieved from the technology has led to improved plant health.
5	Reduced expenses on agricultural inputs	1	0	No expenditure on manures and grass mulch makes the without technology less expensive.
6	Diversification of income sources	0	1	Lemongrass (*Cajanus cajan*), pineapples.
7	Decreased labour constraints	1	0	The without technology required less labour compared to with technology.
8	Simplified farm operations	1	0	Without technology situation does not need new approaches, such as the use of A-frames for contour levelling.
		4/8	**4/8**	**Both situations scored 50% (i.e. four points out of eight) on the production and socio-cultural benefits on site.**
Socio-cultural benefits				
1	Improved food security / self sufficiency	0	1	Improve production should contribute to ensuring food availability, accessibility and utilisation.
2	Community institution strengthening	0	1	Farmer field schools were a necessary pre-condition to support adoption of the technology.
3	Improved conservation / erosion knowledge	0	1	Through adult learning, farmers have been trained in the new technologies.
4	Improved situation of socially and economically disadvantaged groups (gender, age, status, ethnicity, etc.)	0	1	A gender balance is a pre-requisite for FFS formation and operation, enhancing equity of access and benefits.
5	Improved health	0	1	Improved nutrition and farmer ability to meet health services costs.
		0/5	**5/5**	**With technology scored 100% while without technology scored 0% in regard to sociocultural benefits.**

	Sustainable land management benefits	PREFERENTIAL SCORING		Comments
		Without technology	With technology	
Ecological benefits				
1	Reduced evaporation	0	1	The minimal open land surface under the SLM reduces unproductive transpiration.
2	Increased nutrient cycling recharge	0	1	Beans grown in the new system fix nitrogen thus enhancing the overall soil nutrient status for all crops, without the need for purchased fertiliser.
3	Increased soil organic matter / below ground C	0	1	Application of manure and grass mulch restored depleted soil organic matter.
4	Increased soil moisture	0	1	The result of the combination of mulching, furrow traps and improved rainfall infiltration.
5	Improved soil cover	0	1	The result of the combination of mulching, furrow traps and improved rainfall infiltration.
6	Improved harvesting / collection of water (runoff, dew, snow, etc)	0	1	The furrows impede the rainwater runoff and allow it to slowly infiltrate into the soil.
7	Reduced hazard towards adverse events (drought, floods, storms, ...)	0	1	The furrows increased water storage in the soil thus increased availability during any periods of drought.
8	Increased biomass / above ground C	0	1	Application of grass mulch complements traditionally used trashlines.
9	Reduced soil loss	0	1	Bunds and lemon grasses trapped eroding soils and stabilised them.
		0/9	**9/9**	**"With" technology alternative scored 100%, while "without" technology scored 0% in terms of ecological benefits.**
	TOTAL	**4/22 18%**	**18/22 82%**	**The "with" technology situation scored 82% while "without" technology scored 18% of the potential on-site benefits**

Table 5: Comparison of the on-site benefits of the SLM technology (contour bunds, stabilised with lemon grass and pineapples) and the "without" technology situation.

Analysis

> *For improved livelihoods and for adoption and spreading of SLM, costs and benefits play a central role. Given the urgent needs in SSA, investments in SLM should aim at both short-term (rapid) and long-term (sustained) paybacks. Thus inputs for both initial establishment and continued maintenance afterwards need to be compared with benefits.*
>
> Liniger *et al.* (2011)

The contour bunds stabilised with lemon grass, pineapples, and use of farmyard manure and grass mulch in banana farming is a combination of agronomic, structural and vegetative measures. The combined practices provide a number of reinforcing ecological, socio-cultural and economic benefits. The contour bunds once established should continue to increase water infiltration and reduce soil erosion in the long term, with minimal maintenance costs providing it is stabilised with protective vegetation. The vegetative measures (lemon grass and pineapples) diversified production in the short term and will continue to stabilise the contour bund for soil and water conservation benefits in the long term. The agronomic measure (farmyard manure and grass mulch application) maintained soil moisture, increased organic matter and soil nutrients and increased banana and beans production in the short term and their routine application will allow to deliver such benefits in the long term.

The cost benefit analysis (benefit cost ratio) is a quick analysis tool. In this case the benefit cost ratio for the "with" technology (0.64) is less than the "without" situation (3.69). In this case the new SLM technology is profitable but the "without" technology situation is much more profitable in the short term. This research developed further to look into the wider benefits of SLM technology, guided by Gitting (1982) and Kappel (1996).

So far the main focus of soils and water conservation research has been on ecological and technical aspects. Monitoring activities based on social science began in order to make SWC technologies socially acceptable. The main questions are: why do farmers do what they do? What strategies do they apply to cope with land and soil degradation? What indigenous technologies are used and might be improved? How could the acceptance of soil-water conservation be enhanced?

A complimentarily analysis was undertaken, in which all benefits of both "with" and "without" the SLM technology were enumerated, revealing that the "with" technology situation scored 82 percent, much exceeding the benefits of the "without" technology situation (scored 18 percent).

From the interviews with land users, it is confirmed that they had adopted the new technology because of many wider benefits of the traditional one (also see Table 5). These land users have benefited from project-supported extension services and applied the new (short-term grant-supported) strategies to cope with land and soil degradation. They recognise that the establishment of the new technology supersedes the indigenous technology by, for example, improving also through improving protection of planted banana suckers in their fields by trapping banana weevils.

Recommendations

Changes towards SLM should build on – and be sensitive to – values and norms, allow flexibility, adaptation and innovation to improve the livelihoods of the land users.

Liniger *et al.* (2011)

Based on the results of this case study, it is recommended that participatory SLM impact monitoring be implemented to promote a sharing of the views of all stakeholders. Participation means eventually developing a common strategy of intervention and action while dealing with different views, which means being more flexible and helps to avoid missing the target.

The authors recommend that gender-oriented SLM impact monitoring is important, to avoid disregard of the SLM knowledge base of women. For example, separate (gender disaggregated) recording and analysis of results and perceptions of men and women farmers before consolidating the findings and ensure male extension staff/ interviewers become aware of the knowledge and reasoning of the women.

Furthermore it is recommend that land users - male and female - are supported to achieve secure tenure arrangements or land ownership by tapping the existing national strategy of formalising the small-scale businesses in Tanzania (MKURABITA). The formalised land tenure rights enable small-scale land users to access financial resources from institutions and thus acquire loans to invest in improved land use technologies.

It is also recommended that land users achieve assurance of access to markets, by tapping the existing national strategy for one commodity one council, to cope with the commodity price fluctuations.

To conclude, cost benefit analysis combined with a wider participatory impact monitoring approach as used for this SLM technology should be adopted to assess the impacts of the other introduced SLM technologies and approaches to confirm their production and socio-economic benefits, socio-cultural and ecological benefits.

Assessment of the impact of sustainable land management technologies on food security and livelihoods

4.4

Authors: Benard Onzima, Bernard Mwesigwa, Wilson Bamwerinde

Affiliation: Kagera TAMP project staff

Summary

In order to assess the impact of the SLM interventions implemented by the Kagera TAMP on food security and livelihoods quantitative and qualitative methods were used to collect data for the outcome assessment. Resulting data was analysed to assess the adoption of practices and their impact on household food availability and in nutritional values. Also, the impact of practices on livelihood including financial, natural, human, physical, and social capital was evaluated. The case presented is from Uganda and method, that relied on data monitoring, allowed to scrutinise the project achievements and to inform the management about successes and sustainability.

Key words: assessment, qualitative, quantitative, livelihood.

Background

"Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). This definition introduces four main dimensions of food security: physical availability of food; economic and physical access to food; food utilization and stability of the other three dimensions over time. Food availability addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade. Access covers the physical (distance, infrastructure, etc.), financial (purchasing power) and social (ethnicity, religion, political affiliation, etc.) aspects of food (IPC, 2012).

According to DFID (1999), a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

SLM technologies promoted and adopted under the Kagera TAMP had varying impacts on the households and communities that adopted them. This paper presents the impact of the adopted SLM technologies on livelihoods based on the evidence from studies carried out in the project districts and anecdotal evidence.

Methodology

In order to assess the impact of the SLM interventions implemented by the Kagera TAMP on food security and livelihoods, a performance and outcome assessment was conducted among the beneficiary households in all the microcatchments in Uganda.

Quantitative and qualitative methods were used to collect data for the outcome assessment. Qualitative methods were used to collect non-numerical data such as opinions, attitudes and perceptions of the beneficiaries on the project activities and their impacts/benefits as perceived by them. A descriptive research design was adopted to collect quantitative data for this assessment through use of semi-structured questionnaires.

The outcome assessment data was collected from members of farmer field schools (FFSs) that benefitted from the project and key informants in the target microcatchments in the six project districts in Uganda. Beneficiary households were interviewed using questionnaires designed to assess household level changes in output and outcome indicators. Focus group discussion (FGD) guides were also used to facilitate discussions with FFS groups to assess group and community level results such as the level of adoption of SLM approaches/technologies and the community level benefits of SLM approaches adopted by the groups. Additionally, key informant interviews with field officers of partners implementing the SLM interventions were used to corroborate household and FGD data.

Results

SLM practices adopted

The main practice adopted was digging trenches (retention ditches) to reduce the volume and speed of rainwater flowing over the land surface and planting trees across the slopes to stabilise the soils and reduce the likelihood of erosion. Mulching, manure application and use of grass strips were also popular. Table 1 illustrates the number of FFS groups trained in different SLM practices, the proportion of FFS members that were trained and the proportion of FFS members and other farmers respectively in the microcatchments applying the practices.

SLM Practice	# FFS	% of FFS members trained	% of FFS members who have applied this practice	% of other farmers in the micro-catchment (non-FFS members) who have applied this practice
Digging ditches/tunnels	30	92	75	24
Tree planting/afforestation	30	90	69	36
Manure application	27	94	71	36
Mulching	17	90	75	54
Grass strips	11	92	49	9
Nursery bed preparation	10	95	66	31
Terracing	7	89	59	44
Contour cultivation	6	100	82	36

Table 1: Farmers trained in and applying different SLM practices.

Impact of SLM practices on food security

Food availability

Research conducted in the project districts among the beneficiary households indicated increased crop yields for some crops, increased farm incomes and decreased labour constraints as the major benefits of SLM. Increased crop yields were generally attributed to reduced nutrient loss through erosion and adoption of SLM technologies such as mulching, manure application and agroforestry for incorporating leguminous tree species that helped in replenishment of soil fertility. Increased crop yields and increased farm incomes are directly linked due to the higher level of surplus production which households can sell to generate income. The average yields for major crops grown by the SLM project beneficiaries are shown in Table 2. The yield of bananas, the major commercial crop, on which most of the SLM practices were applied increased from an average of 1 135 to 1 553 bunches per hectare over the project implementation period (2010 – 2014). Similarly, the yield of potatoes increased from 14 bags to 19 bags per hectare. Control of erosion reduced the need to fill-up gullies that previously required considerable labour, which is probably the reason why decreased labour constraint was also identified as an important socio-economic benefit.

crop	Unit	Yield/ha (2010/2011)	Yield/ha (2013/2014)
bananas	bunches	1 135	1 553
beans	kg	555	548
potato	bags *	14	19
maize	kg	995	800
sorghum	kg	695	693

Table 2: Average yield levels of major crops grown by SLM beneficiaries.

* A bag of potato is estimated to be 120 kg. Yield for potato is estimated in bags because the unit of bags is easier for farmers to recall than the metric unit of kilogram since bags are the major storage and sale unit.

Yields of bananas and potatoes increased as these were the focus of the FFS learning. There was no change to bean and sorghum yields. The reason for the decline in maize yield was not recorded but may have been poor rain distribution.

Increased livestock production and productivity was also a significant benefit of SLM adoption through improved fodder production (grass and agroforestry species).

This increased productivity can be attributed to better feeding practices and increased availability of feeds as a result of better pasture management and introduction of grass and tree species such as *Pennisetum purpureum* (also known as Napier grass, elephant grass) or Ugandan grass and fodder trees such as *Gliricidia* spp., and *Calliandra* spp. and and *Bracchiaria mulato*. which are used for feeding livestock. The fodder trees particularly have high protein content and nutritive value (INRA *et al.*, 2013). Key informants attributed increased milk yield to the introduced grass and tree species.

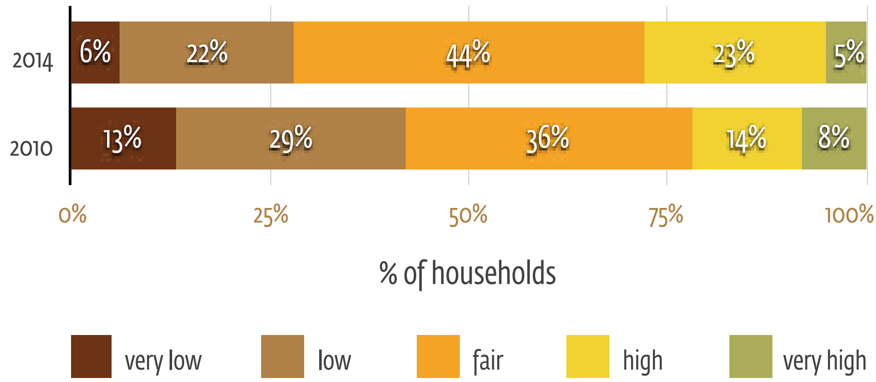

Figure 1: Livestock productivity (milk yields, body score and calving/kidding rates).

Food access

Household dietary diversity score (HDDS) measures dietary quality and dietary variety and has a direct relation to households' access to food of sufficient quality and quantity. Generally, the higher the HDDS the more food secure the household is and, conversely, the lower the HDDS the less food secure the household. The downside of HDDS is that it does not measure food quantities consumed and therefore it may capture small quantities of food consumed that do not contribute significantly to overall household food availability and dietary diversity (Swindale and Bilinsky, 2010). However, it still is a very good proxy indicator for household food access.

To compute the household dietary diversity score (HDDS), each food group among 12 food groups (i.e. cereals, tubers, vegetables, fruits, meats, eggs, fish, legumes/pulses/nuts, milk and milk products, oils and fats, sweets and spices and condiments) prepared and consumed in the household in the 24 hours prior to the survey was assigned a score of one. The HDDS for the individual household is therefore the sum of the scores of the food groups consumed by the household. The average HDDS for the project area was thus computed as the sum of the dietary diversity scores of the individual households divided by the number of sampled households (Average HDDS = {Sum (HDDS) / Number of sampled households}). The average HDDS was 5.7 (Table 3) and this is higher than the widely accepted threshold of a household consuming at least four food groups (IPC, 2012) in any single day of 24 hours.

Number of food groups consumed	Isingiro	Kabale	Kiruhura	Mbarara	Ntungamo	Rakai	Overall
% of hhs < 3	17	7	0	0	2	0	4
% of hhs 3 - 4	42	39	40	7	9	15	24
% of hhs > 4	42	55	60	93	89	85	72
Sum of HDDS	202	219	147	286	282	519	1 655
Number of hhs	49	44	30	44	45	79	291
Average HDDS	4.1	5.0	4.9	6.5	6.3	6.6	5.7

Table 3: Average household dietary diversity score.

The two most important sources of food, own production and market access, are indicative of high availability and access to food (Figure 2 and Figure 3). However, consumption of eggs, meat, fish, oils and fats, that are important nutritionally, was limited and necessitate further investigation in FFS on how to improve the situation. Table 3 shows the source, for example, only 17 percent of sampled households (HH) consumed eggs but 8 percent of those HHs bought the eggs, 17 percent produced them and 2 percent received them as gifts.

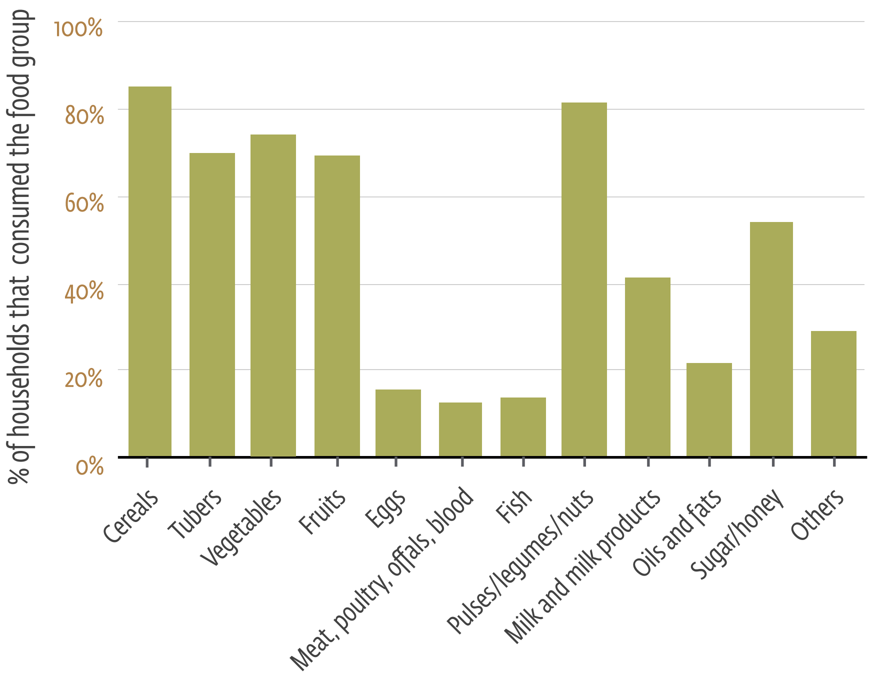

Figure 2: Food groups consumed by different households.

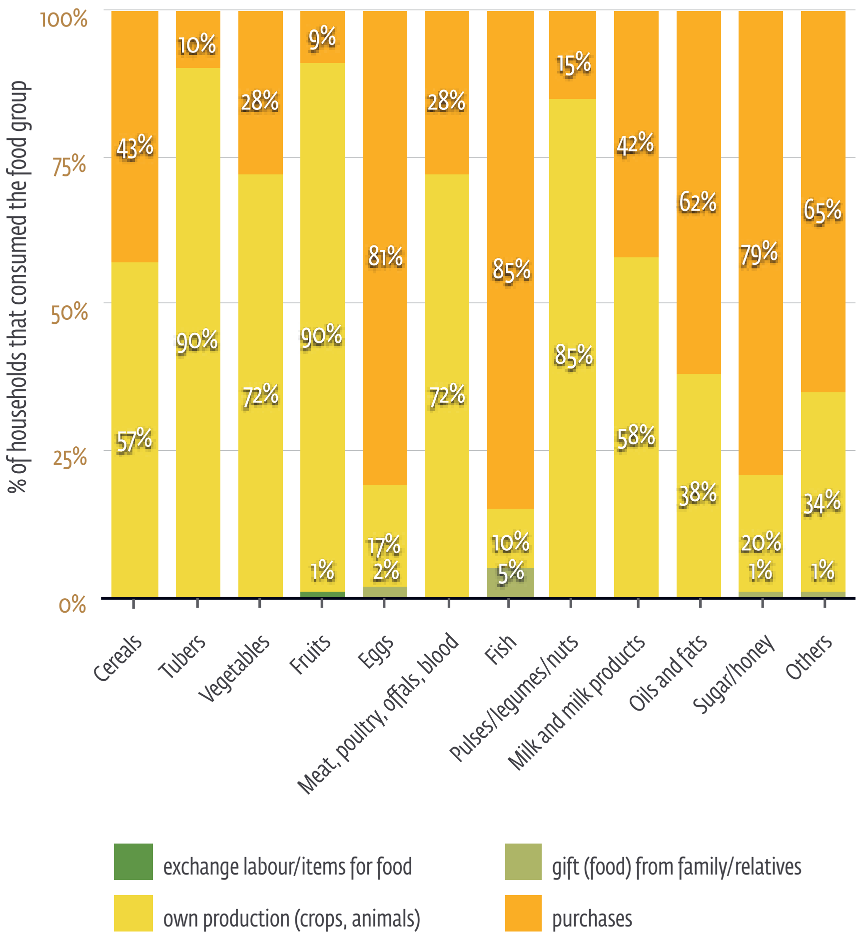

Figure 3: Sources of food of particular food products consumed.

The availability of, and access to, food are two of the most important pillars of food security in addition to utilization as informed by the percent of consumers and main sources of each food category. The proportion of HH that consumed eggs, meat, milk and other livestock products was very low compared to the consumption of crop products. The diversity of foods consumed is indicative of better nutrition but deserves further investigation of diets and quality of food and water for targeted interventions. Only 41 percent of HHs consume milk and milk products and of those 58 percent consumed their own produce while 42 percent accessed milk through the market. Meat and fish were consumed by less than 20 percent of HHs and for meat, 72 percent were the producers (only 28 percent bought) while for fish only 10 percent of the consuming HHs produced/caught the fish and 85 percent bought through the market. This indicates that consumption could be readily increased through enabling more HHs to produce livestock and fish products. Figure 3 also indicates that eggs and fish are relatively rarely consumed as they have to be bought and only few HH have purchasing power. Care is needed on the numbers of days recorded in the nutrition survey as some foods are eaten less often, such as meat which may be eaten once a week. It would be interesting to further investigate how consumption increases with livestock FFS.

Impact of SLM on livelihoods

Impact of SLM on financial capital

Financial capital denotes the financial resources that people use to achieve their livelihood objectives (DFID, 2009). The availability of cash or its equivalent, which enable people to adopt different livelihood strategies, was the main type of financial capital considered in the assessment of the impact of SLM technologies on livelihoods in this paper. Increased crop and livestock productivity emanating from adoption of SLM practices resulted in increased surpluses for sale and this increased household incomes. Sale of wood and wood products from the thousands of trees primarily planted to improve land management by stabilizing the steep slopes is bound to have secondary benefits in terms of income generation. These effects of SLM adoption have increased the stock of financial capital at household level.

crop	% of hhs	Weighted average income 2010/2011 * (UGX)	Weighted average income 2010/2011** ($)	Weighted average income 2013/2014 (UGX)	Weighted average income 2013/2014 ($)
beans	77%	177 580	71	255 652	102
bananas	65%	1 162 403	465	2 097 553	839
maize	45%	104 577	42	96 454	39
sorghum	21%	34 634	14	45 344	18
potato	21%	56 997	23	100 922	40

Table 4: Average income from crop sales.

* Weighted average income is the proportion of households generating income from a crop or livestock type multiplied by the absolute average income generated.

** Income in Uganda Shillings was converted to United States Dollars at the rate 1 $ = 2500 UGX at the time of the assessments

The amount of income generated by beneficiary households from sale of major crop and livestock products at the end of the Kagera SLM project end increased significantly, as illustrated in Table 4. Average income from livestock sales also rose (Table 5).

Livestock type	% of hhs	Weighted average income 2010/2011 (UGX)	Weighted average income 2010/2011 ($)	Weighted average income 2013/2014 (UGX)	Weighted average income 2013/2014 ($)
cattle	44	1 173 943	470	1 452 844	581
sheep/goats	68	359 256	144	536 315	215

Table 5: Average income from livestock sales and average increases in income of target households.

Although these increments cannot solely be attributed to the SLM project (more rigorous impact assessment methods such as Instrumental Variable methods, Propensity Score Matching, Double Difference methods requiring advanced econometric techniques would be required), anecdotal evidence suggests that the SLM interventions contributed to the increments in income.

Impact of SLM on natural capital

The quantity and quality of natural assets such as trees, pastures and soils that facilitate agricultural production were reported to have increased and improved as a result of the SLM interventions. This improvement in the quality of natural assets, which can be attributed to nutrient recycling promoted by the SLM interventions and protection of soils from erosion, makes the ecosystems more resilient to increasing weather variability and climate change.

At the community level, reduced damage to neighbours' gardens, caused by erosion, has also been stemmed. Erosion control at the farm level generates positive effects at the microcatchment level in terms of reduced land use conflicts, reduced downstream siltation and reduced damage to public infrastructure. Nutrient recycling and erosion control generate long-term benefits by reducing the need for external nutrient supplementation, which is quite costly. Reduced need for external nutrients (organic materials and fertilizers) frees-up household income, which inevitably is used to purchase other goods and services. Figure 4 illustrates the improvement in access to fodder resources (i.e. natural capital), in the project areas over the short time-period of the project implementation. A 17 percent improvement was recorded in the proportion of households that had adequate/abundant access to fodder resources at project end compared to the project start.

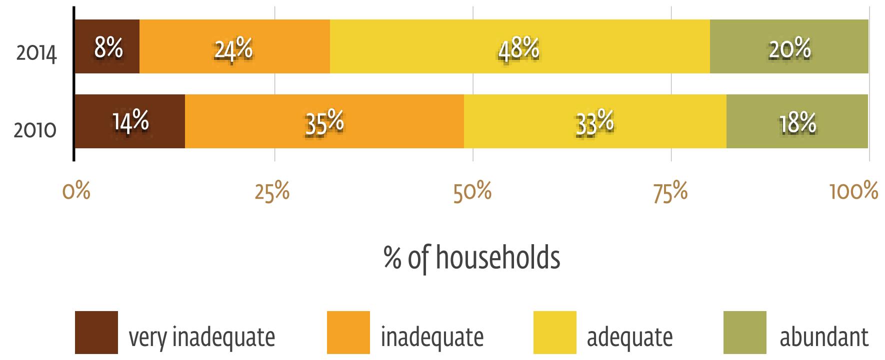

Figure 4: Access to fodder resources.

Impact of SLM on human capital

The knowledge and skills acquired in construction of trenches, terracing and contour ditches is human capital, which can be passed-on to future generations and also to neighbouring communities through social networks. Besides this, district local government staff capacity has been built and strengthened in analysing issues of land management and mainstreaming them in district development plans. The long term effects of this are likely to be greater investment by government in SLM through increased budget allocations.

Impact of SLM on physical capital

Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods (DFID, 1999). Infrastructure consists of changes to the physical environment that help people to meet their basic needs and to be more productive. Changes to the physical environment generated by the SLM practices adopted include, but are not limited to, soil and water conservation structures. These structures not only help households in the basin to preserve their natural resources but also enable them to produce more efficiently. Efficient production of agricultural goods such as crops, livestock products, wood and pastures contribute to achievement of improved livelihood outcomes such as: increased income; increased well-being; reduced vulnerability to climate and related shocks; improved food security (increased availability and better access to food); more sustainable use of natural resource base – as envisaged in the Sustainable Livelihoods Framework.

Impact of SLM on social capital

Skills gained in SLM were shared with neighbours and friends through social networks and connections, leading to an enhancement of these networks. This is important as community objectives, for example rehabilitating entire watersheds, cannot be achieved without social organization. Social networks facilitate synchronized action at the community level and are thus necessary for tangible benefits to be achieved. In the case of the Kagera TAMP, social groups (farmer field schools and other groups) mobilized by CBOs decided on common SLM strategies and activities to be undertaken by group members. This common strategy had the effect of building synergies in the community among households and ensured that a critical mass of households engaged in similar or related activities. Better results were thus achieved in reclaiming degraded lands and conserving the environment.

Conclusion

Adoption and scaling-up of SLM technologies has positive implications for food security and livelihoods, as well as climate change adaptation and mitigation. Even over the relatively short time-period of the project, SLM practices have been shown to have positive effects – improving the productivity of degraded lands by controlling soil erosion and enhancing soil fertility. These have in turn contributed to increased crop yields and food availability, access and stability – helping households become more resilient to climate change. Similarly, SLM approaches targeting livestock such as improved pasture management, introduction of grass and leguminous tree species have the ability to sustain forage and fodder availability and smooth out seasonal variations in feed access. Year round forage and fodder access is necessary for sustained milk production and, thus, enhanced nutrition and/or income generation. Scaling-up of SLM approaches needs to be seriously considered by policy makers since the benefits generated by these approaches are broad and can transform rural agrarian communities.

Assessing ecosystem services at a territorial scale – options for policy making, planning, and monitoring in the Kagera River Basin

4.5

Authors: **Monica Petri, Sally Bunning**

Affiliation: Kagera TAMP project staff

Summary

A participatory multi-sector Kagera Basin assessment and mapping process was undertaken to assess land degradation and sustainable land management. The LADA method (FAO, 2011a), including the preparation of the land use system map (FAO, 2011c) and the production of LADA (FAO-WOCAT, 2011) maps, informed the project intervention strategy, helped identifying best practices for SLM and guided effective and responsive interventions at various scales.

Introduction

Various land assessment tools are available and suitable to be applied at a landscape scale for planning and management of natural resources and ecosystems and for supporting climate smart agriculture (CSA) interventions. The Transboundary Agro-ecosystem Management Project for the Kagera River Basin (Kagera TAMP) has been monitoring interventions in terms of local, national and global benefits that are generated. This included assessment of restoration of degraded lands, carbon sequestration, climate change adaptation, sustainable use of agrobiodiversity and improved agricultural production and rural livelihoods and, indirectly, contributions to the protection of international waters and enhanced food security.

In this framework, through a participatory multi-sector process, an assessment and mapping of land degradation and sustainable land management was undertaken for the entire basin. The resulting data and maps were used to inform the project intervention strategy, to identify best practices for SLM in the region for scaling-up and to guide effective and responsive interventions at various scales. This is backed-up by SLM implementation at farm and catchment levels and field assessment of SLM performance and impacts and analysis of barriers and constraints to wider uptake. Also, this will inform policy making, planning and budgetary allocations by the concerned technical sectors at district and transboundary levels and serve as a baseline for future more integrated landscape management approaches.

Key words: assessment, transboundary, mapping, LADA, WOCAT, causes, impacts.

Description of the assessment method

The land degradation and SLM appraisal was based on a method jointly developed by the FAO executed Land Degradation Assessment in Drylands (LADA) project (see www.fao.org/nr/lada/) supported by GEF / UNEP in collaboration with the WOCAT (World Overview of Conservation Approaches and Technologies) Secretariat in the Centre for Environment and Development of the University of Berne.

The method is based on the Driving Forces-Pressures-State-Impacts-Responses (DPSIR) framework. The analysis has been shaped to focus on the need for national level mapping and guidance for informed decision making. Table 1 presents the list of DPSIR indicators.

DPSIR Framework	Geographical indicators analysed for national level assessment
State of land degradation	Type of land degradation (soil, biological, water) Degree of land degradation Rate of land degradation Extent of land degradation
Direct pressures towards land degradation	Land use area trend Land use intensity trend Crop management level Deforestation Over-exploitation of vegetation Overgrazing Industrial activities Urbanization Natural causes Discharge of effluents Washing out of pollutants Airborne pollutants
Wider influences on land degradation: "driving forces"	Incidence of poverty/wealth Access rights/tenure Population density Labour availability Inputs and infrastructure Occurrence of conflicts Education, knowledge and access to support service Protected areas
Impacts of land degradation	Impact on ecosystem services Productivity decline Carbon storage loss Water availability decline Water quality Biodiversity decline Tourism
Responses	Macro-economic policies Land policies and policy instruments Conservation and rehabilitation Monitoring and early warning systems Commitments to international conventions Investments in land water resources

Table 1: The DPSIR framework for the LADA national level assessment.

The mapping tool is based on the original WOCAT mapping questionnaire (Liniger and Critchley, 2007). It pays attention to issues such as biological and water degradation, and direct and socio-economic causes of these phenomena, including their impacts on ecosystem services. It evaluates what type of land degradation is actually happening where and why and what is being done about it in terms of sustainable land management (SLM) through a participatory expert assessment using the questionnaire.

First, a map of the land use systems (LUS) is prepared (FAO, 2011c), based on existing national data. Land use is the single most important driver of land degradation as interventions on the land directly affect its status and impacts on goods and services. Following the mapping, a participatory assessment is realised by a mutidisciplinary team of local experts under the facilitation of a LADA-WOCAT method expert. Such an assessment covers the entire area being analysed, and is realised for each land use system identified in each administrative unit. A range of sectoral experts and knowledgeable resource persons are involved. The assessment process is iterative, corrections can be made based on their judgements, and the results can be viewed immediately using a software allowing for immediate mapping. Finally, the resulting land use and sland degradation and SLM maps are produced and then validated through field visits by mapping and environmental experts. Such validation material is later re-submitted to the panel of experts that has realised the land degradation and sustainable land management assessment, and the final database and maps are produced.

For each of the LUSs in each administrative unit, the method allows statistical correlations to be determined between, for example, the extent of land degradation and the poverty level or land tenure security. Linking the information obtained through the questionnaire to a geographical information system (GIS) allows the production of maps as well as area calculations on various aspects of land degradation and conservation. The map database and mapped outputs provide a powerful tool to obtain an overview of land degradation and conservation.

For the Kagera basin which covers nearly 60 000 km² the entire assessment cost some 150 000 $ for the four countries. This includes capacity development in the participatory expert assessment method with multiple sectors, quality control and validation harmonization, as well as the finalization of the database and maps. In this case six months were sufficient to complete a first draft set of resulting maps, while 12 to 18 months can be considered sufficient to complete the entire process including mapping and validation and to make available the data set and maps for future planning by districts and technical sectors.

Results

The assessment was conducted across the entire Kagera River Basin: at national level in Burundi and Rwanda (where the basin covers more than the 60 percent of the country territory) and in relevant parts of the Kagera Basin in Tanzania and Uganda. It includes an assessment and mapping of the extent, severity and intensity of various degradation types or processes as well as the extent and effectiveness of various SLM measures being applied by diverse land users in the basin. The results, built through consensus among groups of experts from multiple sectors, provide a multi-factor baseline of (integrated) information and a harmonized territorial estimation of the tangible component of the ecosystem's goods and services, including the impacts of land use and management practices on soil, water, biomass, biodiversity, and social and economic implications. The data and maps can be used to guide the transformation of interventions among sectors at landscape level so that multiple goals including those that address specific climate threats can be reached, and thereby promoting sustainable and climate smart agriculture/land resources management.

The method takes into consideration biophysical, social, economic and ecological dimensions (see Table 2), is based on a combination of biophysical, statistical and expert based data, is cost-effective and can be conducted in a relatively short period of time. A total of approximately 80 maps can be directly derived from the database. Additional interpolation and modelling could lead to the production of more maps depending on users' needs.

<table>
<tr><th>Biophysical</th><th>Use of the land</th><th>Ecological</th><th>Socio-Economic</th></tr>
<tr><td>Elevation, slope, hydrology, land cover
Soil, soil fertility
Climate (temperature, rainfall)</td><td>Livestock density, crop type, land use</td><td></td><td>Population density, poverty</td></tr>
<tr><td colspan="3">Direct causes of land degradation or SLM due to land use and management practices</td><td>Indirect causes of land degradation (driving forces) or SLM</td></tr>
<tr><td colspan="4">Trends in land use change and intensity of trend variation
Types, rate, degree, and extent of land degradation
Types, extent, effectiveness of SLM technologies</td></tr>
<tr><td></td><td></td><td>Impacts on ecological services (water, soils, biomass, biodiversity, climate): negative or positive impact due to land degradation or SLM</td><td>Impacts on productive and socio-economic services: negative/positive impact due to land degradation or SLM</td></tr>
</table>

Table 2: The various dimensions used by the LADA-WOCAT method and that can be presented in various map products.

Transfer of data responsibility to the governments

After producing the biophysical and participatory maps, a handover and ownership building process was undertaken to transfer the results to selected governmental institutions. At least one technical institution, identified jointly with government experts and having the capacity to manage the geographical data per country, received the set of database and maps. All selected institutions include staff that have previously been trained in land use and land degradation mapping through the LADA method. In addition, regional entities such as NBI- NELSAP received the data. After the transfer of data is completed, decision makers in the four countries are able to undertake analysis for each land use system or land degradation type. First, what type of land degradation processes are occurring, including those exacerbated by climate change, where they are happening, what are the trends and why, and with which ecological and socio-economic impacts. For example, change in carbon storage in soil and biomass due to certain land use practices and their impacts on food/energy supply and resilience can be mapped. Second, decision makers are able to analyse current SLM technologies and approaches in terms of extent (hectares) and trends (expanding or decreasing), also the effectiveness and impacts of technologies in reversing land degradation/improving SLM (or even policies or regulations if the extent of application is known).

Potential map use

LADA-WOCAT maps can have a wide range of use spanning from a general analysis, to planning at national scale, prioritization of interventions, definition of best practices, and analysis of the potential costs involved in the scaling-up of technologies. Also, the dataset and the resulting data and maps can be used to inform the project intervention strategy. Finally, these data can inform policy making, planning and budgetary allocations by the concerned technical sectors at district and transboundary levels and serve as a baseline for more integrated landscape management approaches.

For example, comparison of maps showing degradation and SLM effectiveness will allow decision makers to depict areas requiring interventions, and to identify good practices that can be scaled-up or where further SLM measures are needed to address specific degradation problems identified (see Figure 1).

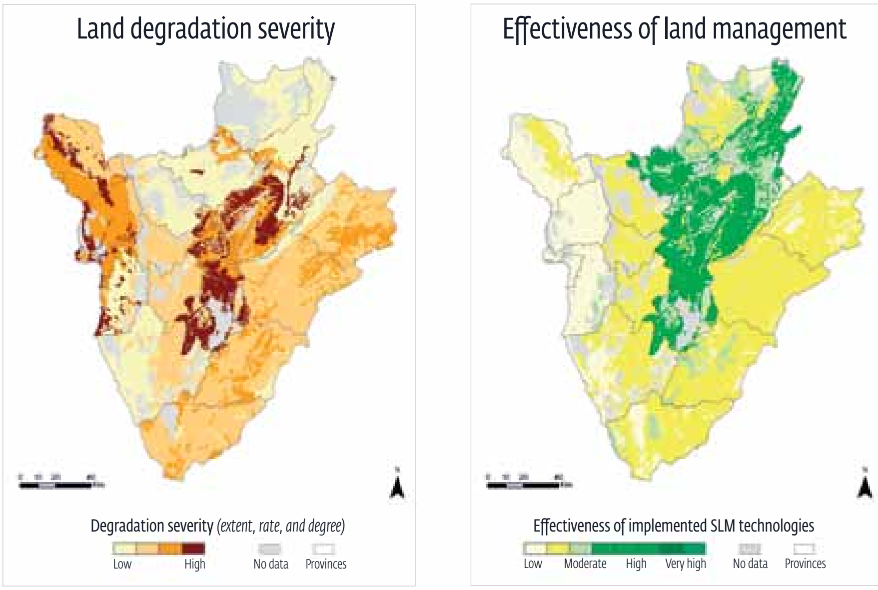

Figure 1: Burundi - Comparison of degradation and intervention effectiveness

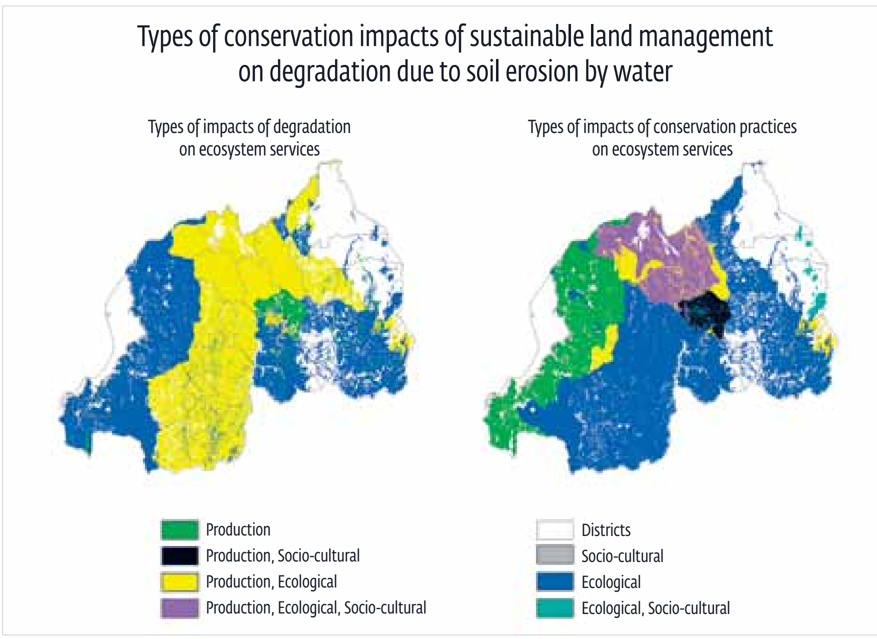

Figure 2: Rwanda – Comparison of impacts caused by soil erosion by water and impact of conservation practices addressing soil erosion by water.

Based on the DPSIR, each SLM technology can be assessed based on its impact on ecosystem services. Policy makers or local level planners could be informed on identified areas where the current intervention is having a significant impact by conserving natural resources. In the example in Figure 2, a significant part of Rwanda is experiencing the negative impacts of soil erosion by water on production services. However, sustainable land management technologies which are in place appear to reduce / avoid these impacts and are improving such ecosystem services.

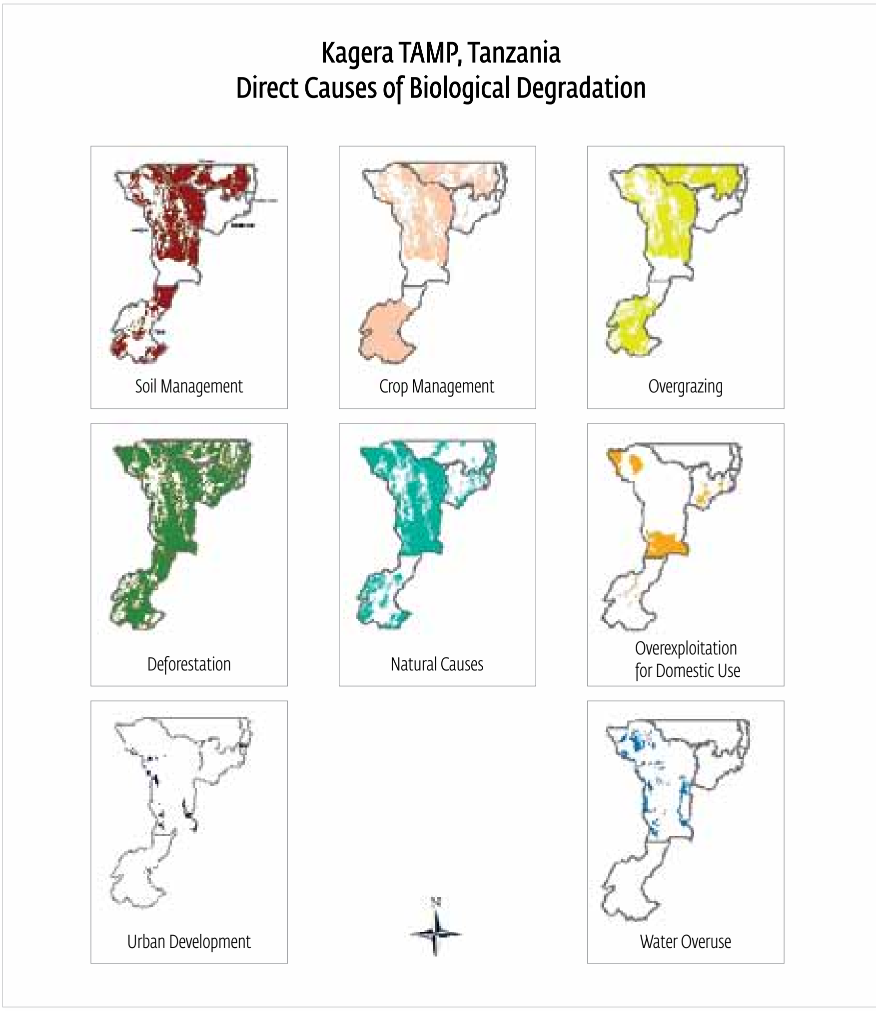

Figure 3: Tanzania – Causes of biological degradation.

Policy makers could be informed on the identified causes of land degradation, as distinct from poor quality land, such as poor cropland management, removal of natural vegetation and deforestation, over-exploitation of vegetation for domestic use, overgrazing, or even climate pressures, such as change in temperature or seasonal rainfall, extreme rainfall, floods or droughts (see Figure 3).

Potential developments

The participatory assessment could be repeated at basin level (for example at the end of the project) or preferably conducted at catchment level at regular intervals (e.g. mid-term and the end of the project), for monitoring the impacts of the project in terms of specific SLM interventions, their impacts on site (before i.e. at field/farm level) and their combined effects if any at a wider catchment/ territorial scale. During project implementation, this can help identifying required adaptations to SLM interventions to improve their performance, potential areas for scaling-up of specific SLM measures, and to analyse best practices that deserve wider investment. The process can be used for justifying and developing

Figure 4: Participants to the multi-country workshop on the LADA-WOCAT QM held to assess land degradation and sustainable land management in Masaka, Uganda.

costed proposals for catchment level interventions by concerned communities and districts and also for developing more substantive investment programmes requiring external support for landscape – or basin-scale interventions. The information gathered will allow landscape/territorial management between sectors and for achieving multiple objectives, including sustainable productivity, resilience to climate variability and change and climate change mitigation. This will allow decision makers to develop more effective synergies among sectoral interventions and identify trade-offs that need to be addressed with all actors / stakeholders concerned in the territory.

Figure 5: Participants to the multi-country workshop on land use system mapping held Gitega, Rwanda.

Assessing the up-scaling of sustainable land management and the associated GHG benefits under the Kagera TAMP Project

4.6

Authors: Janie Rioux*, Uwe Grewer ¥

Affiliation: * *Kagera TAMP project staff*
¥ *FAO expert*

Summary

The Kagera Transboundary Agro-ecosystem Management Project (Kagera TAMP) targets, as one of its central outcomes, the increase in area that is cultivated under Sustainable Land Management (SLM) practices as a means to achieve development and environmental objectives.

The adoption of SLM practices by smallholder farmers in the project area targets improved livelihoods, resilience and food security by providing increased and more stable crop and livestock yields, supporting diversified diets, and optimizing agro-ecological synergies within existing farming systems. At the same time SLM practices address the causes of land degradation and restore ecosystem health and functions.

This chapter presents the type and scope of SLM adoption and scale-up that has taken place in the project area as a direct result of improvements initiated by Kagera TAMP. The diverse SLM practices generate a large set of diverse environmental benefits including mitigation benefits. First, the monitoring system of SLM adoption throughout the project area is presented, which was a key element for targeting, monitoring, and evaluating SLM achievements. Then a focus is placed specifically on the estimation of greenhouse gases generated through the Kagera TAMP activities.

Key words: sustainable land management, monitoring and evaluation, farmer adoption, climate change mitigation, EX-ACT.

Background

Benefits from adopting SLM practices in the Kagera basin are multiple and the WOCAT database provides an overview of some documented cases of SLM practices in the Kagera basin (WOCAT, 2015).

Figure 1: Documentation of selected SLM practices in the Kagera watershed by the WOCAT database (WOCAT, 2015) available at https://qcat.wocat.net/en/wocat/. The same are available in the project website at: http://www.fao.org/in-action/kagera/activities/slm-technologies-and-approaches/en/.

The selection of the specific type of SLM practices that is most adapted to provide benefits in any specific area is highly context dependent (Pender *et al.*, 2004). As SLM is as a knowledge intensive approach to agricultural development, it requires the active participation of farmers during the processes of specification and targeting of interventions. De Schutter and Vanloqueren (2011) underline that the identification of targeted agricultural practices that provide agroecological benefits "require(s) the development of both ecological literacy and decision-making skills in farm communities".

Kagera TAMP engaged in a participatory approach to SLM planning and implementation that was undertaken by local service providers and farmer groups that selected and adapted priority restoration and sustainable intensification measures according to their interests and needs and building from those in 50 selected micro-catchments.

In order to directly promote SLM practices in collaboration with the established farmer groups, Kagera TAMP engaged in two mechanisms. On the one hand improved management practices were established in pilot implementation sites including small-scale improved crop and livestock husbandry and soil and water management measures. On the other hand the FFS approach was used to scale-up sustainable land management to farmers' managed fields in the target catchments. Beyond these direct project impacts with members of FFS and catchment committees, further indirect SLM adoption has taken place through diffusion to close locations by sensitization events.

Methodology

Collecting data on actual adoption of SLM practices is associated to different elements of complexity and can entail high costs. Firstly, no generic remote sensing methods are easily available to assess the adoption of diverse SLM practices, so direct contact to local actors and farmers is a necessity implying potentially high expenditure per area covered, depending on the settlement patterns. Secondly, the definition and understanding of SLM practices varies strongly between locations and stakeholders involved, which makes standardization of the assessment methodology between sites an important priority and also a challenge.

Kagera TAMP utilized service providers by catchment as the smallest unit of information provision. Adoption rates of SLM practices by farmers who are direct beneficiaries of the project were measured. As local service providers have a continuous and direct contact to beneficiary farmers this approach was selected to minimize high cost implications and guarantee adequate information quality. Figure 2 illustrates this multi-level monitoring process.

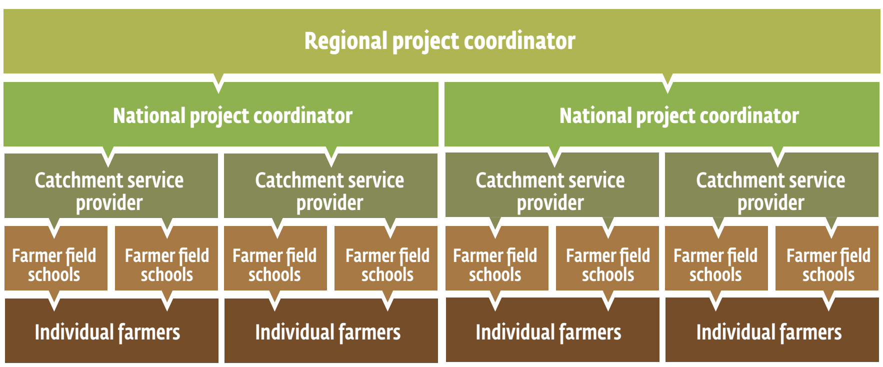

Figure 2: Reporting structure of data on SLM adoption under Kagera TAMP.

Various monitoring and evaluation (M&E) workshops were carried out by national project coordinators to define the clear set of management practices and geographic scope of monitoring data in line with outcome indicators. This approach allowed harmonizing the list and definition of project SLM practices for which information are collected. A final project M&E workshop strengthened and finalized the data harmonization process.

National project coordinators further interacted with service providers in order to: (i) assemble the data that has been collected from the individual catchments; (ii) ensure standardization of data collection procedures and (iii) guarantee the data quality at the disaggregated collection level.

Rigorous monitoring data with regards to type and scale of adoption of SLM practices was collected in SLM pilot fields, while the wider adoption by FFS participants has been estimated through a scale-up scenario. Also, sensitization through visits to pilot sites and farmer field days has been recorded.

The adoption and scaling-up of SLM practices can have important impacts on carbon sequestration and GHG emissions. Soil carbon is an important C stock that can be depleted through soil degradation processes. Also, soil organic carbon plays an important role in the nutrient cycle and contributes to soil fertility. In addition, SLM practices favor carbon stocks in above – and below – ground biomass mainly through afforestation and agroforestry, which likewise contributes to the conservation of biodiversity. In order to estimate the project's GHG benefits the FAO EX-Ante Carbon balance Tool (EX-ACT) was utilized (Bernoux et al. 2010; Bockel *et al*. 2013; Grewer *et al*. 2013). The Ex-Ante Carbon balance Tool is an appraisal system developed by FAO providing estimates of the impact of agriculture and forestry development projects, programmes and policies on the carbon-balance. The carbon-balance is defined as the net balance from all GHG expressed in CO_2 equivalents that were emitted or sequestered due to project implementation as compared to a business-as-usual scenario. EX-ACT is a land-based accounting system, estimating C stock changes (i.e. emissions or sinks of CO_2) as well as GHG emissions per unit of land, expressed in equivalent tonnes of CO_2 per hectare per year.

The tool helps project designers to estimate and prioritize project activities with high benefits in economic and climate change mitigation terms. The amount of GHG mitigation may also be used as part of economic analyses as well as for the planning and design of new interventions. EX-ACT can be applied on a wide range of development projects from any agriculture, forestry and other land use (AFOLU) sub-sectors, including climate change mitigation, watershed development, production intensification, food security, livestock, forest management or land use change. Further, it is cost effective, requires a small amount of data and is equipped with easy to use resources (tables, maps and FAOSTAT data) that help the analysis. While EX-ACT is mostly used at project level it may easily be up-scaled to the programme or sector level and can also be used for policy analysis.

SLM adoption of the project

Monitoring demonstrated that the Kagera TAMP had a direct impact on 65 900 hectares that has been shifted to sustainable land management of which 13 900 hectares by direct pilot field sites and 52 000 hectares through farmers' fields adoption as a result of FFS approach and training.

Beyond the direct impact, further adoption of SLM practices will have taken place by farmers that did not directly participate under the project interventions, but were exposed to pilot sites and farmer field days. These adoption data are not accounted here.

The total number of farmers that have been sensitized is estimated at 229 000. This includes pilot sites visits and farmer field days beyond the direct project trainings.

Farmer field schools have been established in each country (24 in Rwanda, 34 in Tanzania, 40 in Burundi and 41 in Uganda), with a total of 51 000 farmers trained. However, the overall SLM adoption in Rwanda (11 400 ha) and Burundi (7 700 ha) was relatively lower than in Uganda (20 700 ha) and Tanzania (26 000 ha). This is due to the smaller average farm sizes which when aggregated result in the smaller overall project area in both countries. Table 1 identifies the total direct SLM adoption that has taken place as a consequence of pilot SLM sites as well as FFS members' adoption.

	Unit	Burundi	Uganda	Rwanda	Tanzania	Total
Project districts	#	5	6	6	4	21
Project catchments	#	17	12	11	10	50
SLM pilot sites						
Catchment SLM committees	#	17	17	11	17	62
Pilot SLM plots	ha	4 399	4 136	2 161	3 205	13 901
Community members sensitized	#	23 000	95 280	9 632	100 938	228 850
SLM farmer field schools and scale-up						
Farmer field schools	#	40	41	24	34	139
FFS facilitators trained	#	24	41	35	34	134
Farmers involved	#	7 070	14 292	15 411	14 282	51 055
Average farm size	ha	0.47	1.16	0.60	1.60	0.96
SLM adopted on farmers' fields	ha	3 323	16 579	9 247	22 851	51 999
TOTAL SLM	**ha**	**7 722**	**20 715**	**11 408**	**26 056**	**65 900**

Table 1: Total direct SLM adoption under Kagera TAMP.

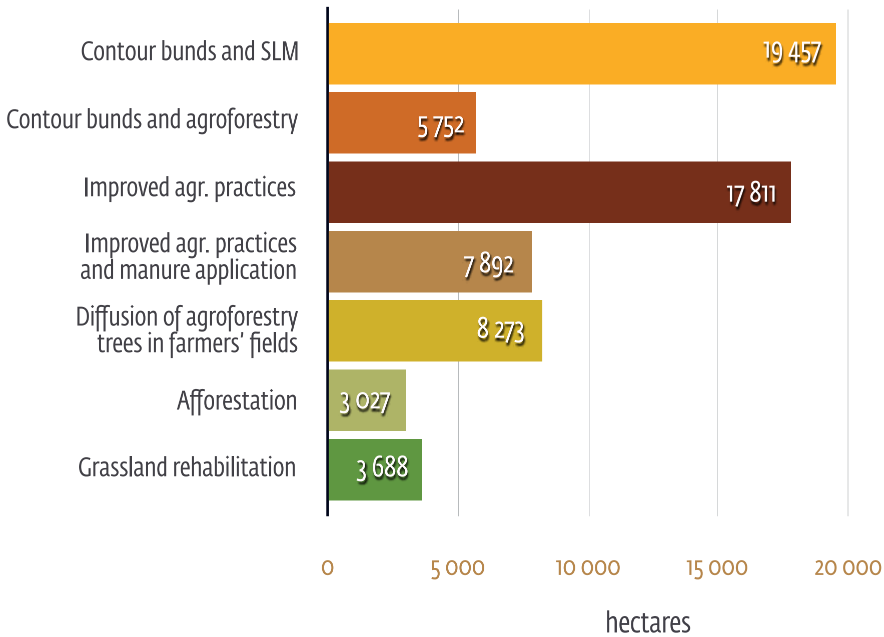

Figure 3a: Aggregated SLM practice categories adopted under Kagera TAMP.

Figure 3a shows that the group of practices most widely adopted by participating farmers are contour bunds combined with improved agronomic practices in hillside agriculture (19 500 ha) and improved agronomic practices as stand-alone measures (17 800 ha). Agroforestry (14 000 ha) and improved agronomic practices with the addendum of manuring (7 900 ha) were also scaled-up.

Figure 3b identifies the diverse practices that were adopted as part of the Kagera TAMP on their own or combined.

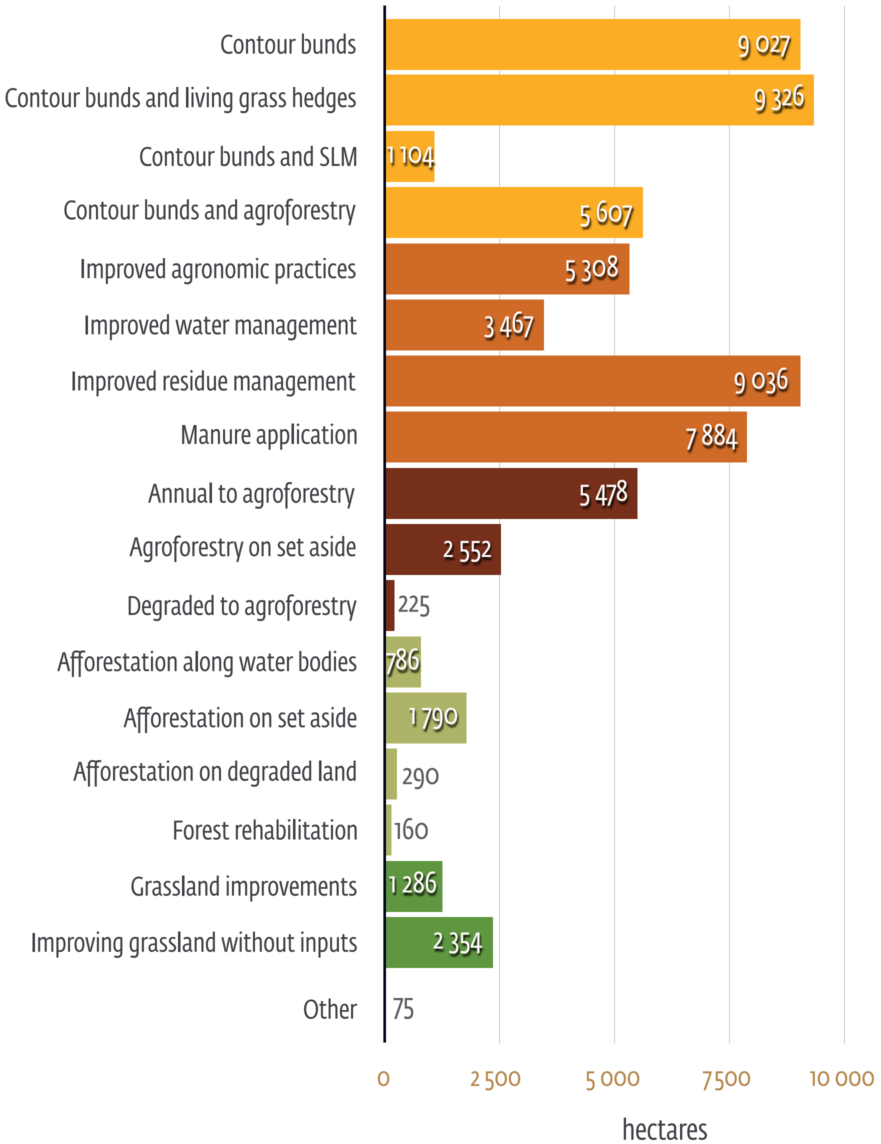

Figure 3b: Detailed SLM practices adopted under Kagera TAMP.

Project impacts on carbon sequestration and GHG emissions

Based on the estimations using the EX-Ante Carbon balance Tool (table 2), the direct project actions on 65 900 hectares lead to the mitigation of -5.6 million tonnes of CO_2 equivalent tCO_2e over the period of 20 years starting from project implementation. This is equivalent to the annual mitigation of roughly -282 000 tCO_2e, which translates into an annual mitigation benefit of -4.3 tCO_2e per hectare.

The 13 900 hectares that served as SLM pilot sites have a carbon balance of -2.0 million tCO_2e over the period of 20 years. This is equivalent to annual benefits of -7.3 tCO_2e per hectare. The SLM activities that are implemented on the pilot sites are characterized by investment intensive activities such as afforestation and agroforestry and the area concerned by the scaling-up of practices through FFS participants focuses on improved management practices on annual cropland.

In general, the main benefits are generated through the new establishment of agroforestry systems (-2.5 million tCO_2e) and the prevention of further land degradation through contour bunds and improved hillside management (-1.4 million tCO_2e). Also, the improved management of annual cropland (-720 000 tCO_2e) and afforestation measures (-680 000 tCO_2e) provide relevant contributions.

The only source of increased emissions as part of the Kagera TAMP project is due to the increased livestock numbers (goats, poultry, swine, cattle) leading to the additional emissions of 76 649 tCO_2e over 20 years. However, the consequent availability of additional livestock manure serves as increased organic matter input on annual croplands. Figure 4 shows that increased biomass carbon stocks (-3.1 million tCO_2e) have a slightly higher contribution the overall generated GHG balance as compared to the increased soil carbon stocks (-2.7 million tCO_2e). GHG emissions of N_2O or CH_4 play a negligible role within project implementation.

Components of the project	Gross fluxes		Balance	Share per GHG of the Balance					Result per year		Balance
	Without	With		CO_2			N_2O	CH_4	Without	With	
	All GHC in tCO_2e Positive = source/ Negative = sink			Biomass	Soil	Other					
Land use change											
Deforestation	0	0	0	0			0	0	0	0	0
Afforestation	0	-580 244	-580 244	-466 832	-113 412		0	0	0	-29 012	-29 012
Other LUC	0	-1 836 553	-1 836 553	-249 555	-1 586 998		0	0	0	-91 828	-91 828
Agricolture											
Annual	0	-719 460	-719 460	0	-719 460		0	0	0	-35 973	-35 973
Perennial	0	-2 516 575	-2 516 575	-2 339 859	-176 717		0	0	0	-125 829	-125 829
Rice	0	0	0	0	0		0	0	0	0	0
Grassland & Livestocks											
Grassland	0	-91 821	-91 821	0	-91 821		0	0	0	-4 591	-4 591
Livestocks	0	76 648	76 648				45 608	31 040	0	3 832	3 832
Degradation & Management	0	-10 345	-10 345	-9 104	-1 241		0	0	0	-517	-517
Inputs & Investments	0	0	0			0	0		0	0	0
Total	0	-5 678 350	-5 678 350	-3 065 349	-2 689 649	0	45 608	31 040	0	-283 918	-283 918
Per hectare	0	-86	-86	-46.5	-40.8	0.0	0.7	0.5			
Per hectare per year	0	-4.3	-4.3	-2.3	-2	0.0	0..	0.0	0	-4.3	-4.3

Table 2: Estimated GHG benefits from SLM practice adoption under Kagera TAMP.

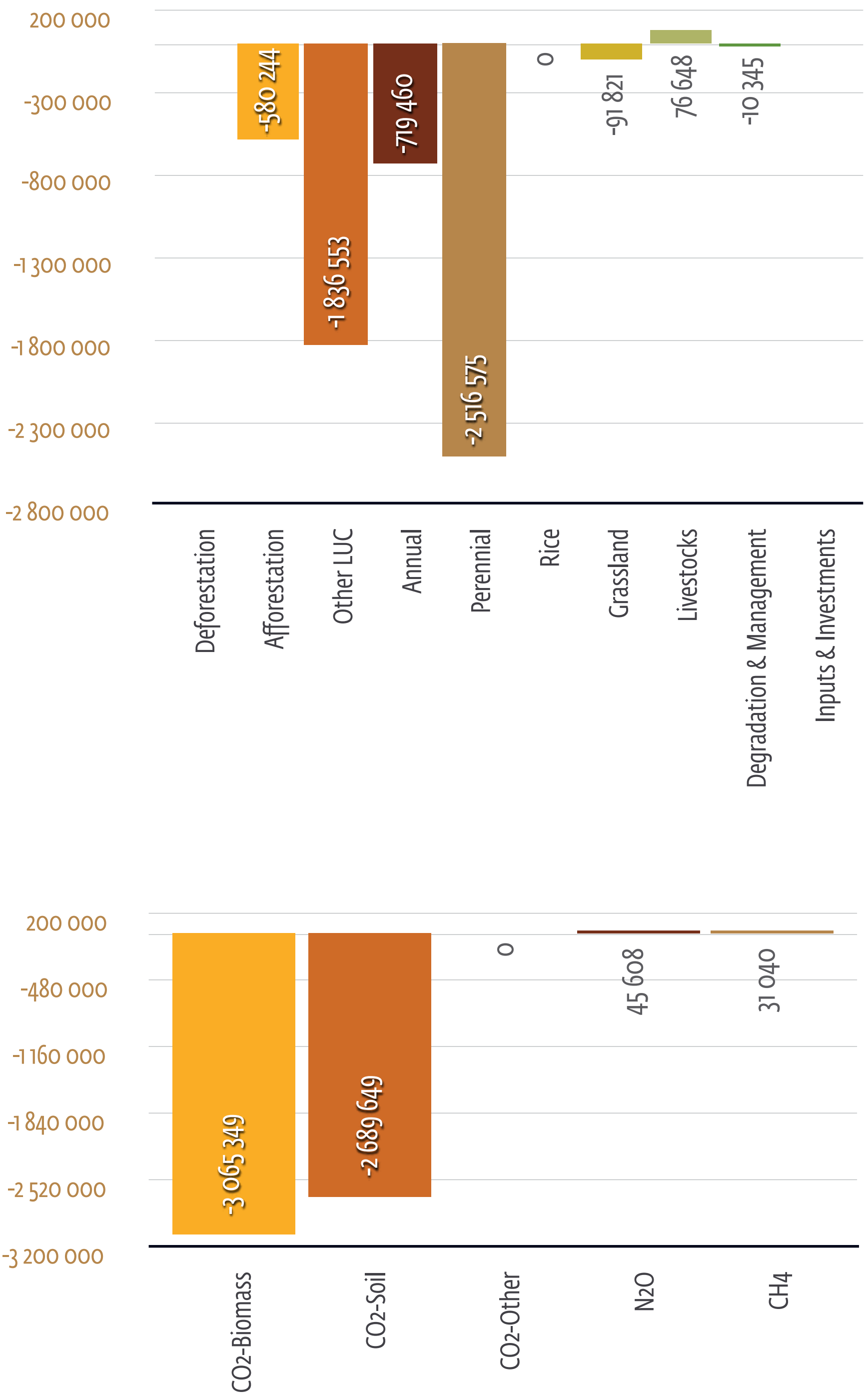

Figure 4: GHG benefits in tCO_2e by agricultural sub-sector (left) and by carbon pool / GHG (right).

Conclusions

The Kagera TAMP project led to the significant uptake and scaling-up of sustainable land management practices. As a direct outcome from pilots and FFS a total of 65 900 hectares of SLM practices have been implemented in areas that were not previously covered by such measures. The further diffusion and SLM adoption by non-beneficiary household is not included in this estimate.

The adoption of contour bunds and living hedges, improved cropland management practices and agroforestry were the most important practices that were identified by FFS farmers and catchment SLM committees as most suitable for providing productivity and adaptation benefits in their production contexts.

Using the FAO EX-ACT tool a first estimate of GHG emissions and carbon sequestration due to the implemented project actions demonstrated that the Kagera TAMP led to significant GHG benefits. Since the majority of GHG benefits are provided by newly generated biomass carbon stocks, there is a high level of confidence regarding the rough scale of GHG benefits generated by the project. In the absence of Tier 2 data, the specific level of GHG impact estimates by each single practice are however associated to high levels of uncertainty. It is concluded that, while project activities at the level of the micro-catchment were designed to provide advantages for productivity as well as for reducing the vulnerability to weather shocks and variability, project actions also provide positive co-benefits for climate change mitigation at a relevant scale.

Conclusion and recommendations Theme 4

4

How multiple-scale diagnostics and assessments enhance project planning and uptake and impact on policy design and implementation

Finally, the method can support comparison of land degradation and sustainable land management with other countries/territories analysed through the LADA DPSIR approach at the global level. The follow-up FAO GEF project "Decision Support for Mainstreaming and Scaling up of Sustainable Land Management 2015-2018" will set-up a global Knowledge Management and Decision-support Platform, allowing users to build on and update existing LADA-WOCAT methods, tools and databases. The project will promote wider sharing and dissemination of knowledge on SLM with countries and development partners. Such a platform will improve the scientific basis for land degradation and sustainable land management analysis, will provide more harmonized methodologies for monitoring and assessment, and will mainstream the upscaling of sustainable land management practices beyond the countries that have used the LADA - WOCAT methods so far.

The ever increasing pressure for natural resources in the Kagera Basin heightens the impact of the different land use demands placed on the land and ecosystem services. This reflects the need for assessing the status and trend of land degradation and to evaluate the relative suitability of potential interventions. Such evaluations are important in guiding development activities. It is important that planning and budgeting decisions are be made on the basis of a comprehensive review of all relevant factors, and involving indigenous and local level knowledge. The LADA and WOCAT analysis have been shown to be feasible and adaptable based on their application in Tanzania and Uganda and substantial results as presented in this case study. Other community based assessments have also contributed to guide the project interventions.

Systematic documentation as planning and policy tool

As revealed in Tanzania, application and use of LADA tools presents opportunities for systematic documentation, dissemination, storage and retrieval of core SLM issues. Such recording has the potential to facilitate land policy analysis and to support legislation for improving land management. It offers powerful tools for lobbying government and donors for funding to implement conservation measures addressing the identified types of degradation. The participatory plans developed using LADA tools facilitate buy-in from communities, especially when they are involved in the field identification and analysis of land degradation processes, causes, impacts, degree and extent from the onset. Finally, documented information and data are easier to share and transfer. In the case of the national land degradation and SLM mapping undertaken for the entire Kagera Basin, after the transfer of data, decision makers in the four countries are able to analyse findings of the assessment in each land use system and for each type of degradation or SLM practice in place, as basis for making informed decisions on priorities of intervention and investments.

Multiplicity of opportunities at the landscape level

Watershed level management allows the concerned land users and development actors to jointly identify and plan for reducing the risks (land degradation, landslide, flood, drought, climate change, biodiversity loss, food insecurity, economic migration) and optimising the opportunities for inhabitants across the landscape taking into account the topography, natural resources and ecological functions and human activities. In this regard, a community driven watershed planning process should focus on the range of practices (soil and water conservation and recharge, soil fertility restoration, adapted and biodiverse land use system. The process allow applying practices in the appropriate position in the watershed. The needs of the community in terms of livelihoods, wellbeing and demands of external resources (agriculture, energy, gathered products and other materials) are also taken into consideration. The various assessments undertaken during Kagera TAMP helped in identifying assessing SLM effectiveness at both farm and landscape level and advising practitioners about effective, responsive interventions at various scales. The use of the FAO EX-ACT tool allowed estimating the project mitigation benefits. Also, the analysis of effectiveness of practices along land gradients confirmed that there is need to combine SLM technologies for maximum impact on land productivity, hydrology and other ecosystem services. In fact, different landscapes and land use situations require a range of different and adapted techniques. For instance, very steep slopes may require planting of trees and grasses for stabilization while trenches and grass bunds may be effective on cultivated slopes that are not too steep, a combination may be needed where steep slopes are farmed besides SWC for soil erosion control and regulating water flow, rainwater harvesting may be needed to optimise water storage and recharge if irrigation is to be conducted in valley bottoms to avoid depleting the ground and surface water supply.

Participatory assessments require significant capacities

The use of a detailed and complex local level monitoring and assessment system while generating useful data also has limitations. The skill levels of facilitators is critically important in the application of LADA and WOCAT tools. Thorough an intensive training of SLM facilitators on the basic principles of "participation" (i.e. aiming at attitude and behavioral changes) and recruitment of capable personnel with good technical grounding are some of the ways proposed to overcome these challenges. Also, national level assessment using the LADA-WOCAT method (FAO-WOCAT, 2011) was grounded on a deep training – facilitation process and in the involvement of highly skilled experts with GIS skills to build national capacity and a sustainable database for future monitoring.

On the ground the lack of flexibility of facilitators and a bias towards seeking problems instead of solutions has been noted. Working on the mind set of development advisers at the field and district level should support their openness in analyzing and supporting indigenous based solutions, and supporting the removal of obstacles to sustainable land management.

The Kagera TAMP experiences confirm the value of WOCAT questionnaires for assessing and documenting specific technologies and identified best practices on the ground (QT, WOCAT, 2008a) but recommend their updating as readily accessible and user friendly tools. Indeed, by the time of publishing this book a "light", easily adaptable version will be available online, in order to facilitate wider adoption of these tools for the assessment of technologies and the associated approaches (QA, WOCAT, 2008b). A phased gender-sensitive land user and stakeholder consultation and diagnostic and planning process (several months using the set of LADA-WOCAT tools) is also advised to facilitate involvement and buy-in.

Technical conclusions derived from the assessments

Technically, the various assessments undertaken allowed to derive a wide set of informed decisions that drove project interventions.

Empirical evidence from SLM documentation and assessments in the four countries using the LADA-WOCAT tools (QM, QT, QA, LADA Local) indicated that erosion by water (exacerbated and accelerated by over-cultivation, over-grazing, mono-cropping, bush burning and deforestation) was the most widespread type of land degradation. However, the less visible processes of soil nutrient mining, compaction and acidification associated with declining biomass and soil organic matter also have severe impacts on land productivity and resilience to climate change. The indirect causes of degradation were limited education, awareness and knowledge on conservation technologies and population pressure and land fragmentation. The effectiveness of soil and water conservation techniques is dependent on the location in the landscape. Steep slopes in upper catchments, that are erosion-prone and difficult to work, are ideally planted with trees; while trenches, grass strips and bunds, mulching, manure application are recommended to be combined on gentler cultivated slopes. Pasture rehabilitation, managed watering points, stall-fed or tethered livestock and fodder production are successfully adopted for enhanced crop-livestock integration backed up by by-laws to control burning and rotational grazing.

A host of factors limit use of SLM techniques. These include the availability of labour to construct and maintain physical SLM structures such as trenches for the safe retention or diversion of excess runoff water, availability of cash resources to acquire some of the materials used in SLM such as mulch, manure (in the absence of livestock on farm) and tree seedlings. Attachment to traditional "ways of doing things" is also a major limitation to SLM adoption. "Seeing-is-believing" for some farmers and they only invest resources in SLM when they see benefits accruing, for example from neighbours engaged in SLM initiatives (guided visits and demonstration plots). Conclusively, one can say that different SLM techniques need to be used in combination for maximum impact across the different land use situations. They also need to be supported by community by-laws to apply and enforce policies and legislation.

The most widely group of practices adopted by participating farmers are of contour bunds combined with improved agronomic practices in hillside agriculture and improved agronomic practices as stand-alone measure. Analysis of the use of contour bunds stabilised with lemon grass, pineapples, mulch and farm yard manure using the benefit-cost approach indicated that the costs of establishment and maintenance were high. The benefit-cost ratio was much higher for farmers that did not use the technology than those that used the technology. Despite this variation, qualitative assessment and comparison of the on-site benefits (production and socio-economic, socio-cultural and ecological) of the SLM technology revealed greater benefits of the technology for farmers that adopted than for farmers that did not. It appears that the low benefit-cost ratio is only short-term. The projected benefits, including unquantified ecological and socio-cultural benefits would outstrip the costs in the long-term. It is apparent that experimentation and adapted combinations of different SLM techniques for different locations is necessary for successful adoption and expansion of SLM

The Kagera TAMP project led to the significant uptake and scaling-up of sustainable land management practices. As a direct outcome a total of 65 900 hectares of SLM practices have been implemented in areas that were not previously covered by such measures. Also, a first estimate of GHG emissions and carbon sequestration demonstrated that it also lead to significant GHG benefits.

Moreover, SLM adoption and scaling-up of SLM technologies have been shown to have positive implications for food security and livelihoods, also climate change adaptation and mitigation. Over the relatively short time-period of the Kagera TAMP (four years on the ground), SLM practices have improved the productivity of degraded lands by controlling soil erosion and enhancing soil fertility and reducing risk of crop failure due to erratic rains and drought. These have in turn resulted in increased crop yields and food availability, access and stability – helping households to become more food secure and resilient to climate change. Similarly, SLM approaches targeting livestock such as improved pasture management, introduction of grass and leguminous tree species have the ability to sustain forage and fodder availability and smooth-out seasonal variations in feed access. Year round forage and fodder access is necessary for sustained milk production and thus income generation. Scaling-up of SLM approaches and integrated agro-silvo-pastoral systems need to be seriously considered by policy makers since the benefits generated by these approaches are broad and can transform rural agrarian communities. Moreover, these approaches potentially address a diverse range of rural development challenges including, but not limited to, improved climate change adaptation; mitigation; enhanced productivity and quality of agricultural goods; reduction of food insecurity; improved productivity of rangelands and pastures; restoration of degraded lands including soil and water resources; and biodiversity and the sustained generation of a range of ecosystem services.

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5

Inter-sectoral cooperation, planning and policy for addressing transboundary land resources management

Introduction

Chronic conflicts amongst over 16 million pastoralists, agro-pastoralists and crop farmers who are dependent on the Kagera River Basin transboundary agro-ecosystem resources for their livelihoods remain a common phenomenon. Such a situation has contributed to the gross mismanagement of natural resources and, hence, extensive degradation of the agro-ecosystems and basin resources. Besides these serious environmental impacts, increasing food insecurity and extreme poverty of the land users are attributable to the declining productivity of the land and other natural resources across the Kagera Basin.

Mismanaged transboundary agro-ecosystems resulting from increasing pressure on the resources by the increasing human and livestock populations coupled with unsustainable land use and poor management practices, has been identified as one of the principle causes of the declining productivity of the Kagera River Basin. Other causes include: (i) lack of acceptable and coordinated laws and regulations; (ii) lack of clear mechanisms to control and enforce them; (iii) weak dispute and conflict resolution mechanisms at grass-root and district administrative levels; and (iv) lack of knowledge on adapted practices for conservation and sustainable use of the land assets (soil, water and biological resources).

During the four years of Kagera Transboundary Agro-ecosystem Management Project (Kagera TAMP) execution, the farmer field school (FFS) extension delivery approach was introduced as the principle means of building capacity and disseminating SLaM best practices to address the prevalent agro-ecosystem degradation challenge. FFS are an effective experiential training methodology that also reinforces community linkages and social networks, potentially contributing to conflict resolution.

Under this theme, three chapters present the transboundary project findings.

Chapter 5.1 presents a study aiming at understanding the transboundary issues of land and other natural resource degradation and conflict associated with livestock management and movement within the basin. The main reasons for livestock movement reasons were adaptation to the shortage of pasture and water and livestock trading. Increased livestock movement being attributed to the lack of enforcement of pertinent laws and by-laws and the limited technologies to intensify grazing management and water infrastructure development. Also, lack of efficient livestock markets in each district and region is one of the most important causes of increased transboundary livestock movements. Based on these findings, recommendations to reduce livestock related degradation were developed targeting not only transboundary level, but also the district and village levels.

Chapter 5.2 analyses grassland and rangeland conditions within the basin, and also relates their degradation with transboundary animal movements and inadequate management regimes. Grassland was shown to be degraded due to many causes: overgrazing, frequent wildfires, soil erosion, transboundary livestock movements, non-existence of appropriate range management technologies and limited enforcement of by-laws, laws and regulations. The study depicts how the introduction of selected pasture species, including these that are thought to be extinct in the area, and improvement of existing grassland cover bring rapid measurable achievements and increase livestock productivity and pasture land carrying capacity within a very short time.

Chapter 5.3 focuses on land and natural resources conflicts as threats to sustainable land and agro-ecosystem management in the basin. The main source of conflicts identified on the ground in target communities included conflicting land tenure systems and transboundary policies, population and migration pressure, overgrazing and deforestation. The Kagera TAMP project successfully initiated the participatory conflict identification and solving process with stakeholders, drawing from the participatory negotiated territorial development approach (PNTD). The project recommended to strengthen the capacity of in-country institutions to use the range of alternative participatory dispute resolution mechanisms, which had proved to be successful and to continue the efforts to reach more communities.

Integrated landscape and ecosystem management

Integrated Landscape Management (ILM) implies a people-centred approach in the sustainable management of natural resources at the landscape scale for the generation of a wide range of ecosystem services and thereby contributing to local livelihood benefits and global environmental benefits as well as a range of national

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development goals. An ILM approach provides a logical framework for putting in place the required governance mechanisms and multi-sector and -stakeholder participation process at relevant intervention levels as a basis for promoting sustainable development and achieving interlinked economic, social and environmental goals. ILM emphasizes the centrality of people, direct actors and other stakeholders in the shaping of landscape and territories (geographic and administrative entities) for meeting the diverse needs and objectives of society including poverty alleviation, food security and well-being. The landscape approach calls for the alignment of sectoral policies and their coordinated implementation through processes of negotiation, consensus building, planning and partnership among sectors and stakeholders with a view to minimizing and managing trade-offs.

Integrated landscape management facilitates the development of multi-purpose production systems for simultaneously meeting the needs of diverse interest groups and considers interactions between land use systems which may have positive or negative trajectories in terms of sustaining ecological processes such as pollination, predation, the hydrological, nutrient and carbon cycles and pollution. An integrated landscape management approach should ensure greater efficiency in the use of resources as well as more sustainable management of natural resources and ecosystems through interventions at a wider spatial scale and in the medium to long term (moving away from a time bound and localized project approach).

Integrated landscape management offers an action-oriented means to achieve multiple SDG targets simultaneously at local and subnational levels. National governments can readily build ILM into their national sustainable development strategies and utilize the approach as an integration and implementation mechanism for achieving multiple SDGs. The international community, donors, investors and national governments should prioritize support for integrated place-based - rather than sector-based - development finance. Collaborative planning, negotiation, and action at landscape scale in particular is essential to support improved coordination, the identification of synergies, and the management of trade-offs among diverse stakeholders.

Source: The Landscapes for People, Food and Nature collaborative partnership in which FAO is a member - www.peoplefoodandnature.org.

Transboundary issues on land degradation related to livestock management and movements across the Kagera River Basin

5.1

Author: Jonas B. Kizima†, Sally Bunning*, Joseph Anania Bizima*, Fidelis B. Kaihura*, Wilson Bamwerinde*, Salvator Ndabirorere*, Emmanuel Muligirwa*, Venuste G. Rusharaza*

Affiliation: † *International consultant Kagera TAMP*
* *Kagera TAMP project staff*

Abstract

A study was conducted with the aim of understanding the transboundary issues of land and /natural resource degradation and conflict associated with livestock management and movement within the basin. After identifying the main cattle corridors, the main causes of movement were determined as well as the ongoing conflicts. The study analyses the major reasons for cattle movement across the surveyed countries; notably the search for pastures during the dry season, water shortages forcing migration in search of water supply and livestock trading. Based on this, recommendations to reduce livestock related degradation at the transboundary, district, and village level were developed. The livestock sector in the Kagera River Basin agro-ecosystems has the potential of lifting many of the rural communities out of the prevailing poverty. However, there is a need to mobilize appropriated and focused development investments.

Key words: livestock, transhumance, overgrazing, conflict.

Introduction

Pastoralists traditionally used mobility as a strategy to bridge the dry season livestock feed supply gap and to seek water. The pastoral communities migrate with their animals from a grazing-deficit area to another with better pastures. The movement may take place within and between countries during dry seasons. The livestock are trekked and reared for periods of three to six months and at variable distances, in search of better pastures and water. The degradation effects on land, soils and water resulting from such movements depend on migrant herd sizes as well as timing and duration of grazing.

This type of unregulated livestock production system was more sustainable in the past as rangeland resources were extensive. With lack of enforced political boundaries and demarcated wildlife reserves; and limited population pressure by people and their livestock. This situation has changed dramatically. The land degradation and conflicts related to pastoral livestock production system were among the major concerns identified in Kagera River Basin agro-ecosystems. This prompted FAO and other key stakeholders including land users, local and district authorities of the border districts of the respective countries and other development partners to carry out an assessment of the real status of the basin pastoral and livestock based agro-ecosystems with the aim of developing and testing a more sustainable strategy and concrete actions.

It is important to realize that increasing human and livestock population and resulting pressures on land and other natural resources, coupled with stringent laws, by-laws and regulations within and between the basin countries, leaves no room for uncontrolled livestock management practices and movements. This situation demands a commitment of the herders and farming communities to consider and agree to develop and implement sustainable grazing practices and regulated movements that are negotiated and supported by government authorities and other stakeholders.

Above all, it is necessary to recognize the important economic contribution that livestock currently makes to the gross production value, and overall national development of the four Kagera River Basin countries. The Kagera TAMP project has demonstrated that the livestock sub-sector presents an enormous potential that needs to be fully exploited through scaling up adapted SLaM best practices for livestock and grazing land management in the drier areas of the basin.

The livestock sector is among the most important sectors of countries sharing the Kagera River Basin. Its contribution to the agricultural gross production

Figure 1: Livestock in Uganda.

value of Uganda, Tanzania, Burundi and Rwanda is significant and accounts for 21.7, 20.5, 7.7, and 9.6 percent, respectively (FAOSTAT, 2012 data). The sector has both positive and negative impacts on the Kagera River Basin agro-ecosystems. This study was conducted with the aim of understanding the transboundary issues of land and other natural resource degradation and conflict associated with livestock management and movement within the basin. The study focused mainly on the districts of Bugesera, Rwanda, Ngara, Karagwe and Missenyi, Tanzania, and Ntungamo, Kiruhura and Rakai in Uganda. Pastoralism and agro-pastoralism were the two main ruminant management systems observed in all visited districts of Rwanda, Tanzania and Uganda[1].

1 Uganda comprises two different set of conditions. Within the districts of Ntungamo and Kiruhula, semi-intensive livestock management system was practiced, as compared to Rakai District, where a majority of the livestock keepers rear their animals under extensive pastoral system, practicing uncontrolled movement within their own access pasture land areas, communal land and transboundary, crossing into Tanzania in search of grazing and water.

Study Methodology

The study was based on discussions with various stakeholders, including key informants (KI) and focus groups (FG). District authorities, administrative officers, district commissioners (DCs), directors and heads of departments of districts were visited at different times and venues for discussion.

Sampling frame, process and sampling technique

A cross-sectional study design was employed during the survey where purposive sampling technique was applied to obtain at least two villages in each visited district. The criteria on village selection was the proximity to the neighboring country's village with which there are ongoing conflicts.

Data collection

In order to gain an in-depth understanding of the trans-boundary issues of land degradation and conflicts related to livestock management and movements, different tools were used in collecting required information, including KI interviews, FGDs and individual household profiles. Checklists were used to guide discussions with key informants and a range of stakeholders during the FGDs. The structured questionnaire was used to collect individual household profile data, whilst personal observations were made also during the study in order to assess different elements in the field and within the wide socio-economic system. Finally, secondary data were collected from district reports, journal articles from libraries and web-based search. The main source of data for Tanzania included the National Bureau of Statistics Tanzania (2013), the Karagwe District Profile (2009), the Missenyi District statistics (2012) and the Ngara District Profile (2009). In Uganda, the following district data were consulted: Kiruhula District statistics (2012), Ntungamo District statistics (2012) and Rakai District Approved Development Plan for the Period 2010/2011 – 2012/2013. Also, data were gathered from the Uganda Administrative Division (2012) and the Uganda Bureau of Statistics (2011). Data from the National Institute of Statistics of Rwanda (2012) was also used. Finally, Kagera TAMP reports were used (Ruzika, 2012).

Lessons learned during the study

Livestock movements and migrant pastoralists and agropastoralists as traditional practice

High livestock populations are observed to exert significant pressure on land and other natural resources within the drier agro-ecosystems in the cattle corridor, causing degradation and loss of productivity. Livestock owners and herders in Uganda, Rwanda and Burundi have traditionally taken their livestock across the national borders towards sparsely populated districts of Ngara, Karagwe, Kyerwa and Missenyi in Tanzania in the dry seasons. Figure 1 shows that Uganda districts within Kagera River Basin still have higher cattle numbers compared to those in Tanzania.

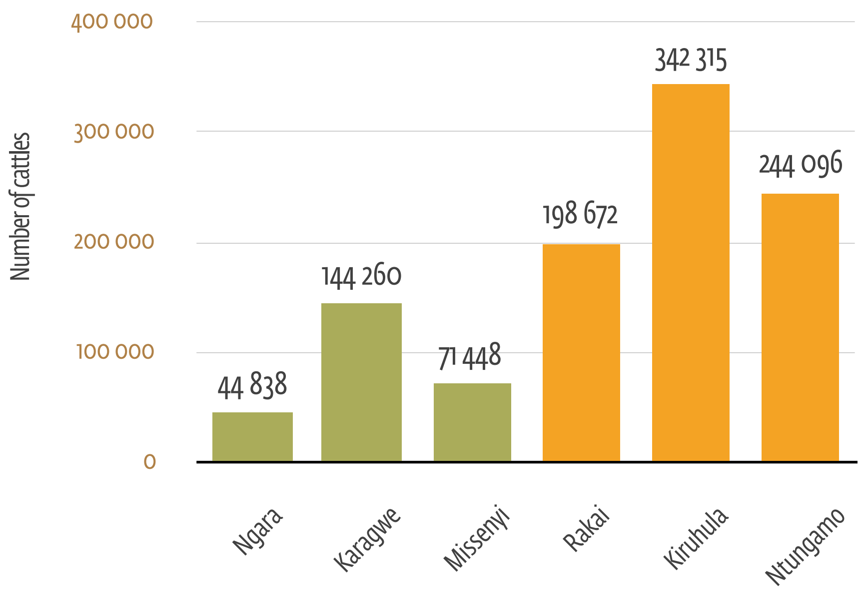

Figure 2: Numbers of cattle per surveyed district in Tanzania (green) and Uganda (orange).

Pastoralists and agro-pastoralists have always migrated seasonally to search for greener pastures and water for their livestock. However increasing population pressure increases conflicts and threatens sustainable extensive livestock management. There have been a number of cases reported of arrested migrant pastoralists with herds of Ankole cattle in different parts of the districts of Karagwe, Kyerwa, Ngara and Missenyi in Tanzania.

Identified corridors of transboundary livestock movement in visited districts

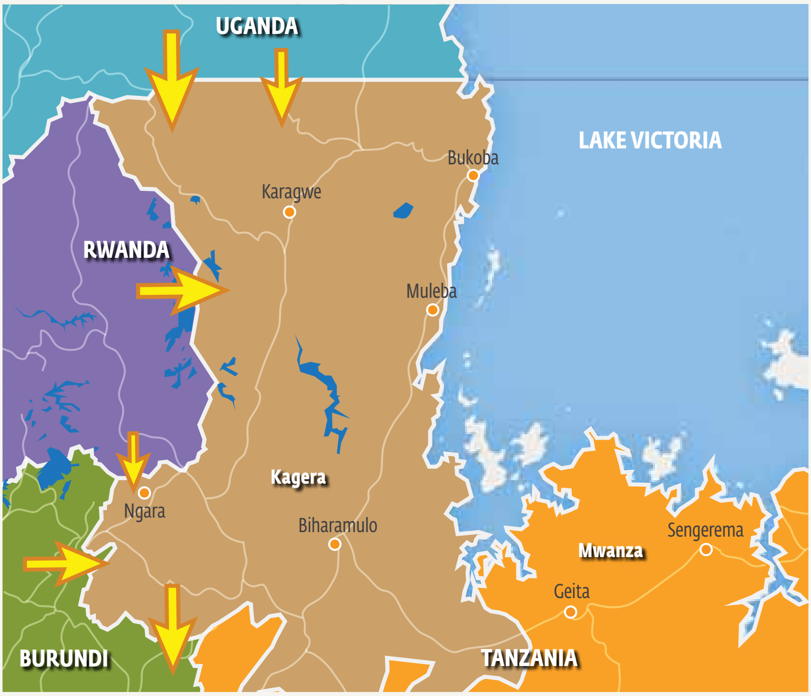

Figure 3: Showing transboundary livestock movements by green arrows (to and from).

The following transboundary livestock corridors were identified:

Ngara District, Tanzania (Rusumo, Murusagamba, Mukarinzi, Muganza, Mumiramira and Mwivuza wards): It was learnt that livestock cross the border from Burundi to Tanzania for various reasons. For example, it was observed that in Mwivuza village, livestock illegally cross the border from Burundi for the purpose of tick-control though dipping, due to the lack of dipping infrastructure and associated facilities in Burundi. Other animals are trekked in the other direction from Ngara via Lusahunga onwards to Mushiha, Burundi, where there is an established livestock market for cattle traded in Burundi.

Karagwe District, Tanzania: The main crossing point is through Chamnyina, Nyamiaga and Bugomora villages in Kibale and Ryabatara wards, respectively, from the cross-border Isingiro District of Uganda. Another entry point used to be from Rwanda through Ibanda game reserve. However, since the land use reform in Rwanda the influx of livestock from Rwanda towards Tanzania for grazing purposes has since been stopped.

Missenyi District, Tanzania: Cattle movements from Uganda are observed along the cattle corridors traversing Minziro, Kigazi, Bubare, Kakunyu and Mtukula wards of Missenyi District.

Kiruhula District, Uganda: Livestock movement is observed towards Lake Mburo National Park in search of grazing and water. However, villagers blame unrestricted movements of game animals causing both human and livestock deaths and crop destruction in nearby farmlands.

Rakai District, Uganda: Rakai District borders Missenyi District of Tanzania and experiences transboundary livestock movements through the corridors of Kabale, Koza, Biwa, Dikiri, Kyakatuma and Kyassindi villages of Kyebisagazi parish of Kakuuto County. Lukoma village was the only corridor observed in the Sangobe sub county

Ntungamo District, Uganda: There are livestock movements from Isingiro District that borders Karagwe District of Tanzania, where animals are trekked to the livestock auction market for trading towards Kampala, D.R. Congo and South Sudan. The animals move through Chikagate, Kajitumba and Milama villages of Rushenyi County.

Signs of land degradation caused by livestock mismanagement

Signs of land degradation in open access, publicly, communally and privately owned grazing lands due to poor livestock management practices and uncontrolled movements were reported during consultations and observed during visits within the districts of Tanzania (Ngara, Karagwe, Missenyi) and Uganda (Rakai, Kiruhula and Ntungamo) as shown in Figure 4.

Figure 4: Signs of overgrazed lands in Katera village, Karagwe District, Tanzania (left) and Kiruhula District in Uganda (righ) due to high grazing pressure.

Overgrazing is a predisposing factor to the problem of soil erosion which is common in these areas, leaving the overgrazed land is bare. Communal grazing lands are more severely affected by overgrazing than privately owned lands, as they tend to be mismanaged as a result of the lack of a sense of responsibility and ownership by the herder groups.

Major causes of trans-boundary livestock movements in Kagera River Basin

Shortage of pastures and water causing livestock movement towards Tanzania

Illegal migrant pastoralists from Uganda cross towards Missenyi and Karagwe Districts, whereas others go further south to Ngara District in search of grazing and water. The temporary migration is mainly experienced during the long dry season extending from July to September, and the short dry period January to March period (Figure 4). This is one of the major sources of conflict: such movements are associated with crop destruction, trespassing into private and communal land reserved for dry season grazing of local resident communities. The resulting conflicts between migrant pastoral and resident land users and their authorities oblige trespassing cattle owners to pay large penalties for the damage caused in the neighboring country, creating social tensions between the two groups.

Figure 5: A farmer-owned water source in Rakai District (Uganda) about to dry out as a result of overuse.

Livestock trading movement towards Uganda and Burundi

The survey revealed that live animals fetch better prices in Uganda than in Tanzania. This leads to herders who moved their cattle from Uganda to Tanzania in search of grazing during the dry season later trekking them back for sale in Uganda auction markets, from where they are mostly transported to Kampala, D.R. Congo and South Sudan. Besides this main route, some pastoralists illegally trek their animals across the Burundi border via Murusagamba and Lusahunga to the Mushiha livestock market in Burundi. Most of the latter group of animals are then traded in D.R. Congo. Livestock movement for trading purposes was also observed in Missenyi District where live pigs are illegally traded towards the Uganda border.

Observed competing claims and conflicts related to transboundary and within-country livestock movements and management

The main causes of conflict related to livestock management can be placed into six distinct categories (Table 1). However, all these conflicts arise due to the lack of appropriate participatory approaches towards improved livestock production, which could result in a mutually agreed livestock development strategy.

	Category	Main cause of conflict
1	Livestock herders (Tanzania vs Uganda)	Competing for grazing land and water for livestock
2	Livestock herders between countries (Uganda vs Tanzania vs Burundi vs Rwanda)	Livestock smuggling
3	Livestock herders vs national authorities	Breaking migration laws
4	Livestock herders vs crop farmers within-country and transboundary	Crop destruction
5	Livestock herders vs Environment Management Authority	Deforestation for charcoal making
6	Livestock herders vs national parks	Resource use and game poaching

Table 1: Main causes of livestock related conflicts between different categories of stakeholders.

On-going strategies and potential solutions within program sites for intensification of livestock management systems

Impressive improvements of strategies for natural pastures management are ongoing within Kagera TAMP FFS demonstration sites through initiatives to create sources of seeds of improved forage species for further multiplication and scaling up with the aim of rangeland reseeding.

Discussion

The traditional coping strategies of pastoralists focus primarily on their livestock. Pastoralists have indigenous ways of adapting to droughts by moving their livestock. However, due to the current land use pressure coupled with the effects of increasing weather variability and climate change, there are new challenges that render these indigenous adaptation strategies inappropriate and even prohibited in some cases.

During discussions with stakeholders and key informants, it was clearly stated that two main reasons for transboundary livestock movements are the shortage of pasture and water causing livestock movement towards Tanzania and the livestock trading movement towards Uganda and Burundi. Due to these movements, pastoralists collide with other land users within their areas, hence persistent conflicts related to resource use, breaking of laws and by-laws and livestock smuggling arise. The lack of enforcement of laws and by-laws, adapted technologies to intensify grazing management, limited water infrastructure development and lack of efficient livestock markets are some of the most important causes of transboundary livestock movements. It is also important to note that strategies to attract investors in the livestock sector from the national to district levels are still lacking. Strict enforcement of laws and by-laws on uncontrolled livestock movements are therefore highly recommended, hand-in-hand with strategies for improved management of grazing lands. Appropriate land tenure and security for livestock keepers with strict adherence to proper stocking rates are highly recommended to settle conflicts and maximize the economic potential of land and livestock resources within the Kagera River Basin agro-ecosystem.

The extensive land degradation attributed to over-grazing and trampling effects of uncontrolled movements of large herds of cattle needs to be resolved by all key stakeholders and actors at all levels, in order to come up with a harmonious integrated, profitable and environmentally friendly livestock management system suitable for the Kagera River Basin. This is possible if there is adequate political will, appropriate land policy and strategic mechanisms, along with increased investment on best-bet livestock technical approaches.

The livestock sector in Kagera River Basin agro-ecosystem has the potential to lift many of the rural communities out of the prevailing poverty. However, the sector is characterized by minimal investment, and thus low productivity, low profitability and sluggish progress towards modernized livestock production. The challenges leading to this low productivity include, among others, the dominance of the sub-sector by small-holder farmers and herders who lack modern technologies, face poor infrastructure, inadequate extension services delivery including veterinary services, lack of value addition, lack of appropriate financing mechanisms, limited and unreliable markets, and environmental degradation. Both smallholder farms and existing commercial ranches and sub-blocks still need capital investment for improvement. There is still a long way to go, and the need for district councils to mobilize investments in the livestock sector is highly crucial.

Conclusions

The study improved understanding of transboundary livestock movements and their impacts in terms of natural resource degradation and conflict. The major reasons for cattle movement across the Kagera countries which are mainly concentrated in the drier cattle corridor countries are the search for pastures and water supply during the dry season and livestock trading. While transboundary movement of cattle is the most common feature, transboundary pig movement has been identified as an up-coming issue due to a trade wave through Missenyi District towards Uganda. There is a need for local authorities to facilitate dialogue and the development of negotiated livestock and natural resources management plans along the grazing routes between the pastoralists, agro-pastoralist and farming communities, within and between districts and across country borders. There is also a need to create formal and organized border markets of cattle and pigs with the purpose of increasing the benefits accruing from the business for both farmers and traders. The following recommendations for follow up were developed in consultation with the project Regional steering committee comprising representatives of the concerned sectors from the 4 countries help addressing the ongoing land degradation issues linked to livestock transhumance.

Recommendations at regional level

i. Need for the respective governments and district authorities to recognize the important contribution of pastoral livestock production systems within the overall district and national economy;

ii. FAO, Kagera TAMP and other stakeholders to facilitate consultation within and between border districts so as to expedite the preparation of village land-use and livestock management plans with the aim of identifying and demarcating suitable land for investment in livestock related enterprises (at medium to large scale) including communal grazing land and migratory routes for seasonal movements and formalize and transboundary collaboration investment procedures at national, district and village levels;

iii. The need to scale-up land resource conservation through planned afforestation of overgrazed steep slopes and gullies through the use of multi-purpose tree legumes (MTPL) for protecting downstream grazing and cultivated lands and providing additional feed;

iv. There is a need to carry-out genetic conservation strategies for traditional long horned Ankole cattle to value and develop this robust but low performing indigenous breed;

v. Improvement of the indigenous zebu cattle herds through use of pure-bred sires of recommended specialized dairy or beef breeds would increase performance and profitability and reduce conflicts (e.g. higher producing cross-breds with the trypanotolerant N'dama from West Africa, Sukuma Zebu from Tanzania and Sahiwal Zebu from Pakistan that are adapted to the harsh tropical conditions as well as European breeds such as Jersey, Frisonne and Friesian Holstein), where reliable access to feed, water and veterinary advice can be assured;

vi. Need for border districts to promote rangeland rehabilitation and sustainable livestock management practices through livestock FFS and to initiate annual competitions associated with award giving ceremonies for on livestock keepers;

vii. Need to train livestock keepers and community members in pasture quality assessments (e.g. LADA local tool) for informed decisions on grazing movements backed up by conduct botanical assessments aimed at improved management of pastures and livestock to maintain the carrying capacity of grazing land.

Recommendations at district level

i. Need to enforce livestock identification for traceability purposes, so that this can also be used to control unplanned livestock movement between districts and between neighboring countries;

ii. In districts where extensive grazing rangelands are still available, planned livestock movements are recommended in order to utilize these vast grazing lands in an economically sustainable manner with planned range improvement strategies;

iii. Need to fence off legally owned land for livestock production using cheap locally available live fences such as minyaa (e.g. *Euphorbia tirucalli*) – already commonly used in Uganda and parts of Rwanda – while maintaining cattle migratory routes for planned movements and coping with drought;

iv. Respective district councils to collaborate with livestock and other stakeholders to construct modern livestock auction markets, equipped with appropriate facilities (including weighbridge, loading chute etc.), as this would reduce livestock movements for trading purposes and would be an important source of revenue from increased livestock offtakes.

Recommendations at ward/village level

i. Livestock herders/farmers to establish "grazing committees" at village or ward level, which would support livestock development, sustainable management and ownership of grazing lands (communal, private and public lands);

ii. Kagera stakeholders should facilitate agro-pastoralists to initiate model farms through "livestock farmer field schools" (LFFS)

iii. Livestock keepers in collaboration with sector veterinarians and other local authorities to manage up-to-date livestock data at village levels in a "village livestock register" and where possible emphasize use of mobile (text messages on livestock births, sales, slaughter and deaths) to transfer data from livestock keepers to livestock ward officers;

iv. Local and district authorities to facilitate training of livestock keepers on simple conservation techniques such as hay and silage making.

Rehabilitation of degraded rangeland pastures caused by transboundary livestock movements

5.2

Author: Fidelis B. Kaihura*, Jonas B. Kizima†, Wilson Bamwerinde*, Salvator Ndabirorere*, Emmanuel Muligirwa*, Venuste.G. Rusharaza*

Affiliation: * *Kagera TAMP project staff*
† *International consultant Kagera TAMP*

Summary

A study was conducted with the aim of understanding the grassland and rangeland conditions within the basin, including effects of transboundary animal movements. After assessing the main causes of grassland degradation, the study identified the best practices that the Kagera TAMP project is bringing to the area. Also, major positive impacts of the project have been analyzed through botanical and livestock production analysis.

Key words: grasslands, degradation, rehabilitation, seeds.

Introduction

Rangelands comprise grasslands and wooded grasslands. These are the main land resource base for the livestock sector in the countries of the Kagera River Basin (Tanzania, Uganda, Burundi and Rwanda). Grasslands are among the most degraded land use types in the basin, due to a range of factors: notably overgrazing, frequent wildfires, soil erosion, transboundary livestock movements, lack of land management technologies and limited enforcement of by-laws, laws and regulations.

Grasslands have for a long time been communal lands, with de facto nobody responsible for their management. The survival of pastoralism has largely been due to the mobility strategy adopted by pastoralists, which has maintained equilibrium of the rangelands. However, recent changing scenarios – above all growing population of both people and livestock – have increased land use pressure resulting in rangeland degradation (Figure 1) and chronic conflicts. Most grasslands have no improved drinking water points and livestock have to trek long distances in search of water, thereby exacerbating degradation. Shifting livestock after pastures degrade has been a common practice, but this is becoming less and less feasible. The Kagera TAMP project in Tanzania has been at the forefront of applying modern technologies for rehabilitation of degraded pastures, with remarkable success.

Figure 1: Ankole cattle grazing on degraded pasture in Rakai District, Uganda.

Study methodology

The present article is based on various field level analyses including a vegetation examination, a rangeland survey and an animal production study. A cross-sectional study design was employed during the survey where purposive sampling technique was applied to obtain at least two villages in each district visited. The criteria on village selection was the proximity to the neighboring country's village with which there are ongoing conflicts.

Botanical composition assessment

The assessment aimed at defining the dominant pasture and forage species within the grazing lands of all visited districts. The rangeland assessment was realised through the Frequency method. A total of 20 randomly thrown quadrants at the interval of ten meters along the transect were sampled in each of the sampled area within the districts visited. A one meter square quadrant was used as the sampling unit in all communally and privately owned grazing lands. The technique involves tallying of all species appearing within the sampling unit and classifies them into three categories: as (i) desirable, (ii) less desirable, and (iii) undesirables, representing pasture species which are palatable, intermediate and unpalatable, respectively. All pasture species were first identified by their scientific names and/or common names.

Herbage dry matter yield

Measuring of the herbage yield was carried out hand in hand with the botanical composition analysis using the same sampling unit. After tallying the available pasture species within each sampled quadrant, the desirable species and intermediates were clipped using a pair of secateurs and weighed to obtain the sample fresh weight.

Carrying capacity and stocking rate estimates

Forage sampling was done using a one meter quadrat in the grazing area of visited villages in private, communal and public owned grazing land areas. Twenty quadrats of fresh samples were taken at an interval of 50 steps, and clipped using a pair of secateurs and weighed. Sub-sampling of the fresh forages was done so as to remain with manageable samples that were air-dried before being submitted for oven drying. The dry matter (DM) yield was extrapolated on a per hectare basis to obtain forage dry matter yield per hectare. In order to avoid calculating carrying capacity to a level that implies overgrazing, 70 percent of the forage yield was considered as the proper use factor (PUF) maintaining lenient grazing[1]. This considered vegetation regeneration where usable forage was the total forage yield times the factor. Using the usable forage yield data obtained, stocking rates were estimated basing on the worldwide common assumption that a mature animal (cattle) on a daily basis consumes 2-3 percent (De Leeuw, 1990) of its live weight, that is nine kg DM per day (300 kg × 0.03). Whereas, on a monthly basis, the forage consumed by one adult animal is 9 kg DM / day × 30 days = 180 kg DM / month (or 1 animal unit month, or AUM) and annual carrying capacity was estimated based on 365 days. An average of 300 kg live body weight (for Ankole cattle) was used instead of an average of 250 kg which is commonly used.

Kagera TAMP strategies for rehabilitating land

Since the beginning of the project in 2010, communities were sensitized on the extent of pasture degradation and its impact on land and livestock quality and farmers' and herders' livelihoods. Various activities are among the technologies demonstrated by extension facilitators in different microcatchments. This includes the capacity building of communities on pasture improvement using farmer field schools to introduce improved grass and legume (herbaceous and tree legume) species. Also, area enclosure of degraded pasture has been used against trespassing. The enforcement of by-laws has supported bushfire control. Technologies such as pasture seed production and establishment in degraded fields have contributed to increase the land cover and have protected soil, as well as increasing grassland productivity. Construction of contour bunds and tilling of sealed and crusted bare surfaces have enhanced soil water infiltration contributing to climate change adaptation.

1 In other areas the rule of "graze half and leave half" (50 percent or less PUF) can be used depending on status of plant regeneration.

Achievements by Kagera River Basin TAMP

Using an agroecological pasture improvement approach, selected pasture species have been introduced since the start of the project. Until mid-2013, more than 70 hectares of grassland (22 hectares in Kihanga/Katera in Kyerwa and Karagwe District, 20 hectares in Rusumo Ward, Ngara District and ten hectares each in Kirushya, Murongo and Bujuruga microcatchments) have been rehabilitated, partly through farmer field schools (FFSs) and community collective works (Figure 2). This kind of agroecological pasture improvement was really appreciated by farmers as no land tillage was involved and costs are low therefore both for the improvements and maintenance. Approaches on pasture establishment were also introduced on individual farmer plots, for those who were ready to collaborate with the project as an initiative to increase the yearlong availability of pasture for their animals for increased productivity.

Figure 2: Contact famer under Kagera TAMP showing his forage garden as a FFS in Kiruhula (left) and tree seedlings for afforestation of degraded water micro-catchment in Ngara District (right).

Improved pasture seed introduced to farmers and into the grasslands were obtained from livestock research institutes. They were distributed to most microcatchments' groups for degraded pasture improvement. Introduced species included grasses (*Chloris gayana* and *Cenchrus ciliaris*) and legumes (*Sesbania sesban*; *Cajanus cajan*; *Cannavalia braziliensis*, *Stylosanthes scraba*; *Clitoria ternatea*; *Centrocema pubescens*; *Macroptilium atropulpureum* and *Desmodium intortum*).

Besides introduction of improved seed in degraded grasslands, efforts have been made to produce seed for continued grassland improvement at Ward Agricultural Resource Centres (WARC) – also known as Farmer Extension Centres (FECs) – of Kabirizi and Kyema in Bukoba District, Kihanga/Katera, Murongo and Bujuruga in Kyerwa and Karagwe Districts and Kayanga in Missenyi District. Seed production is ongoing for *Chloris gayana*; *Centrocema pubescens*; *Desmodium* *intortum; Cannavalia braziliensis* and *Clitoria ternatea*. Different farmers and leaders in the districts visited the WARCs/FECs for exposure to improved technologies in sustainable land management. Inclusion of improved pasture species in the WARCs has been a new dimension which had previously not been addressed.

Other measurable achievements in pasture technologies to rehabilitate degraded land include improved carrying capacity through FFS studies and area closure. As an example, in Katera village (Karagwe District), deferred grazing was practiced to restrict degraded land grazing. This increased carrying capacity from 5 to 0.4 hectares per Tropical Livestock Unit (TLU) and forage biomass yield from 570 to 7,050 kg DM per hectare in one year (see Figure 3 and Table 1). Thanks to regeneration of pasture, desirable species re-appeared in the botanical composition. With rehabilitation of grasslands, it is now also possible for traditional medicine practitioners to collect medicinal plants that were previously thought to be extinct. Other achievements include an increase in surface vegetative cover from less than 40 percent in some areas to about 95 percent, and thus a significant reduction in bare surfaces that are vulnerable to high runoff rates and soil erosion. Bare surfaces have also been tilled to reduce the soil crust and sealing and improve infiltration of rainwater, which has also been improved through construction of contour in the pasture land.

Figure 3: A farmer in Katera village (Karagwe District) admires regenerated natural grassland after being restricted from grazing for one year.

District	Management	Usable forage yield (kg DM/ha)	Monthly stocking rate (AUM)	Carrying capacity	
				(TLU/ha/year)	(ha/TLU)
Ngara, TZ	Ungrazed land	4 000	17.8	1.5	0.7
	Grazed land	1 000	4.4	0.4	2.5
Karagwe, TZ	Ungrazed land	7 030	31.2	2.6	0.4
	Grazed land	570	2.5	0.2	5
Missenyi, TZ	Ungrazed land	3 750	16.7	1.4	0.7
	Grazed land	800	3.6	0.3	3.3
Rakai, UG	Ungrazed land	2 369	10.5	0.9	1.1
	Grazed land	200	0.8	0.1	10
Kiruhula, UG	Ungrazed land	1 000	4.4	0.4	2.5
	Grazed land	400	1.8	0.2	5
Ntungamo, UG	Ungrazed land	1 200	5.3	0.5	1.7
	Grazed land	400	1.8	0.2	5

Table 1: Forage yield, stocking rate and carrying capacity estimation. Source: Kizima (2013) Kagera TAMP consultancy report on Transboundary Livestock issues. DM: dry matter; AUM: animal unit month; TLU: Tropical Livestock Unit.

When grazing was restricted from degraded natural pastureland for one rainy season, there was a vivid recovery and regeneration of the botanical composition and diversity of palatable species.

Pasture species diversity is very important in grazing areas. Carrying out botanical composition analysis is crucial to be able to monitor ecological succession, including disappearance and regeneration of desirable, intermediate and undesirable pasture species. Appropriate livestock management through timely rotational grazing and pasture improvement should aim at reducing the frequency of undesirable /less palatable species in the Kagera River Basin rangelands. The assessment of stocking rates and carrying capacity (based on forage yield) can clearly indicate the estimated livestock numbers in terms of Tropical Livestock Units (TLUs) per unit area of rangeland per year. This contributes to more informed decision making and recommendations on appropriate rangeland management practices. The carrying capacity is indicative as the key management issues are to maintain a reasonable herd size for manuring the land but to keep moving the herd before the plants are damaged through overgrazing, as demonstrated by the holistic management work of Alan Savary in Zimbabwe and elsewhere[2].

Lessons learned from Katera village in Karagwe District have motivated livestock keepers to invest in pasture improvement for increased livestock productivity. Farmer group members are now allowed to bring in calves for grazing; others are cutting and carrying grass for stall feeding their livestock, house thatching and other uses. Several medicinal plants which were thought to be extinc have regenerated and traditional healers can now readily access them.

Kagera TAMP has also accessed some technologies being developed by national agricultural research (NAR) for on-field and rangeland trials. Some of the introduced pasture species that had shown promising results on-station can be obtained from the Karama Agricultural Research station, Rwanda (Figure 4). These species include *Stylosanthes* spp., *Centrosema pubescens*, *Leucaena leucocephala*, *Panicum maximum*, *Brachiaria brizanth* and *Cenchrus ciliaris*.

Figure 4: Introduced pasture species under nursery evaluation at Karama Agricultural Research Station, Rwanda.

2 The Savory Institute (http://savory.global/), located in Zimbabwe, has the mission to promote large scale restoration of grasslands.

Challenges on pasture improvement approaches

The main challenges faced in scaling-up pasture restoration include farmers' resistance to allocate land for pasture improvement, wildfire outbreaks, limited enforcement of by-laws on wildfire control and the land tenure systems where land grabbing is common in communal lands for tree planted with trees by ex-community members who now live and work in nearby towns for investment purposes. Most areas under pasture rehabilitation under the Kagera TAMP were burnt in 2014, which reversed the progress made during the project. Efforts have been made to establish micro-catchment committees, which will assist extension site facilitators in controlling burning especially in rehabilitated pasture areas. These committees include village leaders and other influential community leaders.

Other challenges are linked to the limited availability of improved seed for multiplication. Furthermore, a challenge is the lack of knowledge to harvest and conserve fodder during the rainy season – when there is surplus herbage production – in the form of silage and/or hay for animal feeding during the deficit dry season and other difficult periods. Inadequate knowledge of extension staff to select appropriate pasture species for different agro-ecological zones is also an issue. Finally, the rapid extinction of valuable indigenous species due to lack of forage germplasm conservation is also a growing challenge.

Future plans

Main recommendations for future activities include both input availability and community awareness raising.

On the input side, more improved pasture seed should be purchased and introduced to farmers in order to improve the degraded grassland and increase production of palatable livestock feed.

Also, communities should be sensitized to respect by-laws and to identify and punish individuals setting fires. Burnt land should be under strict watch out by project members, village leaders and the micro-catchment committees. A further sensitization of communities on the benefits of establishing farmer grazing committees to take care of grazing lands should be entailed, as it will create sense of ownership and awareness of planning and appropriate management of improved grazing lands.

The situation of land and natural resources conflicts in the Kagera River Basin

5.3

Author: Syprose Ogola

Affiliation: International consultant Kagera TAMP

Abstract

Transboundary land and natural resources conflicts are threats to sustainable land and agro-ecosystem management in the basin. The basin is currently witnessing severe population pressure, which is exacerbating resource competition and conflicts. The basin countries have well developed policies, laws, legislation and by-laws including regional arrangements for sustainable land and agro-ecosystem management and conflict resolution mechanisms. Identified land and natural resource conflicts include: conflicting land tenure systems; migration and competition over land; overgrazing and uncontrolled livestock movements; bushfires and deforestation. The situation has been exacerbated by climate change and by conflicting policies, regulations and laws regarding land and natural resources across the basin countries hindering effective application and enforcement. It was critical for Kagera TAMP to address transboundary conflicts in the agricultural landscape in the process of adapting and promoting integrated and participatory approaches for sustainable land and agro-ecosystem management (SLaM), and thereby improve food security and rural livelihoods. Recommendations from the project's experience include building the capacity of institutions dealing with natural resources especially at community and district/provincial levels; strengthening transboundary defense and security committees and harmonization of policies, regulations and laws at the regional level.

Key words: conflicts, PNTD, livestock, croplands.

Background

The Kagera River Basin is endowed with land and other natural resources (forests, grazing areas, wildlife, water and wetlands) that support cultural aspects, socio-economic development, food security and communities' livelihoods. It is estimated that over 16 million people live within the basin - covering over 59 700 km^2 - are largely dependent on the natural resource base.

However, transboundary land and other natural resources related conflicts are major contributing threats to sustainable land and agro-ecosystem management in the basin. Due to intensification of land use for increasing the production of food, some for sale and export, and to meet energy requirements and other needs of rapidly growing rural and urban populations, the Kagera River Basin is facing significant degradation of soil, vegetation and water resources. This is affecting the ecosystem services provided by agricultural landscapes and the wider watershed. The high population pressure is causing increasing land fragmentation and competition over land and other natural resources, as people strive to sustain their livelihoods. It is noteworthy that the four countries of the Kagera River Basin have well-developed policies laws, regulations and by-laws and some regional arrangements for SLaM and conflict resolution mechanisms to regulate sustainable utilization of natural resources. However, decentralization as a policy instrument still falls short of providing an effective enabling environment for successful implementation and enforcement of this policy apparatus among resource users by the various levels of governance within the countries. Also the different in-country policies, regulations and laws governing land and other natural resources present a "gap" in regional (transboundary) integration and enforcement. The result is unplanned use of resources, over-exploitation, degradation and resources conflicts.

Methodology and approach

The study adopted a qualitative research methodology and applied the FAO time tested Participatory and Negotiated Territorial Development (PNTD) approach. Qualitative research methodology and techniques including key informants (KI), focus group discussions (FGD) and individual interviews were conducted. These were carried-out at national, district and community levels using triangulation to ensure accuracy and reliability of the results. The qualitative research techniques were undertaken at the preliminary stages of the project, and the PNTD was proposed as methodology for a long-term conflict solving process.

Identified transboundary land and natural resources related conflicts

Conflicting land tenure systems within the basin

Different forms of land tenure systems (in-country) co-exist within the Kagera Basin and are sources of conflicts within and across administrative and territorial borders. Uganda has five different tenure systems namely: customary; statutory; *mailo*; freehold; and leasehold. Burundi has a dual tenure system: customary; and statutory. Rwanda abolished the customary forms of tenure in the recently enacted Organic Land Law[1] (revised version 2013). Tanzania still derives the formal/legal basis from two laws, namely the Land Act and the Village Act that were passed in 1999. The Land Act (1999) states that a Customary Right of Occupancy is in every respect of equal status and effect to a granted Right of Occupancy. This law is open to abuse and a source of conflict between local leaders, investors and villagers.

From the assessment carried-out in the basin, it appears that customary tenure systems pose the biggest challenge to SLaM because women, although the majority are engaged in the agriculture sector, have no recognized tenure rights; leading to land ownership and user rights' conflicts. At the same time, land conflicts emanate mainly from customary rights such as inheritance. Customary tenure systems are responsible for severe land fragmentation, as each family member has a right to inherit land, a factor that contributes to serious problems of management as farms are sub-divided with every generation – often resulting in land degradation. From the assessment, it is concluded that the customary land tenure system makes it difficult to resolve land use conflicts and generates little personal interest in the status of land resources and the environmental management ("the tragedy of the commons") – the main causes of unsustainable land use and degradation.

1 N° 43/2013 of 16/06/2013 Law governing land in Rwanda was gazetted in the *Official Gazette n° Special of 16/06/2013*.

Population pressure, migration and competition for land

A complex interaction exists between high population pressure, population movement and competition for land, resulting in serious land conflicts within the basin and across borders. The search for more land for cultivation and access to grazing and water has led to movements of people and their livestock into more fragile or risk prone areas (steep slopes and floodplains) or protected areas (nature or forest reserves) that has exacerbated extensive degradation of the ecosystem resources including loss of biodiversity. At the time of the assessment (August–September 2012) there were serious conflicts[2] in the Kagera Basin between Tanzania citizens and illegal migrants from more heavily populated Rwanda, Burundi and the highlands of southwest Uganda. The types of conflicts varied as shown by these two examples:

i. Conflicts over land between Tanzania and Rwandan citizens in Karagwe (now Kyrewa) District, whereby the Village Chairmen (Custodians of Village Land according to the Village Land Act of 1999) were irregularly allocating village land to Rwanda citizens (mainly, refugees with marriage ties) for farming activities, without following due processes and, to make matters worse, without the knowledge of the Village Council.

ii. Conflicts over access to village land and informal/irregular land sales to foreigners along the border Districts of Missenyi, Karagwe, Kyerwa and Ngara in Tanzania. Large chunks of village land, traditionally grazing areas for Tanzania herders, were allegedly sold to Rwanda pastoralists in Kihanga/ Katera, Isingiro which resulted in internal conflicts between Tanzania herders and farmers over encroachment.

Overgrazing, uncontrolled livestock movement and bushfires

Transboundary conflicts emanating from the increasing number of livestock (cattle mainly) and unsustainable grazing land management practices (e.g. uncontrolled bushfires and grazing regimes) leading to the extensive degradation of the rangelands are common. Increasing pressure on the more fragile, drier ecosystems in the so called "cattle corridor" is caused by increasing numbers of livestock coupled with uncontrolled movements across the basin and increasing competition and conflicts over the resources. Tanzanian citizens expressed how large numbers of livestock from Rwanda and Uganda have resulted in overgrazing in certain areas, and in most cases are constant sources of conflicts

2 It is important to mention that conflict resolution and restitutions institutions were heavily compromised and there were allegations of corruption.

over water and grazing areas (pastures and animal corridors) in places such as Kimisi, Burigi, Ibanda and Rumanyika Game Reserves. Also, Rwandan citizens irregularly acquired land and fenced-off plots, a fact that accelerated overgrazing in Nyakasimi, Kihanga/Katera, Isingiro and Rusumo, and exacerbated conflicts over grazing land between Tanzania citizens and Rwanda refugees.

Deforestation

There were recorded conflicts emanating from massive forest destruction between Tanzanian residents and immigrant pastoralists from Burundi, Rwanda and Uganda. The areas worst affected by uncontrolled cutting of trees and illegal bushfires were Minziro Forest Reserve, along the Ruvubu River, also Nyakasimbi and Ibanda Game Reserves. Immigrants engaged in illegal charcoal burning, cutting wood for fuel, unlicensed brick making (which uses large amounts of fire wood) and wildlife poaching activities also create conflict with local residents.

Conflicting policies and other legal instruments on land and other natural resources

In the four countries of the basin, there are contradictions and overlaps in policies, laws, regulations and acts, making enforcement difficult. In Tanzania, for instance, the Agriculture Policy allows farmers to cultivate wetland areas during the dry season, contradicting the Water and Environment Acts. In Rwanda, tea is grown within the wetlands because of the fertile soils and good water supply, but this diminishes the natural functioning of the wetlands which naturally act as sponges to control river levels thereby increasing the risks of floods and periods of low flows.

In the same vein, the lack of harmonized regional natural resources policies, regulations and laws and conflict resolution mechanisms one major setback in terms of land and natural resources management. Moreover, different institutions dealing with resource conflicts in each country have specific challenges such as lack of capacity, technical and financial support by the State.

Well-coordinated regional policies on human migration and livestock movements across border districts is lacking particularly on seasonal (short-term) migration in search of pastures and water during the extended dry season (June to September-October). Pastoralists are often affected by weak policies and legal instruments (migration, land use and other policies) coupled with corruption along the border districts.

What Kagera TAMP has done to address transboundary conflicts

- Training sessions on NRM and conflict resolution was carried-out in August-September 2013 in each country. A follow-up evaluation in October 2014 showed how participatory approaches such as the "Participatory and Negotiated Territorial Development" (PNTD) tools have been widely adopted by the participants for natural resource management and conflict resolution;

- Further training modules on NRM and conflict resolution have been developed to address issues such arising.

Proposals on how to address transboundary conflicts

- Build the capacity of in-country institutions to handle land and other natural resource conflicts at the regional level and alternative dispute resolution mechanisms using participatory approaches such as PNTD, which has proved successful during the Kagera TAMP.

- Develop transboundary FFS networks as a forum to advocate for SLaM and integrate conflict resolution, adopting the training modules developed in 2013 as guidelines for scaling-up.

- Support regional forums on good governance of land and other natural resources to boost opportunities for collaboration on conflict resolution.

- Strengthen cross-border committees such as the existing District Defence and Security Committees through capacity building (e.g. training on participatory conflict management and dispute resolution mechanisms).

- Harmonize policies, regulations and laws on land and other natural resources within the Kagera Basin to support SLaM practices; amend any country policies that pose a threat to sustainable land management; and share these proposals at the wider East African Community level for greater buy in.

- Post project members of Kagera TAMP regional and national project steering committees should further catalyse coordination and partnerships with other key players for scaling up and mainstreaming sustainable land and agro-ecosystem management, such as interventions under Lake Victoria environmental management programme (LVEMP II) and Nile Basin Initiative (NBI), and TerrAfrica and other Global Environment Facility (GEF) projects.

Conclusion

The overall situation of land and natural resources in the basin is currently witnessing the effects of severe population pressure, exacerbating competition and conflicts that eventually threaten SLaM. There are in-country issues of land/ natural resources governance and management with "spill over effect" to other countries. It is therefore critical to scale-up and mainstream the successful efforts and initiatives of the Kagera TAMP and to address transboundary conflicts whilst promoting sustainable land and agro-ecosystem management approaches at the landscape level across the basin, as a means to improve food security and rural livelihoods.

Conclusion Theme 5

5

Recommendations for transboundary land resources management

Sustainable land resources management across the transboundary in Kagera River Basin is affected by livestock mobility and existing conflicts between different land uses and users of land resources. An approach allowing for detailed analysis of the transhumance system and its ecological effects, linked to a historical analysis that takes into account the prior experiences and customary expectations of different groups, is a basis for negotiation and dialogue in conflict-solving terms. The process can result in a comprehensive understanding of the cultural complexities surrounding land use and land ownership, including attitudes to resources such as water, animals, and freedom/restrictions on transboundary movement and migration/settlement. Based on the lessons learned by Kagera TAMP, the following recommendation for future transboundary actions are drawn from the case studies under this theme "transboundary land resources management".

Policy harmonization within and between countries

The most important policy recommendations to address the challenges of transboundary conflicts are:

- Establishing laws and legal instruments through a participatory and all-inclusive approach, and designing acceptable mechanisms for their control and enforcement;
- Strengthening capacity of land users and local authorities in dispute and conflict resolution over land and other natural resources, SLaM best practices, including measures to mitigate spread of transboundary animal and plant diseases, supporting livestock keepers (agro-pastoralists) to maintain a "Village Livestock Register" and strengthening communication technologies;

- Ensuring that all policies and legal instruments on sustainable land management (SLaM) are harmonized and well coordinated within a single country;
- Harmonizing policies and legal instruments for the four countries sharing the Kagera River Basin (e.g. width of protected land along riverbanks to stabilize and reduce erosion).

Studies and increase knowledge

Various studies were conducted by the project with the aim of understanding the transboundary issues and identifying and prioritising interventions. Studies included analysis of grassland status and grazing land carrying capacity, along with an assessment of ongoing conflicts. These studies were shown to be valuable in allowing project partners and concerned institutions in the region to prioritize interventions more appropriately. They can also be beneficial in assessing impacts in more depth than is feasible using participatory monitoring and evaluation methods and in guiding larger investments. In this regard, the contribution of national agricultural research (NAR) to agro-ecosystem rehabilitation and to transboundary studies and analysis should also be reinforced. The monitoring of impacts from activities such as agro-ecological pasture improvement, selected pasture species introduction and native grassland seed production could be undertaken by NARs. This would significantly contribute to the development of the livestock sector, for example by prioritising the need to overcome the chronical lack of seeds for productive forage species (grasses and legumes) . Also, the rapid extinction of valuable indigenous species due to lack of forage germplasm conservation was identified as a growing challenge that NAR could address through guiding and monitoring conservation programs at the local level.

Strengthening negotiation between actors through increased capacity

In general terms, strengthening capacity development of land users and key institutions on the wider up-stream-down-stream effects of unsustainable practices (e.g. overgrazing, overstocking, encroachment of watersheds and wetlands, etc.) and their impacts that go beyond international frontiers is needed. This includes multiple levels of training such as:

- Strengthening the capacity of communities and institutions within the Kagera River Basin on conflict resolution mechanisms using “Participatory and Negotiated Territorial Development (PNTD)" and "Welcoming Capacity" approaches for addressing transboundary conflicts that were demonstrated to be successful within the project and could be replicated and scaled up;

- Increasing the capacity of the staff of key institutions engaged in SLaM on recognizing the importance of pastoral livestock systems in improving the socio-economic condition of the beneficiaries and adapting to climate change and contributing to the overall national economies of the basin countries;

- Increase the knowledge of extension staff to select appropriate pasture and tree species and soil and water conservation measures for the various positions in the watersheds and agro-ecological zones in order to ensure an ecologically sound rehabilitation; and to integrate value addition through bee keeping, fodder production, marketing and so forth;

- Expand the FFS extension delivery approach as the principle means of disseminating SLaM best practices to address the alarming agro-ecosystem degradation challenge. Sensitizing and supporting livestock keepers (agro-pastoralists) to initiate model livestock farms as Livestock or Agropastoral Field Schools (LFFS or APFS) would further reinforce the livestock sector. Supporting training of FFS master trainers, SLaM FFS /APFS facilitators and grass-root and district personnel on dissemination of grassland and livestock management best practices and in applying the FFS approach, and carrying out associated follow-up activities, would also deeply contribute to the sector improvement;

- Finally, putting in place the required governance mechanisms and multi sector and multi-stakeholder collaboration for promoting an integrated landscape management approach. This can be done through a nested multi-scale process that combines SLM practices for sustainable and productive crop, livestock/pasture and forest management in target catchments and partnerships and funding for their scaling up to wider watershed and transboundary levels.

Conclusion

The conclusion of the book builds on the relevant activities mentioned in the five themes the book covers, namely:

Theme 1: Farmer field schools approach for successful learning and uptake of adapted SLM technologies at farm and ecosystem level;

Theme 2: Catchment planning and local governance for integrated land resources management;

Theme 3: Agro-ecosystem management for multiple benefits (production, SLM, climate and biodiversity and ecosystem services);

Theme 4: Natural resources and livelihoods diagnostics and Impact assessment for SLM planning and monitoring;

Theme 5: Inter-sectoral cooperation, planning and policy for addressing transboundary land resources management.

The lessons learned build on the 26 case studies and experiences documented by local authors on sustainable land resources and agro-ecosystem management across the transboundary Kagera River Basin based on the farmer field school and participatory catchment/watershed management approaches with farmers, livestock keepers and local communities. This includes conflict resolution and governance mechanisms among the various users of natural resources as well as the use of a number of land resources assessment and planning tools from local to transboundary level with guidance and support of technical sectors and district and national actors.

The lessons that are presented here are also informed by wider lessons learned from a stocktaking of experiences under the TerrAfrica Strategic Investment Programme (SIP) on sustainable land management in Sub-Saharan Africa. Such evaluation included Kagera TAMP and three other transboundary watershed/ river basin management projects, 17 national SLM projects, four regional thematic projects and an institutional support project (FAO-TerrAfrica, 2016).

Regarding the transboundary projects, the Kagera Basin project is nested in the Lake Victoria Environmental Management Programme (LVEMP-II) which is also shared with Kenya and, in turn, in the wider "Eastern Nile transboundary watershed management project", NELSAP, which is shared with Sudan, Ethiopia and Egypt. The other watershed project "Enhancing decision making through interactive learning and action in Molopo Nossob River Basin" is shared by Botswana, Namibia and South Africa.

Many of the TerrAfrica SIP national projects also built capacity of communities and partnerships in watershed, landscape and ecosystem management and planning, including rainfed and irrigated cropping and agropastoral systems (Djibouti Eritrea, Ethiopia, Gambia, Kenya, Lesotho, Madagascar, Malawi, Mali, Niger, Nigeria, Senegal, Swaziland and Tanzania), as well as coastal ecosystems (Comores) and oases (Niger and Mauritania). The national and regional projects also provided support for stimulating initiatives and strengthening capacity of communities and civil society and local governance, for agricultural sector development and private public sector partnerships (e.g. Malawi), knowledge management and coordination (e.g. Nigeria), building an enabling environment (e.g. Uganda), enhancing and monitoring carbon benefits (Madagascar and Niger) and enhancing the regional Equatorial Africa deposition network.

The conclusions are presented under five topics:

- Lessons learned about SLM technologies and local knowledge and innovation;
- Approaches that enhance adoption and scaling up;
- Development of capacities for innovation and adoption;
- Smallholders benefits and improved governance;
- Sustainability of project results.

The final section summarises the most important conclusions for scaling up sustainable land management and recommendations for follow-up.

Lessons learned about SLM technologies and local knowledge and innovation

The main Kagera TAMP technological driver has been the **diversification of land and agro-ecosystem management practices** in order to sustain and enhance ecosystem services provision including productivity and livelihoods. A wide range of SLaM knowledge and practices have been learned, validated, adapted, and adopted through the FFS learning approach in order to conserve soil and water resources and biological diversity, to rehabilitate degraded lands and to build resilience and cope with climate vagaries. **Participatory approaches have also underpinned the smallholder farmers' technology selection and innovation for their farms and the wider community territory.**

In fact, farmers' knowledge together with technical experts, service providers, and research created an intellectual and social space for innovation that FFS groups and communities should be able to sustain over time. The **learning-by-doing showed that different SLM techniques need to be used in combination and adapted to the local context for maximum impact at farm and landscape levels** (on- and off-site). Moreover, selected crops, livestock, trees, fruits, vegetables and energy products can be integrated in the farm and community territory or wider landscape according to the land potential and the geographical position in the catchment/watershed and the household and community aspirations. The farmers and communities also learned the importance of soil and water conservation measures on farm and across hillsides for minimising soil erosion, enhancing soil fertility/productivity and making efficient use of seasonal and often erratic rainfall. The knowledge and learning showed that **integrated crop-livestock, agro-forestry or agro-silvo-pastoral systems are a sound basis to enhance productivity and resilience of the agro-ecosystem and hence enhance the adaptive capacity and livelihoods of land users as well as contributing to biodiversity conservation and ecosystem health.**

The various participatory **land diagnostics and assessments allowed the project team to derive a technology menu of options** that guided project interventions. The process started with an in-depth participatory diagnosis of the livelihoods and land resources status and recent trends (ten years) which raised awareness of the implications of continued degradation (business as usual). This allowed the communities to develop a concrete vision for their landscape

/ territory (20 or 30 years) and to agree on specific actions for improving land management and livelihoods at catchment or watershed wider level.

Technical / extension staff were encouraged together with the local farming communities to identify a number of "best" practices already known and used in the various agro-ecosystems and to assess them using the WOCAT questionnaires on technologies and approaches (WOCAT, 2008a and 2008b). This was instrumental to ensure that the **practices selected for wider adoption and scaling up in the catchment were drawn from local experience and innovation and that there was information available on their costs, benefits and expected impacts**. Furthermore, inserting the documentation in the WOCAT global database of SLM practices and as fact sheets (two or four pages) means that the case studies are available for wide use by extension services not only in the Kagera Basin, but in the four countries that share the basin and in similar contexts worldwide.

Measuring and demonstrating the multiple benefits and impacts proved to be complex as they vary in time and space. In order to empower stakeholders though a self-assessment process, the **FFS, communities and service providers were encouraged to monitor and assess the benefits of their improved management practices** both on farm and in the wider catchment. Measures included productivity (per unit of land and labour), soil fertility (nutrient cycling), water availability (retention, flow), protective vegetation cover, biomass (energy and carbon) and pest and disease control. However, the experience also showed that it is difficult to mobilise technical staff from district offices in monitoring the impacts of activities. Universities or research bodies - including young scientists - should be involved from the start of a project to demonstrate the multiple benefits of investing in SLM for sustaining land resources potential in the short and long term.

Adoption on farm and scaling-up of SLM technologies across a micro-catchment with involvement of communities have shown multiple benefits over the relatively short time-period of the Kagera TAMP project. The sustainable increase of the productivity of degraded lands has been achieved by controlling soil depletion and enhancing soil fertility, backing this practices up by using improved germplasm (seeds and seedlings) and by boosting livestock management practices. This has resulted in increased food availability, access and stability – helping households to become more food secure and resilient to climate change.

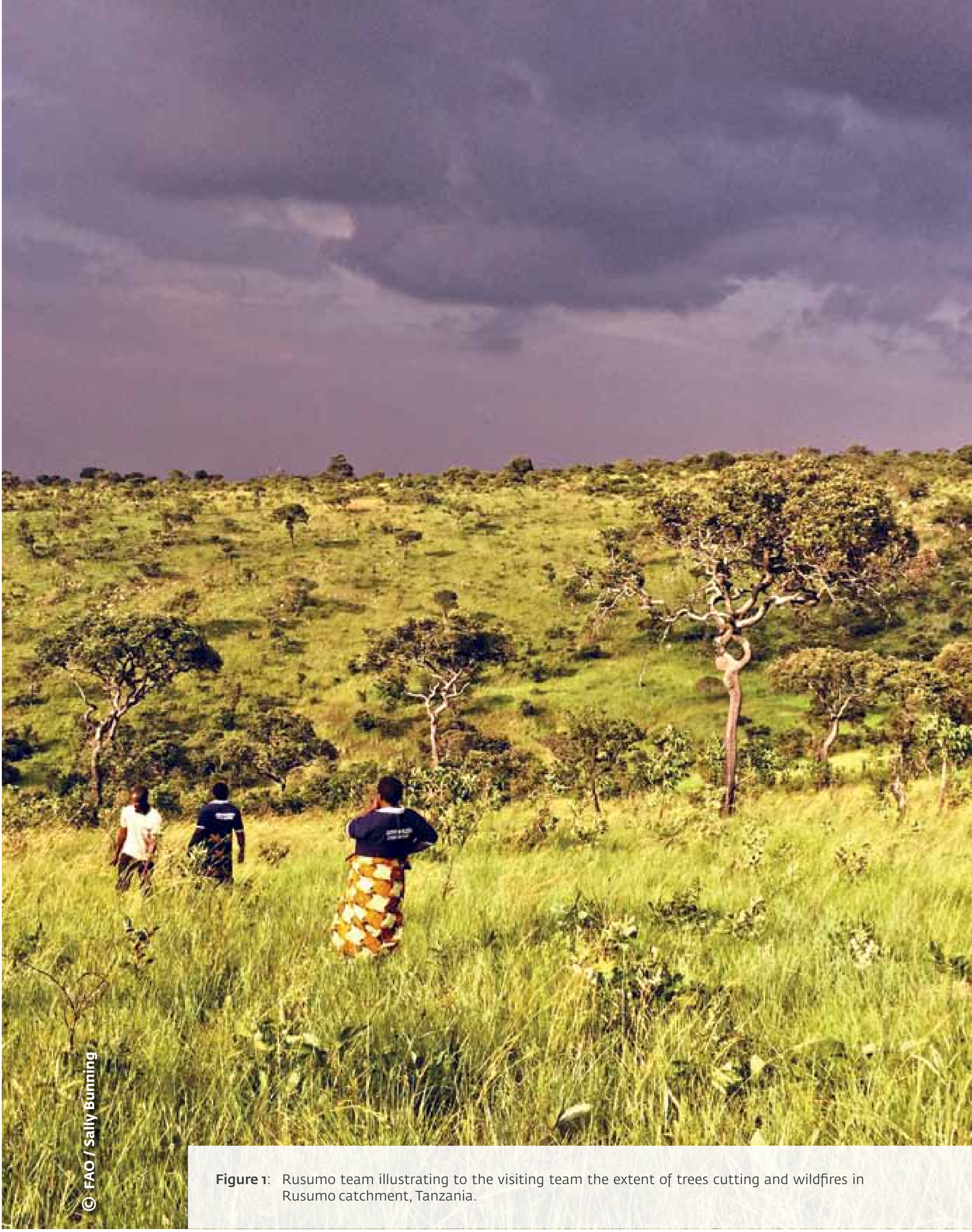

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Figure 1: Rusumo team illustrating to the visiting team the extent of trees cutting and wildfires in Rusumo catchment, Tanzania.

In summary, **capacity development** was a key aspect of technology adoption and implementation and demonstrated that **technology integration at farm, catchment and watershed level** is able to support both the well-being of the rural communities and to sustain and regenerate natural resources and ecosystem services while contributing to climate adaptation and mitigation.

Box 1 presents the main lessons learned that the Kagera TAMP shares with the SIP TerrAfrica, including the list of adopted technologies.

BOX 1 - Key messages on SLM technologies that Kagera TAMP shares with the wider TerrAfrica SIP

All SIP projects have been useful for testing, developing and applying SLM technologies in a wide range of sub-Saharan Africa agroecosystems to restore soil properties (physical, chemical and biological), catalysing improvements in above and below ground (soil) biodiversity and ecosystem services (rainfall infiltration and storage, carbon sequestration in soils and biomass, etc.). These changes have led to improvements in yields (crops, fodder, woody biomass and livestock productivity) and hence contributed to food security and poverty reduction of beneficiary households.

List of SIP technologies that are also used in the Kagera TAMP:

- crop rotations, fallowing, intercropping and green manures, particularly using nitrogen-fixing crops to improve soil fertility;
- compost and mulch;
- tree planting in agroforestry systems, shelter belts, woodlots etc.
- crop - livestock integration for improved ecological efficiency (nutrient cycling-manure, compost) and risk aversion (climate and market shocks) manure production;
- soil and water conservation including erosion control and rainwater harvesting structures – stabilization of river banks, vegetation strips, stone lines, tied ridges, bench terraces, also zaï and half-moon terraces;

- rangeland restoration (area closures, re-seeding, holistic grazing management, assisted natural regeneration, tree planting, etc.);
- gully healing.

Important technology lessons learned that the Kagera TAMP shares with the SIP:

- land users need to be fully informed and trained, with local information on the range of appropriate SLM technologies and their conditions for success along with the costs, benefits and other possible socio-economic disadvantages (e.g. increased labour, inputs, time required for impacts);
- rather than advocating one or a small number of structural technologies alone, success is more likely using combinations of technologies from a "menu" of appropriate practices;
- most SIP projects used participatory approaches, where decisions on how to intervene to reduce and reverse land degradation were "bottom-up" and agreed in close consultation with well-informed land users.

Box 1: adapted from FAO & TerrAfrica, 2016

Approaches that that enhance adoption and scaling up

The Kagera TAMP used the **farmer field school** (FFS) **approach** as the main practical training and learning tool for farmers' groups and their communities and contributed to awareness raising as well as **participatory planning for scaling up SLM at catchment or landscape level**. Beneficiaries were able to share experiences on how they were benefiting from restoring and managing healthy ecosystems, which has led to improved productivity and yield reliability, hence reduced vulnerability to climate or market fluctuations. The farmer groups, catchment committees and community leaders provided the local mechanisms for a more **people-centered planning** as well as enhanced dialogue with district levels with a view to more targeted and integrated support from the various technical sectors.

Also, linking SLM practices with cash or inputs for work and other **income generating activities** was important for gender balance and sustainability. The project demonstrated that farmers can be supported to operate as peer to peer service providers (for example, farmer facilitators for setting up new FFSs or training in building improved stoves, or establishing seedling nurseries, etc.), with the win-win of increasing their revenues and increasing awareness of the benefits of sustainable land and agro-ecosystem management.

Finally, the project used a **participatory catchment/watershed scale and management approach** to integrate the planning vision and governance mechanisms (catchment plans, community land use plans, grazing agreements, etc.) with the participatory technology selection and implementation. As much as possible, the project sought to focus not only on improving cropping systems but also on **grazing/pasture land rehabilitation and sustainable livestock management and tree or bamboo planting to protect steep slopes and for riverbank and lakeshore management**. Besides leveraging co-funding through other projects and district or national funds, success in terms of empowerment of local communities and service providers in SLM is already leading to enhanced investments at country level and transboundary level through the district governments, bilateral donors, LVEMP-II and forthcoming support for landscape restoration by the World Bank group.

Box 2 presents the main lessons learned that the Kagera TAMP shares with the wider TerrAfrica SIP, including a discussion on adopted approaches.

BOX 2 - Key messages on SLaM approaches the Kagera TAMP shares with the TerrAfrica SIP

Many projects worked with land users to encourage them to take ownership of planning how the land resources could be better (more sustainably) managed in their local landscape. The landscape approach was referred to integrated watershed or landscape or territorial management as well as rangeland or forest landscape restoration. This included developing catchment/watershed plans, community land use plans, grazing agreements, soil and water conservation zones, riparian corridors, shelter belts, etc. The landscape approach is becoming increasingly favoured in projects and programmes as the logical geographical unit for implementation to support the integrated management of different functions including ecosystems services, food production, economic development and interactions (e.g. upstream-downstream interactions) within defined territories the scale varying greatly from wide regions to micro-catchments

In Kagera TAMP the focus was both on micro-catchments and integrated agro-ecosystems for scaling up SLM practices or technologies.

Farmer field schools proved to be particularly successful in the projects which used this approach, enabling farmers to "learn by doing" and in some cases innovative farmers have been inspired to conduct experiments in SLM.

Income generating activities were important in most projects, to ensure that land users cannot only produce for household subsistence but also to store, process and market additional produce, diversifying from high dependence on natural resources for survival to agro-business for enhanced livelihoods (e.g. through value addition, processing etc.).

Box 2: adapted from FAO & TerrAfrica, 2016.

Development of capacities as innovation support

The Kagera project used **farmer field schools as the main capacity development tool** using the study plot for learning and decision making by farmers groups by monitoring and comparing improved and typical farmer practices and encouraging members to test, adapt and integrate the improved practices on their own farms. Moreover, FFSs using soil and agro-ecosystem analysis considered the ecological effects related to production systems, including soil health and fertility, vegetation cover and water retention, pest and disease control, etc. This was backed-up by demonstration measurements, of rainfall (using rain gauges), hydrology (using small weirs) and carbon stocks (using the EX-ACT estimation tool of potential to sequester carbon) in selected sites. Capacity development at catchment scale was through development and implementation of catchment management plans, monitoring the results in terms of not only farm productivity but the area under SLM, reduced erosion, increased vegetative cover, increased water flow in streams and SLM adoption by other farmers.

The SLaM approach, linking FFS learning and catchment management, embraces a number of interrelated enterprises towards the final goal of sustainable use of land resources and sustained provisioning of ecosystem services. Experience showed that capacity development needs to include **vertical and horizontal dimensions for scaling up SLM**, so as to be scale-independent and address multi-sector concerns on-farm and in the wider agro-ecosystem / landscape (horizontal). Also, vital is link local community plans with those of wider communes, districts and national levels for decision making, investments and institutional support through extension, research, planning and budgeting (vertical).

Above all, capacity needs to be built through nurturing a sense of ownership of the proposed SLM practices, so that stakeholders are willing to contribute and introduce endogenous knowledge to further fine-tune and widely adopt the technologies. Ownership was created through participatory decision making processes on farm study plots or experiential learning sites, measuring impacts (water, carbon, etc.) and sharing across FFS groups with different enterprise focus through exchange visits and demonstrations for wider awareness raising. In order to increase spontaneous adoption of labour-intensive practices, such as the construction of retention ditches and water harvesting structures, deepened awareness raising is required and innovative knowledge solidarity/labour sharing avenues should also be encouraged.

In Kagera as in the wider TerrAfrica SIP process, farmers were at the centre of the capacity building process as shown in Figure 1, Box 3. However, it is also necessary to expand capacity development beyond the farmers and herders level to the various actors and stakeholders operating in the landscape (other land users, governments, civil society organisations and partner projects) as this will further harmonise approaches and contribute to the socio-economic dynamics. In fact, strengthening capacities of actors at different levels should reinforce the **negotiation and decision-support processes**. For example, capacity development of land users and key institutions on addressing the reasons for upstream-downstream effects of land management practices and their transboundary impacts (e.g. erosion and sedimentation, excess runoff and flash floods in river courses, eutrophication, drought and flooding as result of poor cropping, overgrazing, overstocking, crop expansion onto fragile steep slopes and wetlands, etc.). The training in Participatory and Negotiated Territorial Development (PNTD) demonstrated the opportunities of enhancing dialogue and resolving conflicts between farmers, livestock keepers and transhumant pastoralists, for example, regarding fodder resources, burning of residues, grazing rights, impact of other land users putting pressure on the land and water resources, charcoal production for urban centres, mining of sand for construction, irrigation for rice production in wetlands and digging of ponds for aquaculture.

Figure 2: Community participatory planning with site and service providers as facilitators in Kihanga, Katera catchment, Karagwe District, Tanzania .

Box 3 presents the main lessons learned that the Kagera TAMP shares with the SIP TerrAfrica on capacity building.

Box 3 - Key messages on SLaM capacity building the Kagera TAMP shares with the SIP

- Project design teams should be familiar with the key guidelines on SLM – designers and implementing teams should be aware of the win-win-win benefits of SLM, how these can be most effectively integrated into land users' systems. This is likely to include community participation for capacity development for community participation (community driven approaches), knowledge of available tools for FFS/APFS support, effective communication, also gender sensitivity and tenure security - ensuring that communication materials/media resources targeted for land users are produced in local languages.
- SLM projects frequently introduced new approaches and technologies that required capacity development tailored for each group of stakeholders, technical training for government technical officers and local NGO "service providers". Projects are making frequent good use of demonstrations and short courses for all the participant groups.
- The farmer field school approach was successful in numerous projects.
- Results of the SIP review (Figure 1) showed that land users were the most frequently reported participants in training in SLM (approaches and / or technologies), followed by extension then technical staff. The low numbers of decision makers trained in any aspects of SLM limits the scope for mainstreaming as this is not a standard subject in school or university syllabuses. This may to some extent be compensated by workshops and policy brief that also help raise knowledge of decision makers.
- Exchange visits / study tours can be a highly effective means for the exchange of knowledge and contribute greatly to motivating participants, including land users, extension staff and technical officers – as "seeing is believing".
- Only a few SIP projects integrated a specific component on capacity development in the design of their projects – but this would have been very

beneficial, as it focuses attention on this vital aspect. Capacity development should feature as a component of future projects and programmes.

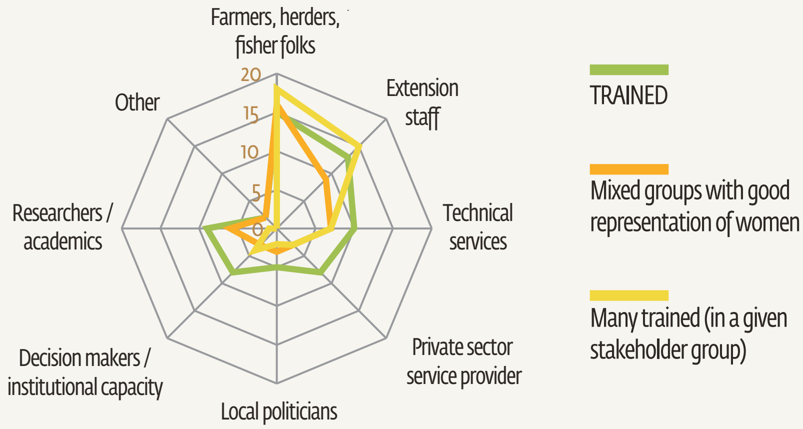

Figure 1: Stakeholder groups trained (SIP Country online survey: 36 replies, 62 skipped).

Box 3: adapted from FAO & TerrAfrica, 2016.

Smallholder benefits and improved governance

The Kagera TAMP **planning phase focused** mostly **at micro-catchment or watershed levels**. The priority activities selected by the communities resulted from an in-depth diagnostic of the status and trends, drivers and pressures of change and impacts on livelihoods and ecosystem services (using LADA Local – FAO, 2011b – manual and set of tools including PRA, transect walk, soil and vegetation analysis, focus group discussion, etc.). This led to development of a catchment management plan and proposed combinations or range of practices to be used in the appropriate geographical position (upper catchment, mid-slope, valley bottom, etc.) to halt or minimise degradation and improve productivity of the agro-ecosystem. The participatory plans developed by the project facilitated buy-in from communities, especially when they were involved in the field diagnostic and technology identification.

Systematic documentation was also an important planning and policy tool, and the use of the WOCAT technologies and approaches questionnaires provided opportunities for analysis of costs and benefits, as well as dissemination, storage, knowledge sharing and future retrieval of SLM best practices for a given situation. Demonstrating benefits on production and income was shown to be key for encouraging farmers to invest in appropriate SLM practices and to sustain project lessons learned over time.

Scaling-up of specific SLM practices can also be informed and guided by the mapping of land degradation (types, extent, severity and trend as well as drivers/ pressures and impacts) and SLM practices (type, extent, effectiveness on the ground). This was conducted across the basin in year one of the project and provided a useful database for selecting suitable catchments for intervention by Kagera TAMP and partners, also for guiding future investments.

The review of policies, legislation and institutional capacities at the start of the Kagera project provided some entry points for targeting policy harmonisation and development across districts, countries and the transboundary basin, for example in the context of transhumance grazing. In terms of integrating policies, the Kagera project studied options for policy harmonization both within and between countries, especially it supported the setting of local regulations or by-laws for controlled burning, grazing and riverbank cultivation. It also lobbied governments and donors for integrating FFSs and catchment management for SLM scaling up in district workplans and budgets, also for promoting multisector approaches as an alternative to fragmented sector plans.

Institutional capacity development is also necessary to support promotion and scaling up of SLM activities. In fact, in order to ensure effective governance, capacity development needs to integrate a variety of beneficiaries and to focus on a wide set of skills, training levels, socio-economic abilities, technologies and geographical perspectives. Capacity might be the foundation for an increased social construct aiming at improved negotiation with institutions and in conflict solving processes. Decentralized government institutions benefit from a wider capacity to apply existing policies and by-laws and put in place or enhance governance mechanisms and skills, providing the relationship with central level entities is supportive (enabling environment). In most countries there were many overlapping plans for addressing land degradation, biodiversity, climate change and agriculture, food security and poverty reduction and these need to be implemented at district or commune levels through intersectoral and harmonised process. The SLM project steering committee needs to be institutionalised as a country SLM task force or advisory body for sustaining project outcomes. Moreover the country strategic investment frameworks (CSIFs) developed by some TerrAfrica SIP countries, such as Uganda, provide an important basis for collaboration and coordination provided that they are developed through a truly multi-stakeholder and multi-sector process.

Box 4 presents the main lessons learned that the Kagera TAMP shares with the SIP TerrAfrica in the context of policy and institutional support.

Figure 3: Fish ponds associated with pork production at the Shirubute FFS in the commune of Buhiga, Karusi province, Burundi.

Sustainability of project results at the small scale

Box 4 - Key messages on SLaM policy and institutional issues the Kagera TAMP shares with the SIP

- All the SIP country projects included activities to promote inter-sectoral approaches, mainstreaming on-the-ground and, in most cases, mainstreaming SLM into sectoral policies. But most projects found cross-sectoral work challenging.
- The SLM agenda /interventions should be linked to the food security, poverty reduction and climate change agendas (adaptation, mitigation and resilience) to benefit from synergies.
- Inter-sectoral work success is more achievable at local levels, enacting and enforcing by-laws against actions which degrade land (e.g. avoiding cultivating up and down steep slopes, cultivation in riparian zones, deforestation for charcoal burning, lighting of bush fires, enclosing or ensuring that livestock do not enter degraded rangeland areas to enhance recovery). Optimistically, in time this will influence national levels, as awareness grows of the win-win-win benefits of SLM.
- Early and regular involvement of locally-based government technical services (more common now with decentralization) in project activities may influence their design of annual work programmes and budget decisions and inform national strategies.
- SIP created opportunities for countries to explore innovative options for SLM financing. Country strategic investment frameworks (CSIFs) for SLM are expected to be essential tools for future cross-sectoral planning and aid harmonization.

Box 4: adapted from FAO & TerrAfrica, 2016

Lasting farmer field schools are key instruments for the sustainability of the project results. Site-specific technology adaptive management drives farmers' interest in adopting SLM practices. One of the major interventions in FFS groups on SLaM was the introduction and execution of "adoption contracts" at the end of the FFS cycle. The aim was to support and ensure that members are willing and able to adopt SLaM technologies and practices in their own home environments.

An important result of the Kagera TAMP that will likely allow for the sustainability of the project results is the transformation of the FFS in cooperatives in Uganda – where there is a government-supported drive to revitalize cooperatives. The FFS groups established under the Kagera TAMP and the new FFS can be readily co-opted into established cooperatives because of the similarity in the enterprises and benefits generated from use of sustainable land management practices. In this way, the member farmers can expand their incomes by exploiting their productive and marketing potential, which is the basis for sustainability.

Box 5 presents the main lessons learned that the Kagera TAMP shares with the SIP TerrAfrica regarding the scaling up and sustainability of the approaches.

Box 5 - Key messages on SLaM scaling up and sustainability the Kagera TAMP shares with the SIP

Several projects began by building the organizational and technical capacities of farmer field schools, through which large numbers of land users have become aware of and started using SLM technologies on their own plots. In numerous instances these FFS are being supported to convert to operate as cooperatives, a factor which should enhance the likelihood of sustainability after the cessation of project funding and support. In other cases, enhanced access to funding may enable the spreading and scaling up of interventions that are accessible to single farmers or small groups.

Box 5: adapted from FAO & TerrAfrica, 2016

Conclusions for scaling up and out and recommendations for follow-up

The Kagera TAMP project highlighted multiple lessons for scaling up and out. **First, the importance of using win-win-win or multiple benefit technologies and approaches in order to speed-up adoption and increase sustainability. Secondly, the prominence of the community-based planning process (also through FFS) to inform and train stakeholders at all levels, to raise awareness and build on local knowledge systems and to adapt practices to local conditions including ground-based innovation. Thirdly, the importance of creating and adhering to a significant set of knowledge (baseline) as a basis for monitoring and impact assessment created by appropriate land assessment tools**.

The project widely demonstrated that **there is no blanket / silver bullet approach and a one size solution does not fit all**. A menu of options needs to be provided to farmers for them to experiment according to their context and needs and supporting them to adopt the practices they consider the best or most appropriate. Watershed management is an approach that allows **multiple opportunities** and benefits to be generated in the landscape over space and over time, taking into account upstream-downstream linkages. In this regard, a **community planning and management process** should focus on the whole range of practices to be used on farm and throughout the watershed. Integrating the various dimensions of production, environmental conservation and enabling environment provides win-win solutions. Integration of multiple practices facilitates SLM adoption by farmers and links impacts to national and global level benefits. Furthermore, the provision of enabling planning and regulatory environment, boosts institutions and supports input supply, advice and access to incentive measures and financing.

Box 6 presents the main lessons learned that the Kagera TAMP shares with the SIP TerrAfrica.

Box 6 - Key messages the Kagera TAMP shares with the SIP

- SLM technologies can bring "win-win-win" benefits (Figure 2) to farming systems, contributing local, national and global benefits including increased productivity and restored ecosystem services, leading to improved livelihoods and human wellbeing.
- The SIP projects improved the understanding of land degradation issues and the urgent need for SLM to address land degradation in the basin.
- Although landscape approaches seem the most appropriate units with which SLM projects should be designed for on-the-ground implementation, this is not universally the case – local circumstances determine the most appropriate approach.
- Many (if not all) SLM technologies contribute to climate smart agriculture (CSA) and contribute to the achievement of sustainable development goals.
- Rather than advocating one or a small number of structural technologies alone, more success has been achieved using combinations of technologies, ideally blending technologies with quick and long-term paybacks, bringing "quick-wins" and also sustaining benefits.
- The prospects for sustainability at more local levels are favoured when projects have ensured that pro-SLM by-laws and other local regulations have been enacted and are enforceable.
- Projects and programmes to scale-up SLM need to remain flexible, able to react to changes in context and priorities (local to global) between design and implementation and encouraging farmer innovation.
- Women represent a large share of the beneficiaries of the SIP projects and should be well documented (involvement, decision making and benefits).

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- People and their actions are central factors in land degradation and thus they need to be at the centre of SLM projects and programmes – genuinely involved from the design phase onwards.

Figure 2: Win-win-win solutions for livelihoods, ecosystems and productivity (Liniger *et al.*, 2011) [Fs is farming systems.]

Box 6: adapted from FAO & TerrAfrica, 2016.

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Glossary

Adaptation (to climate change): Adjustments to current or expected climate variability and changing average climate conditions. This can serve to moderate harm and exploit beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (FAO, 2011d). 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: 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, 2007).

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.

Agroecology: The integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions (Francis *et al.*, 2003).

Agroforestry: A land use system where the deliberate growing of woody perennials on the same unit of land as agricultural crops and/or animals, either in some form of spatial mixture or sequence has a significant interaction (positive and/or negative) between the woody and non-woody components of the system, either ecological and/or economical (Nair, 1993).

Benefit sharing: Distribution of benefits between stakeholders.

Biodiversity (a contraction of biological diversity): The variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part. Biodiversity includes diversity within species, between species, and between ecosystems (Millennium assessment, 2005). Biodiversity may be described quantitatively, in terms such as richness, rarity, and uniqueness.

Biological diversity: see *Biodiversity*.

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

Carbon sequestration: The process of increasing the carbon content of a reservoir other than the atmosphere (Millennium assessment, 2005).

Catchment: The area from which a stream or waterway and reservoir receives surface flow which originates as precipitation (synonymous with river basin and watershed).

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).

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).

Compost: Organic matter that has been decomposed and recycled as a fertilizer and soil amendment. At the simplest level, the process of composting simply requires making a heap of wetted organic matter known as green waste (leaves, food waste, etc.) and waiting for the materials to break down into humus after a period of weeks or months. Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air, and carbon- and nitrogen-rich materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture. Worms and fungi further break up the material. Aerobic bacteria and fungi manage the chemical process by converting the inputs into heat, carbon dioxide and ammonium. The nitrogen is the form of ammonium (used by plants). When available ammonium is not used by plants it is further converted by bacteria into nitrates (NO_3) through the process of nitrification

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.

Crop-livestock integration: Integration of the systems of grain and livestock production, together with direct planting. These systems have the potential to increase production and reduce risks of degradation while improving the soil chemical, physical and biological properties and the productive potential of grains as much as forage. [The innumerable benefits of the crop-livestock integration can be synthesized as: agronomic, through the recuperation and maintenance of the soil productive capacity; economic, by means of product diversification and higher yields and quality at less cost; ecological, through the reduction of crop pests and consequentially less pesticide use as well as erosion control; and socially, by more uniform income distribution as the livestock and crop activities separately concentrate income generation. The higher generation of direct or indirect benefits as well as reduced urban migration also need to be considered. The cost of the creation of a new job in rural areas is much less than in urban. New benefits inherent to the crop-livestock integration are constantly being seen by researchers and farmers.]

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 which can occur with high frequency but with minor impacts compared with droughts.

Ecosystem management: An approach to maintaining or restoring the composition, structure, function, and delivery of services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.

Ecosystem services: All benefits that humans receive from ecosystems (Daily, 1997). These benefits can be direct (e.g. food production) or indirect, through the functioning of ecosystem processes that produce the direct services. The Millennium Assessment (2005) classified these ecosystem services in four categories (supporting, provisioning, regulating, and cultural).

***Ekibanja*:** see *kibanja*.

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.

***Fanya chini*:** *Fanya chini* is like a *fanya juu* (see below), except that the soil from the ditch is thrown downslope rather than upslope so as to optimise water capture and retention (as in a fanya juu).

Fanya juu**:** progressive terraces are constructed by throwing soil up slope from a ditch to form a bund that runs across the slope along a contour. The dimensions vary, in SSA a typical ditch or trench is 60 cm wide by 60 cm deep, and the bund or ridge 50 cm high by 150 cm across at the base. The distance between bunds depends upon the slope and may be from five meters apart on steeply sloping lands to 20 meters apart on more gently sloping lands.

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

Improved cooking stove: A piece of domestic equipment for which studies confirm the energy savings, compared with traditional "three-stone" cooking stoves. [The use of improved cooking stoves to reduce the quantity of wood used for meal preparation reduces the rate of deforestation and associated degradation processes. It also brings many social advantages, such as revenue generation (e.g. local artisans skilled in making the improved cooking stoves), less time spent collecting wood, improved air quality and hence better health inside homes, fewer risks of burns for children and the satisfaction of being able to self-regulate resources.]

Integrated landscape management: The process of formulating a planned course of action with all sectors and actors concerned (participatory) across a specific hydrological unit of land – the catchment or watershed – to address the biophysical, social, and economic issues affecting land and water resources and their use and the provisioning of ecosystems services.

Integrated soil fertility management (ISFM): A set of agricultural practices adapted to local conditions to maximize the efficiency of nutrient and water use and improve agricultural productivity. ISFM strategies centre on the combined use of mineral fertilizers and locally available soil amendments (such as lime and phosphate rock) and organic matter (crop residues, compost, animal derived and green manure) to replenish lost soil nutrients. This improves both soil quality and the efficiency of fertilizers and other agro-inputs (Roland *et al.*, 1997).

Integrated watershed management approach (IWM): The process of formulating a planned course of action with all sectors and actors concerned (participatory) across a specific hydrological unit of land - the catchment or watershed - to address the biophysical, social, and economic issues affecting land and water resources and their use and the provisioning of ecosystems services. The aims are multiple see Box xx

Kagera TAMP: The Kagera Transboundary Agro-ecosystem Management Project supported by the Global Environment Facility (GEF) and implemented by FAO with the executing partners - the Governments of Burundi, Rwanda, Tanzania United Republic and Uganda during the period 2010-2015.

***Kibanja* farming system:** The Farming Systems Research Program in Kagera region of Tanzania defined the traditional banana based cropping system to comprise the *Kibanja*, *Kikamba* and *Rweya* based on dominant crops, management intensity and hence fertility gradient and distrance from the homestead. The *Kibanja* is banana based and most intensively managed land use type surrounding the homestead. Typical of multi-layers of annuals of maize, beans, fruits, and trees where nutrient recycling is highest.

***Kikamba* farming system:** The Farming Systems Research Program in Kagera region of Tanzania defined the traditional banana based cropping system to comprise the *Kibanja*, *Kikamba* and *Rweya* based on dominant crops, management intensity and hence fertility gradient and distrance from the homestead. The *kikamba* has weak bananas and coffee due to low intensity of management (and hence low fertility), where annual crops are gradually replacing weakening bananas and coffee, with incidences of weeds, pests and diseases (neglected *Kibanja*) away from the homestead. *Kikamba* are typical degraded *Kibanjas* for people leaving outside in towns with limited attention of their *Kibanjas*.

Land degradation (LD): The reduction in the capacity of the land to provide ecosystem goods and services and assure its functions over a period of time for the beneficiaries of these (FAO, 2011a). Most of the degradation is due to soil erosion and biodiversity loss in the less populated areas, while water shortage, soil depletion and soil pollution are most common in most agricultural areas. Land degradation is more than an environmental problem alone and should be considered holistically, taking into account different ecosystem goods and services, biophysical as well as socio-economic. Results should be referred to a given time period and solutions require full consultation with stakeholders and imply trade-offs between environmental and socio-economic environmental services.

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.

Mailo land: A Ugandan tenure system that guarantees long term or perpetual ownership security and collateral possibilities that are usually required to invest in large commercial production. This can also be done under leasehold, but to a lesser extent as the expiry of the lease reduces the incentive for the farmer to invest heavily especially in fixed costs.

Maladaptation: Actions that increase vulnerability to climate change. This includes making development or investment decisions while neglecting the actual or potential impacts of both climate variability and longer-term climate change.

Micro-catchment: Smallest hydrological units in river basins which drain into a tributary river – often demarcated for special tasks and projects community management interventions.

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

***Omusiri* farming system:** The Farming Systems Research Program in Kagera region of Tanzania defined the traditional banana based cropping system to comprise the *Kibanja*, *Kikamba* and *Rweya* based on dominant crops, management intensity and hence fertility gradient and distrance from the homestead. Overall, *Omusiri* is an inclusion of annual monocrops (e.g. yams, sweet potatoes, etc.) replacing weakening bananas and coffee in the *Kikamba* or planted in pockets of moderately fertile/deep soils in *Rweya*. Crop residues from *Omusiri* crops in the *Kikamba* and *Rweya* and grass cut from *rweya* are imported into the *Kibanja* to improve its fertility.

Payments for ecosystems services (PES): Schemes which involve payments or other incentives to the managers of land or other natural resources in exchange for the provision of specified ecosystem services (or actions anticipated to deliver these services) over-and-above what would otherwise be provided in the absence of payment. Payments are made by the beneficiaries of the services in question, including individuals, communities, businesses or governments acting on behalf of various parties. Beneficiaries and land or other natural resource managers enter into PES agreements on a voluntary basis and are in no way obligated to do so.

Participatory watershed management (PWM): AA participatory watershed management approach puts communities living in the watershed at the centre of the watershed planning, development and management process. The process comprises a number of elements that help orient IWM programmes towards a holistic rural development process (economically viable, environmentally-sustainable, production-oriented, conservation alternatives built upon indigenous knowledge for overall development).

Rain-fed agriculture: Agricultural practice relying exclusively on rainfall as its source of water.

Rainwater harvesting: Low-cost practices – such as planting pits, stone bunds, and earthen trenches along slopes – that capture and collect rainfall before it runs off farm land.

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.

River Basin: The entire geographical area drained by a river and its tributaries; an area characterized by all runoff being conveyed to the same outlet (synonymous with watershed and catchment) which are at nested smaller scales.

***Rweya*:** The Farming Systems Research Program in Kagera region of Tanzania defined the traditional banana based cropping system to comprise the *Kibanja*, *Kikamba* and *Rweya* based on dominant crops, management intensity and hence fertility gradient and distrance from the homestead. The *rweya* is an extensive open grassland characteristic of shallow soils with steep slopes turning into rock outcrops in some areas. They are used for open grazing and mono-cropping in pockets of moderately deep and fertile soils. Pockets of annual mono-crops in *Rweya* and *Kikamba* are refered to as *Omusiri*. Extensive grasslands have of recently decreased due to land grabbing in the region where pine trees are intensively being planted.

Scale: The measurable dimensions of phenomena or observations. Expressed in physical units, such as meters, years, population size, or quantities moved or exchanged. In observation, scale determines the relative fineness and coarseness of different detail and the selectivity among patterns these data may form.

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 management practices / technologies that enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources.

Sustainable land and agro-ecosystem management (SLaM): The adoption of management practices / technologies that enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the wider functioning of the agricultural system (living and nonliving components involved in that unit as well as their interactions).

Sustainable use (of ecosystems): Using ecosystems in a way that benefits present generations while maintaining the potential to meet the needs and aspirations of future generations.

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: Strictly an area or ridge of land that separates waters flowing to different rivers, basins, or seas (generally now used as meaning the land from which water drains into a single river – synonymous with river basin and watershed).

Welcoming Capacity: A post-conflict reintegration and natural resources management approach originated from the initial stages of the FAO intervention in Angola, at the end of the civil war, in 1999 (Achieng *et al*., 2014).

Watershed management: An organized set of actions aimed at ensuring a sustainable use of watershed / river basin resources. See also integrated watershed management and participatory watershed management.

Notes

Sustainable Land Management (SLM) in practice in the Kagera Basin

Lessons learned for scaling up at landscape level

Results of the Kagera Transboundary Agro-ecosystem Management Project (Kagera TAMP)

This book compiles a set of 26 papers that present the direct, practical experiences and results of a large number of local practitioners and experts that supported the Transboundary agro-ecosystem management project of the Kagera river basin (Kagera TAMP) during the period 2010-2015. The book has been compiled by the Land and Water Division of the Food and Agriculture Organization of the United Nations (FAO) to reflect the wide range of experiences, approaches and tools that were used for promoting participatory diagnostics, adaptive management and adoption of sustainable land and agro-ecosystem management (SLaM) practices from farm to watershed / landscape scale. The project was supported by the Global Environment Facility (GEF), the Governments of the four countries that share the transboundary basin - Burundi, Rwanda, the United Republic of Tanzania and Uganda and project partners. It is hoped that the lessons learned are considered and taken up by the Governments and the TerrAfrica partnership for scaling up and mainstreaming SLaM as part of the wider set of lessons learned from the 36 projects in 26 countries under the Terrafrica Strategic Investment programme, including Kagera TAMP.

Food and Agriculture Organization of the United Nations

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