REPUBLIC OF UGANDA
Ministry of Agriculture
Animal Industry and Fisheries

CLIMATE SMART AGRICULTURE

Community of Practice Guide

2019

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LIST OF ACRONYMS

ACORD	-	Agency for Cooperation and Research in Development
ADRA	-	Adventist Development and Relief Agency
AEZ	-	Agro Ecological Zone
ASSP	-	Agriculture Sector Strategic Plan
ATAAS	-	Agricultural Technology and Agribusiness Advisory Services
BANDERA	-	Balimi Network for Developing Enterprises in Rural Agriculture
BBW	-	Banana Bacterial Wilt
BTC	-	Belgium Technical Cooperation
CA	-	Conservation Agriculture
CBO	-	Community Based Organisation
COMESA	-	Common Market for Eastern and Southern Africa
CSA	-	Climate Smart Agriculture
DAP	-	Di Ammonium Phosphate
DLG	-	District Local Government
FAO	-	Food and Agriculture Organisation
GDP	-	Gross Domestic Product
GHGs	-	Green House Gas Emissions
IDPS	-	Internally Displaced Persons
IFDC	-	International Fertilizer Development Centre
IMO	-	Indiginous Micro Organism
iNGOs	-	International Non Governmnt Organisations
ISSD	-	Integrated Seed Sector Development
MAAIF	-	Ministry of Agriculture, Animal Industry and Fisheries
MWE	-	Ministry of Water and Environment
NAADS	-	National Agriculture Advisory Services
NAP Agr	-	National Adaptation Plan for the Agriculture Sector
NAPA	-	National Adaptation Programmes of Action
NARO	-	National Agriculture Research Organisation
NDP	-	National Development Plan
NFA	-	National Forestry authority

OWC	-	Operation Wealth Creation
PPBs	-	Permanent Planting Basins
SACCO	-	Savings and Credit Organisation
SCIDO	-	Sheema Community Integrated Development Organization
SLM SIF	-	Sustainable Land Management Strategic Investment Framework
SLM	-	Sustainable Land Management
UNDP	-	United Nations Development Programme
ZARDI	-	Zonal Agriculture Research and Development Institute

FOREWORD

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The imperative to address climate change through adaptation and mitigation is evident globally and nationally. The climate is no longer as predictable as it used to be, as evidenced by drought, flooding, and disease, impacting rain-fed agricultural dependence. The implications are twofold: on individual livelihoods, recognizing that over 70% of the population derive their livelihoods from agriculture; and, in aggregate terms to the economy, evidenced by the sector contribution to GDP while at 24%, experiencing a decline.

The nature of agriculture in Uganda is largely subsistence and epitomized by dependence on rain, basic tools and equipment, seed often saved from one season to the next, and labour provided mainly by women. Productivity over the years was achieved through good climate and fertile soils. In addition, the sector benefits from technical support afforded by agricultural research and development and extension services, alongside infrastructure development and provision of credit and agricultural finance, albeit with limitations on reach and scope. Collectively, these are all critical growth factors for the sector.

However, the sector is on a decline with a congruence of factors limiting the growth potential. While climate change is critical to unpredictability and decline in the sector, climate change must also be construed from the perspective of inequality. The majority of the population who derive their livelihood from agriculture are also income insecure. The economic status of these communities – and the sector contribution to the economy - can be raised through support for farmers to enhance agricultural productivity.

Further, in addressing inequality, interventions aimed at reducing gender inequality are critical. Enabling women to derive the benefits of their labour in agriculture will steadily improve women's economic empowerment for broader socio-economic benefit.
Addressing community approaches to Climate-Smart Agriculture in cognizance of the realities of many of these communities that depend on agriculture can shift the sector decline and enhance productivity.

This is a critical approach since a decline in the sector affects the entire population and the economy in aggregate terms through less production, increased prices of food and agricultural commodities, ultimately affecting competitiveness in regional and global markets.

This publication on Climate-Smart Agriculture as a response to climate change for the agriculture sector is the outcome of collaboration by the iNGO Alliance and the Government of Uganda to provide practical interventions in response to climatic factors adversely affecting agricultural production. It responds to policy commitments in line with the National Climate Change Policy (NCCP-2015) and the Nationally Determined Contributions (NDC-2016). Climate-Smart agriculture is also recognized as an approach. It brings together practices, technologies, policies, and institutional arrangements, that are not necessarily new but used in building resilience to support farmers at various levels of agricultural production to adapt to and mitigate the impacts of climate change on agricultural production.
Through the Ministry of Agriculture, Animal Industry and Fisheries in partnership with the iNGO Alliance on CSA, the Government of Uganda has produced this Community of Practices Guide and Catalogue of Actors to advance the scaling-up of CSA in Uganda.

On behalf of the iNGO Alliance, which includes World Vision, CARE, CRS, and Oxfam, I am privileged and honoured to present this booklet to you.

ACKNOWLEDGEMENT

Pius Wakabi Kasaija
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The Government of Uganda, through the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), welcomes collaboration with the international NGO (iNGO) Alliance on Climate Smart Agriculture (CSA). MAAIF is thankful for the joint effort to spearhead the scaling up of CSA in Uganda. The Government specifically appreciates the iNGO support towards production and publication of the Uganda CSA Guide and Catalogue of Actors, which is a field guide for extension officers, community workers and other actors to disseminate CSA technologies and practices to the farmers and other actors.

The MAAIF wishes to convey special thanks to members of the iNGO Alliance, including Mr. Jackson Muhindo of Oxfam, Immaculate Luwedde Sekitto of World Vision Uganda, Monica Anguparu of CARE International Uganda and John Bruce Nabimanya of Catholic Relief Services Uganda for the invaluable input during the technical review of the Guide. Special thanks go to the National CSA Task Force Coordinator in MAAIF for ably facilitating the review of the Guide. Gratitude also goes to Zonal SLM Specialists, Staff of District Local Governments; international, National and District level NGOs; Faith Based Organizations' (FBOs); Community Based Organizations' (CBOs); Research institutions; Private sector and individual farmers for providing information compiled in this Guide.

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INTRODUCTION

1.1 Agriculture sector in Uganda

Agriculture is a key sector that significantly contributes to the national economic development, poverty reduction, livelihoods, and food and nutrition security for the majority of Ugandans. During the FY 2018/19, the sector contributed 21.9% to the GDP, 43.2 % to the labourforce and about 54% to the export earnings (UBOS, 2018). The major food crops produced include bananas, maize, beans, potatoes, cassava, sorghum, millet and rice while coffee, tea, cocoa, cotton, maize, oil palm and oil seed crops are the major cash crops. There is a wide variation of crop mix which is linked to the agroecological zones (AEZs). Agriculture production is expected to improve further due to the recent revamping agriculture extension system to enhance advisory service delivery to farmers.

The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) mandated to promote agriculture production in Uganda is taking measures to modernize and commercialise farming. The Ministry has a mission of transforming subsistence farming to commercial agriculture. In order to achieve this mission, Government developed a National Agriculture Policy in 2013 with the overall objective of achieving food and nutrition security and improving household incomes through coordinated interventions that focus on enhancing sustainable agricultural productivity and value addition, providing employment opportunities and promoting domestic and international trade (MAAIF, 2013). To operationalise the Policy, MAAIF prepared a sector Strategic Plan for FY 2015/16 – 2019/20 with the objectives of (i) improving agriculture production and productivity; (ii) increasing access to critical farm inputs; (iii) increasing agricultural markets and value addition; and (iv) improving service delivery through strengthening the institutional capacity of MAAIF and its agencies.

The strategic direction of the agriculture sector is to promote the entire value chain development of 12 priority and 4 strategic commodities focusing on research, extension, pest and disease control, provision of inputs, sustainable land use and soils management, post harvest handling, value addition and improving marketing. The priority commodities include

CHARACTERISTICS OF AGRICULTURE IN UGANDA

- **Dominated by subsistence and smallholder farmers - farm holdings average 2 hectares.**
- **Minimal mechanization – most farmers use rudimentary tools (hand hoe and panga) to cultivate their land.**
- **Agropastoral and pastoral communities predominantly rearing indigenous and cross-bred livestock (cattle, goats, sheep and poultry).**
- **Majority of farmers depend on rainfed agriculture with minimal use of irrigation - only 0.3% of irrigable land under irrigation (MAAIF and MWE, 2017).**
- **Farmers rely heavily on local materials - with minimum use of external inputs (improved seed, inorganic fertilizers and agrochemicals) to improve crop production.**
- **Poor post harvest handling and storage - post harvest losses up to 40% (MAAIF, 2015).**
- **Lack of value addition and reliable markets for the produce.**

bananas, beans, maize, rice, cassava, tea, coffee, fruits and vegetables, dairy, irish potatoes, fish and meat and other livestock products, while the strategic commodities include cocoa, cotton, oil seed crops and oil palm (MAAIF, 2015). In addition to the above-mentioned commodities, strategic investments include appropriate mechanization, water harvesting and irrigation technologies and agroprocessing industries that will expand the market for the increased volumes of agricultural produce. These industries will attract labour from farming to industry and services thereby accelerating economic growth and transformation to modernize agriculture.

1.2 Climate change and agriculture in Uganda

Climate change is a reality and has adversely impacted agriculture and other natural resource based sectors of the economy (MAAIF, 2018). Over 96% of farming households in Uganda depend on rainfed agriculture (UBOS 2017), making them highly vulnerable to the adverse impacts of climate change and variability. Climate change distorts the length of rainy seasons making the farmers uncertain on when to prepare land and when to plant crops. This shift in rainy seasons negatively affects water availability for agricultural production leading to reduced crop and pasture yields.. The foreseen challenge is meeting the growing population's food demand which calls for increased food production amidst a changing climate. However, Uganda's farming systems are not sufficiently developed to adequately adapt to or cope with the impacts of climate change.

IMPACTS OF DROUGHT ON AGRICULTURE

- **Widespread crop failures**
- **Livestock losses**
- **Famine and population displacement**
- **Degradation of crop and grazing lands**
- **Drying up of water bodies**
- **Increased temperatures**
- **Dust Storms**
- **Incidences of wild fires**

In Uganda, the major climate change hazards affecting agricultural production are droughts, floods and extreme temperatures. Droughts usually occur in Uganda's dryland belt (cattle corridor) which is a diagonal stretch from northeastern Uganda (Karamoja region) through Teso and central Uganda up to southwestern Uganda (Ankole region). Prolonged dry spells are also common in northern Uganda. Droughts are becoming increasingly frequent and more severe, with profound impacts on agriculture production in the affected areas. This has an overall negative impact on household food and nutrition security, household incomes and local and national economic development.

Drought affects availability of water and pastures for livestock production impacting negatively on animal growth and production. Overgrazing of livestock during drought periods leads to vegetation depletion causing soil erosion and land degradation, especially around watering points.. Prolonged droughts cause severe water shortages leading to loss of animals, reduced milk production, and food and nutrition insecurity, which in turn negatively impact on the farmers' livelihoods and the country's

IMPACTS OF DROUGHT ON AGRICULTURE

- **Destruction of crop fields**
- **Risk of water borne diseases**
- **Loss of livestock**
- **Intense soil erosion,**
- **Landslides.**

economic development. Affected pastoralists resort to transhumance as the coping strategy or sell off their livestock cheaply to avoid total loss.

- **Water logging of low lying areas.**
- **Destruction of agricultural infrastructure**
- **Human displacement and migrations**
- **Incidences of wild fires**

1.3 Agriculture sector response to climate change

The Government of Uganda recognizes climate change as a cross cutting issue that needs to be addressed using a multisectoral approach. To this end, Government has integrated climate change issues into the current national planning framework i.e. the Second National Development Plan (NDP 2) and sectoral policies, plans and budgets. Government also prepared a National Climate Change Policy (2015) which identifies the key climate change issues and impacts on the various sectors, including agriculture. It also prepared National Adaptation Programmes of Action (NAPA) which identifies vulnerabilities and coping strategies for the different sectors (MWE, 2007).

With regard to agriculture, Government prepared a National Agriculture Policy (2013) which identifies key issues affecting the agriculture sector, including climate change, as well as strategies to promote and modernize agricultural production. Government also prepared the Agriculture Sector Strategic Plan (ASSP) for 2015/16–2019/2020 which, among others, highlights medium term strategies for addressing climate change impacts on agriculture. Furthermore, Government prepared a Sustainable Land Management Strategic Investment Framework (SLM-SIF) (2018-2030) which highlights strategies for long term improved land management, including addressing climate change impacts on agriculture (MAAIF, 2018).

MAAIF also prepared a National Adaptation Plan for the Agriculture sector (NAP-Agr) in 2018, which identifies key climate change issues specifically affecting agriculture and the corresponding coping mechanisms to address the impacts. The coping strategies include

COPING STRATEGIES FOR CLIMATE CHANGE ON AGRICULTURE

- **Promoting highly adaptive and productive crop varieties and animal breeds;**
- **Climate Smart Agriculture and other ecologically compatible cropping systems;**
- **Sustainable management of rangelands and pastures;**
- **Irrigation agriculture;**
- **Sustainable land use and soils management;**
- **Agriculture diversification;**
- **Post harvest handling, storage and value addition.**
- **Innovative credit and insurance schemes.**
- **Supporting community based adaptation strategies.**

1.4 Efforts to scale up Climate Smart Agriculture in Uganda

Climate Smart Agriculture is an approach to farming that sustainably increases productivity, enhances resilience to the impacts of climate change (adaptation) and reduces or removes Green House Gas (GHG) emissions (mitigation), where possible, and enhances development of national food security and development goals. In line with the Africa Climate

Smart Agriculture Alliance (ACSAA) commitment, MAAIF, Ministry of Water and Environment (MWE) and the Uganda iNGO Alliance established a partnership that is spearheading initiatives to scale up CSA in Uganda, with the objective of improving productivity and resilience for 6 million farming families by 2021. The partners constituted a Task Force to coordinate and provide technical backstopping to the various CSA initiatives implemented in Uganda.

Government, through MAAIF and MWE, prepared a comprehensive Climate Smart Agriculture Programme (2015–2025). The programme has five objectives, namely (i) increasing agricultural productivity through climate smart agriculture practices and approaches that consider gender; (ii) increasing the resilience of agricultural landscapes and communities to the impacts of climate change; (iii) increasing the contribution of the agricultural sector to low carbon development pathways through transformation of agricultural practices; (iv) strengthening the enabling environment for efficient and effective scaling up of climate smart agriculture.; and (v) increasing partnerships and resource mobilization initiatives to support implementation of climate smart agriculture. The programme has six result areas, namely, improved productivity and incomes; building resilience and associated mitigation co-benefits; value chain Integration; research for development and innovations; improving and sustaining agricultural advisory services; and improved institutional coordination.

A number of projects have been or are being implemented by Government and its partners in context of the CSA country programme. These are supported by UNDP, COMESA, FAO and other development partners. Other stakeholders are also implementing CSA community-level initiatives in different agroecological zones of Uganda. These include Oxfam, Clusa and other members of the iNGO Alliance.

1.5 Climate Smart Agriculture Stakeholder Mapping

LIST OF 9 AEZ AND THEIR RESPECTIVE ZARDIS

- **Southwestern Rangelands - Mbarara**
- **Lake Victoria Crescent - Mukono**
- **Southwestern Highlands - Kachwekano**
- **Western Highlands - Rwebitaba**
- **Northern - Ngetta**
- **Lake Albert Crescent - Bulindi**
- **West Nile - Abi**
- **Eastern Highlands - Buginyanya**
- **North Eastern Semi Arid - Nabuin**

Under this study, Uganda was divided into nine (9) agroecological zones (AEZs), which are grouped following the various Zonal Agriculture Research and Development Institutes (ZARDIs) The role of the ZARDIs is to develop and disseminate appropriate agricultural technology packages and offer tailor made agricultural advisory services on crop, animal and fisheries production, including CSA technologies and practices.

Climate Smart Agriculture technologies and practices are already being promoted by various actors and implemented by farming communities to varying levels in the different AEZs. A stakeholder mapping exercise commissioned under this study identified and documented the stakeholders implementing CSA technologies and practices in all the nine zones. The study also presented the tools, methodologies and approaches used to promote CSA, and experiences, best practices, lessons learnt and challenges regarding CSA. The information gathered facilitated the production of this CSA Community of Practice Guide and Actors' Catalogue, which is a one stop centre providing the different actors with information on CSA implementation in Uganda.

The major CSA technologies and practices identified during the mapping exercise include terraces, contour bunds, agroforestery, Conservation agriculture, agronomic practices,, fertilizer application (organic and inorganic), early maturing, drought and disease resistant varieties. Other CSA technologies/ practices are woodlots, crop rotation, mixed/ inter cropping, double digging, animal breed improvement, pasture improvement, pasture conservation, use of renewable energy (such as biogas and improved cook stoves), agricultural mechanization, rain water harvesting, irrigation; use of screen houses, band farming, backyard gardening and Integrated Pest Management. In addition, a number of approaches have been applied by actors in promoting CSA. These include agroecology, watershed/ landscape approach, land degradation target setting, and a wide range of knowledge management tools to promote learning and scaling up e.g. farmer to farmer learning exchanges.

2.1 Southwestern Rangelands Agro Ecological Zone

This zone comprises of Ankole region and hosts Mbarara ZARDI. The zone lies within the southweatern part of the cattle corridor and is severely affected by climate change impacts, particularly drought during the dry season and flooding during the rainy seasons. The topography mainly comprises of undulating hills with gentle slopes ending in valleys. The major vegetation type is savanna grasslands with scattered acacia shrubs mainly used for grazing animals. The major economic activities in the zone are crop and livestock farming. The major crop enterprises include bananas, maize, beans, sorghum, and millet as major food crops while coffee, tea, banana and rice are the major cash crops.

Within the zone, the CSA mapping exercise was conducted in five (5) District Local Governments (DLGs), namely, Kiruhura, Mbarara, Ibanda, Ntungamo and Sheema. In order to mitigate and adapt to the impacts of climate change, farmers are adopting different CSA technologies and practices to improve resilience of their farming systems ro the impacts of climate change. During the mapping exercise, a number of CSA case studies were documented in the zone to establish the coping mechanisms to the impacts of climate change and variability. These are presented below.

2.1.1 Climate Smart Mixed Farming in Sheema District

Banana and coffee growing had become challenging farming enterprises owing to the adverse weather patterns, particularly prolonged dry spells and erratic rainfall, experienced in Sheema district.. The district experiences prolonged dry seasons and mid season droughts from January to April. Sometimes the dry seasons are quickly followed by violent rainy seasons with hailstorms which ravage the crops and kill animals. Mr. Enoth Turyamuru, a banana and coffee farmer from Rushoroza zone, Sheema Central Division, Sheema municipality, had his plantations adversely affected by the prolonged droughts coupled with pests and diseases, particularly Banana Bacterial Wilt (BBW), Banana Weevils and Coffee Wilt Disease. This led to a decline in banana and coffee production that resulted into a drastic decline in yields.

The farmer sought for advice from Sheema Community Integrated Development Organization (SCIDO), a local Non Government Organisation (NGO) operating in the district. He said "I got so worried when I realized that I was losing my banana and coffee plantations to the prolonged droughts and pest and disease infestation. I was supported by SCIDO with 1,000 elite coffee seedlings; trained and adopted the banana-coffee mixed farming using CSA practices".

KEY CSA PRACTICES IMPLEMENTED

- Planted a banana - coffee intercrop.
- Dug fanya ju and fanya chini contour bunds.
- Dug roadside runoff water diversion channels.
- Regularly poured cow and goat manure into the trenches
- Mulched plantation with maize stover and grasses.
- Planted elephant grass bunds and calliandra hedge rows along the contour bunds.

KEY BENEFITS OF BANANA-COFFEE INTEGRATION UNDER CSA

- Increased income from banana and coffee sales.
- Increased soil fertility and productivity from manure application and in situ mulch.
- Improved soil health – enhanced SWC due to grass and in situ mulch from banana and coffee leaves.
- Increased on-farm resource use efficiency through crop-livestock integration.
- Reduced pests and disease pressure.
- Increased resilience of intercrop to droughts.
- Farmer bought more land to expand his plantation.
- Receives over 20 farmers every month to learn about mixed farming.
- Grass bunds control soil erosion and provide animal feeds.

A section of Mr. Turyamuru's banana-coffee intercrop located in Rushoroza zone, Sheema municipality

Over the last one year, banana production both in terms of number of bunches harvested per month and bunch sizes tremendously increased. "I was previously harvesting 30 bunches per month and now I harvest more than 60 bunches over the same period and the bunch sizes have more than doubled, which has almost tripled my income from banana sales" said the farmer. His three year old coffee also yielded more than 250 kg during the 2018a season. After adoption of CSA practices, the farmer registered a multiplicity of benefits which increased productivity of the intercrop and enhanced the natural resource integrity

CHALLENGES	• Limited access to climate related advisory services. • High cost of establishing SWC structures. • Scarcity and high cost of manure. • Long distances to the sources of mulching materials. • Competition for the mulching materials as animal feeds.

OPPORTUNITIES	• Presence of other actors in the district offered opportunity for collaboration and increased access to CSA knowledge.
LESSON LEARNT	• Crop-livestock integration and SWC structures significantly improve and sustain resilience and productivity of farming enterprises.

2.1.2 Innovative Climate Resilient Intercropping in Sheema District

Kyamatongo Tukwatanize Farmers Group is located in Sheema municipality, with crop and livestock farming as the main economic activities of members. They grow a variety of crops including bananas, pineapples, oranges, maize and sorghum, and rear both local and exotic livestock. Crop production drastically declined over the years due to declining soil fertility, prolonged dry seasons and pest and disease infestation. This resulted into food and nutrition insecurity, famine, low household incomes and persistent poverty among the group members.

This situation prompted the group members to seek for collaborative support from SCIDO, Operation Wealth Creation (OWC) and Sheema DLG. The group was trained in sustainable agriculture practices and established a demonstration garden in Kyamatongo zone. The demonstration garden was set up on a five acre landscape with low fertility laterite soil on the slopes and a swamp downstream. The farm was divided into two sections, with three acres on the hill slopes planted with a pineapple-orange-banana intercrop, while the remaining two acres in the valley were planted with eucalyptus tree woodlot. The members pooled labour and worked together in order to improve productivity and increase resilience of the intercrop to weather vagaries.

Under the collaboration, OWC provided orange seedlings, SCIDO provided pineapple suckers while the group members brought banana suckers. SCIDO and Sheema DLG Production Department provided training and supported the group to dig contour bunds and mulch their garden. The farmers collected manure locally and applied between pineapple rows to improve soil fertility.

Mrs Edida Bihagoro a group member narrated:

- *"We are getting very high crop yields. The contour bunds we dug in the garden and the mulching helped to conserve soil moisture and suppress weed growth".*
- *The cowdung manure improved the soil structure and added nutrients to boost crop growth and production".*
- *"We use rocket to kill pests and diseases, and practice irrigation during the dry season to improve the resilience of the crops to the climate change impacts".*
- *"Woodlot provided building poles for expansion of the school owned by the demo farmer and contributed to modulation of the environment.*

A bananana-coffee intercrop established by a farmer in Sheem district

The bananas are harvested and shared among members for domestic consumption while the pineapples and oranges are sold for income. Members are happy with interventions as they are reaping increased income from the garden. Part of the proceeds go to the demo farmer and the rest goes to the CBO account strengthen the group. Other group members who participated in the demo management are adopting the intercrop and hope to form a Savings and Credit Organisation (SACCO) and put a revolving fund to enable the group members save and borrow money whenever they have a need.

Members are planning to add value to the fruits by making wine and juice from the oranges and pineapples to earn a better income. They also receive many farmers who come from near and far to learn about their success story. The group got more strengthened as a result of working together and members got more committed after realizing the tangible benefits.

CHALLENGES	• Lack of commitment to group work by some members. • Limited availability of manure and mulching materials in the community. • Lack of a ready market for the produce. • Intensive labour required to establish the SWC structures.
OPPORTUNITIES	• Presence of other actors (SCIDO. OWC and Sheema DLG) provided the opportunity to for the group to freely acquire inputs and training.
LESSON LEARNT	• Pooling together labour and collaboration with other actors are key to successful implementation of the interventions. • Realization of tangible benefits by members improves their commitment to participate in farming activities (sharing banana harvest and some income from dale of fruits deposited on group account)

2.1.3 Irrigated Passion Fruit Growing in Mbarara District

Passion fruit growing has been a challenging farming enterprise in Mbarara district owing to erratic weather patterns characterized by prolonged droughts and unpredictable rains. This scenario is exacerbated by the low fertility and water holding capacity of the soils in Rubaya sub county. Mr. Kenneth Mujinya is a 25 year old youthful passion fruit farmer located in Itara village, Rubaya sub county. He faced the problem of withering and sometimes drying of his 2 acre passion plantation making him register losses as a result of the extremely high temperatures during the drought periods. Consequently, he sought for advice from Mbarara ZARDI on how best to manage his plantation and overcome the climate related challenges.

The Zonal SLM Specialist from Mbarara ZARDI visited the farmer and provided him with a set of irrigation infrastructure, including a water pump and hose pipes. He also recommended him to adopt a number of CSA interventions. These included digging contour bunds and roadside runoff water harvesting channels, cowdung manure application, irrigation during the dry season, mulching using maize stover and grasses, and insecticides for pest and disease control.

The farmer irrigating his garden with a horse pipe

RECOMMENDED SCA INTERVENTIONS

- Contour bunds - controlled soil erosion and harvested water.
- Water diversion channel- harvested roadside runoff water and diverted it into the garden.
- Cowdung manure – put in planting holes for soil fertility improvement..
- Irrigation – increased water availability during drought periods..
- Grass mulch – enhanced SWC in the garden
- Insecticides – controlled passion fruit diseases.
- Overall - Increased productivity and resilience of the garden to climate change impacts.

Following adoption of the CSA technologies, the passion fruit harvests increased four-fold from 10 to 40 bags per acre. He sold each bag at UGX 200,000 giving him 4 million from the two acres per season before and UGX 16 million after adoption of CSA technologies.

Prior to adoption of CSA, the farmer spent average UGX 2.1 million on labour and insecticides and under CSA, he spends average UGX 5 million on management including labour, insecticides, irrigation establishing SWC structures and mulching, Before adoption of CSA, the farmer made a net profit of UGX 1.9 million while under CSA, he makes a net profit of UGX 9 million. He used some of the profit to buy 2 more acres of land which he has used to expand his passion fruit plantation. He targets to expand his passion fruit plantation to 10 acres in the next 3 years. He also recently bought five (5) dairy cross breed cattle which he keeps under the zero grazing system.

The youthful farmer also takes care of and pays school fees for his 3 elder brother's children, and plans to marry in the near future. The farmer also plans to start fish farming. He plans to visit Mbarara ZARDI to learn more about aquaculture after which he will dig and stock the fish ponds with tilapia and cat fish.

A recently established extension of Mr. Mujinya's passion fruit garden

CHALLENGES	• Lack of access to credit to enable him expand his plantation. • High cost of agricultural inputs (cowdung manure, inorganic, barbed wires, fertilizers, pesticides and supporting poles).
OPPORTUNITIES	• Collaboration with other actors (e.g. Mbarara ZARDI and Mbarara DLG) provides opportunity to acquire knowledge, skills and equipment to enhance production.
LESSON LEARNT	• Adoption of CSA technologies that improve soil fertility, SWC and pest/ disease control make passion fruit a very profitable farming enterprise which can quickly transform the farmer's livelihood to another level.

2.1.4 Climate Smart Banana Production in Ntungamo District

Kagarama Town Council is one of the areas most affected by land degradation and other climate change impacts in Ntungamo district. Mr. James Banyenzaki, a prominent banana farmer from the Town Council had his 5 acre banana plantation seriously affected since the 2017 drought which lasted for 6 months from January to July. The plantation was

also affected by BBW disease which seriously undermined its productive potential. Recognising these challenges, the farmer sought for assistance from the district agricultural office.

Mr. Banyenzaki received training and was advised to adopt climate resilient farming practices so as to improve and sustain the productivity of his banana plantation. He dug fanya ju and fanya chini contour bunds and water diversion channels for harvesting and diverting roadside runoff into his plantation. The farmer also applied cowdung manure into the trenches and mulched the entire plantation with dry grass. He also tied the dry fibers around banana stems to minimise water loss from the bananas during the dry seasons.

BENEFITS OF CSA TECHNOLOGIES ON BANANAS

- Banana productivity tremendously increased
- Contour bunds - harvested and allowed water to infiltrate into the soil
- Mulching –provided effective soil cover which improved soil moisture retention.
- Cowdung manure improved soil fertility
- Uprooting, chopping and burning infected plants controlled BBW disease

As a result of the above-mentioned CSA interventions, productivity and resilience to the banana plantation to climate change impacts tremendously improved. The farmer reported three-fold yield increases from about 35 to 120 bunches per month, and increased bunch sizes. He sold a bunch at UGX 15,000 getting income of 1.8 million up from the previous UGX 175,000 he used to get while selling a bunch as UGX 5,000 prior to adoption of the CSA interventions.

A well dug contour bund dug by the farmer in his banana plantation.

The increased income from banana sales transformed Mr. Banyenzaki and his family's life. He used some of the income to buy additional land to expand his plantation and started maize, beans and groundnuts farming enterprises to diversify his income sources and achieve household food and nutrition security. The farmer reported improvement in family harmony and welfare as life became easier for all members in the home. All family members participate in the plantation management and benefit from the income. He pays school fees for his six children and those of his sisters, and meets other domestic expenses without much stress.

Sometimes he supplies schools with bananas and the income is computed as school fees for his children. He attributed the transformation of his life to adoption of CSA practices which made his plantation resilient to climate change impacts and improved its productivity.

CHALLENGES	• High initial capital required - intensive labour to dig contour bunds, high cost of manure (Ug. Shs. 200,000) and mulching grass (Ug. Shs. 150,000). • Lack of access to credit to enable him buy a truck to transport the bananas to Ntungamo town where he would sell at higher prices. • Lack of a reliable market and fluctuating market price of bananas. • Limited availability of extension services and agricultural inputs.
OPPORTUNITIES	• Collaboration with othr actors such as the DLG enabled the farmer to acquire knowledge and skills wihich enable the farmer to increase his banana yields.
LESSON LEARNT	• High enterprise profitability motivates the farmer to invest in CSA technologies to enhance yields.

2.1.5 Climate Smart Backyard Vegetable Farming in Mbarara District

Mbarara district is prone to prolonged droughts which led to difficulty for farmers to grow vegetables. The adverse weather led to premature drying of vegetable leaves due to moisture stress as well as pests and disease attack resulting into low quality vegetables. This made the farmers abandon vegetable growing for fear of yield losses. Realising this challenge, the Agency for Cooperation and Research in Development (ACORD) Western Regional Office mobilized women into groups to promote vegetable production both for domestic consumption and income generation.

One of the women' groups located in Mbarara Municipality benefited from this initiative. The NGO trained group members and supported them to establish backyard vegetable gardens integrating CSA practices to demonstrate that vegetable growing was still a viable farming business despite its high vulnerability to the climate change impacts. Realising the successful demonstration of climate smart innovations, the individual group members adopted vegetable growing using the new practices to improve household nutrition and income generation.

One of the group members grew early maturing, high yielding and disease tolerant cabbage and spinach varieties. She established a nursery after which she transplanted the

The farmer explains to the visitors about vegetable growing under irrigation

seedlings to her quarter-acre back yard garden. She had earlier prepared the garden and dug contour bunds and planting basins at a spacing of 1ftx2ft for both crops, and applied a handful of cowdung (or poultry) manure into the planting basins. One seedling was planted in each basin for both crops and the gardens mulched to ensure water conservation in the soil. Whenever the drought became serious, she would use a watering can to irrigate the vegetable gardens to improve their resilience to the prolonged dry seasons.

Visitors admiring the front-yard garden

The farmer narrated the key benefits of CSA interventions. *She said "vegetables gave very high yields when integrated with CSA practices. The cabbage yielded very big sizes averaging 4 kg and the spinach leaves were also big. Off- season harvesting of the vegetables gave maximum price, with a cabbage going for shs.1,500 and a big bundle of spinach leaves fetching shs. 5,000. The vegetables have improved my family nutrition, increased household income and give me self satisfaction when other farmers come to learn about better farming practices".*

The farmer narrated a number of benefits she received from her gardens. The cowdung and poultry manure added improved soil fertility which enabled her to grow vegetables throughout the year with irrigation. Vegetable growing improved her income and livelihood, especially when grown at peak demand during the dry seasons. Income from the vegetable sales enabled her to pay school fees for children without much hustle and she ploughs back some of the money to grow more vegetables the following season.

CHALLENGES	• Lack of land ownership. • Limited availability of manure and high cost of pesticides • Intensive labour required for manure application and irrigation. • Fluctuation of market prices for the vegetables.
OPPORTUNITIES	• Existence of a ready market for the vegetables in the town. • Presence of NGOs and other CSA actors to support the group. • Presence of women groups enables easy provision of trainings and other services.

LESSON LEARNT	• If well managed, vegetable growing is very profitable even when done on a small piece of land.

2.1.6 Rain Water Harvesting Using Ferro-Cement Tanks in Mbarara District

Mbarara district is located in the southern part of the cattle corridor and is prone to the adverse impacts of climate change, particularly prolonged droughts and water scarcity which result into crop failures and loss of animals. The drought has also resulted into water scarcity both for domestic use and animal production. This was a serious challenge as local communities had to walk long distances to collect water for domestic use and watering animals.

Noting the water scarcity challenge, ACORD South Western Regional Office based at Mbarara in collaboration with Mbarara, Isingiro and Kiruhura District Local Governments developed a project to address the water scarcity in the three districts. Women groups from drought-prone sub counties were selected as project beneficiaries. In Mbarara, ACORD and Mbarara DLG identified beneficiary sub counties, which included Mbarara municipality. The project constructed Ferro-Cement rain water harvesting tanks for domestic use for selected group members.

The identified groups were sensitized about the project objectives and beneficiaries were selected following set criteria. ACORD trained the selected groups in group dynamics, saving and credit, revolving fund management and low cost rain water harvesting and storage technologies. Through a cost sharing scheme, ACORD constructed the water harvesting tanks for selected members in the beneficiary sub counties.

Ms. Nshozi Kukwatanise a project beneficiary said *"my husband and I had difficulties in getting water for domestic use because we are old and cannot afford to collect water from the long distances. We were given priority in the group and now we are the proud owner of a 10,000 litre capacity water tank which costed about UGX 1.9M". She added "I used to spend a long time collecting water from distant sources and would come back very tired. Sometimes I would fail to prepare meals due to lack of water".* **She proudly said that she can now easily access clean water for domestic use.**

A Ferro cement water harvesting tank connected to a drip irrigation system

She pointed out that she used to spend a long time collecting water from distant sources and during drought periods, she would sometimes fail to prepare meals due to lack of water.She further noted that after acquiring the tank, she now has enough time to rest or do other domestic chores like washing clothes and attending to her garden. She has also set up a back yard vegetable garden and sometimes irrigates her vegetables using water from the tank. The vegetables have improved household diet which has enhanced nutrition security.

2.2 Lake Victoria Crescent Agro Ecological Zone

The Zone is located in central Uganda and covers 20 districts extending over four agricultural production zones. These include Lake Kyoga plains, Lake Victoria crescent, western savannah grasslands and the pastoral rangelands. The zone extends from the western side of River Nile and borders with Sembabule district in the southwest up to Mubende in the west and Lake Kyoga in the north. It hosts Mukono ZARDI, a NARO institute which conducts applied and adaptive research on crop, livestock and fisheries resources suitable for the zone. The zone has two main farming systems, namely, the intensive banana-coffee along the Lake Victoria shores and the Western banana-coffee farming system. The majority of farmers practice small scale subsistence farming producing for domestic consumption. Coffee is the main cash crop while banana, maize and beans are the major staple food crops.

The major climate change impacts in the zone include unreliable rainfall, droughts and extreme temperatures. These partly result from reduced vegetation cover due to conversion of forests to agricultural land and degradation of forest reserves such as Mabira and Budongo forests for timber, charcoal and firewood production. Encroachment on marginal lands such as wetlands, lake shores and river banks for farming, sand mining and other exploitative activities leads to degradation of these resources. The zone generally has low soil fertility levels and majority of farmers grow crops without addition of any soil fertility enhancing inputs. Other challenges include soil erosion, soil nutrient depletion, population pressure, poor agronomic practices, sand mining, stone quarrying and seasonal bush fires.

2.2.1 Innovative Sustainable Agriculture Practices: A Case of St. Jude Family Project

St. Jude Family Project is a rural training center located in Busense village, Kyamuyimbwa parish, Kabonera sub county in Masaka district. The project runs an integrated mixed enterprise model farm established over 20 years ago in order to demonstrate sustainable agriculture practices, alternative livelihoods and food and nutrition security for both rural and urban small-scale farmers. The Centre is located on a 3.7 acre piece of land and is specialized in training and demonstration of sustainable agriculture innovations and practices. The project was established to build capacity of farmers in sustainable farming practices that respond to adverse impacts of climate change, particularly prolonged droughts, soil degradation, food and nutrition insecurity and water scarcity, among others.

St. Jude training centre strengthened its training programme by constructing hostels and providing residential practical training courses to organized farmer groups and other interested stakeholders. The Centre trains and demonstrates

SOME CSA TECHNOLOGIES DEMONSTRATED AND THEIR IMPACT

- Compost making - soil fertility improvement,
- SWC - water harvesting and conservation and soil erosion control,
- Irrigation – improved water availability,
- Agroforestry – soil fertility improvement;
- Agronomic practices – improve production,
- Solar driers - post harvest handling and value addition,
- Diversification of enterprises – alternative livelihood,
- Zero grazing – improved animal production

for integrated pest management; kitchen gardening for vegetable production and improved pasture management and conservation for zero grazing livestock, among others. St. Jude training center has had a strong impact on rural farming communities, especially in Masaka, Rakai, Kalungu, Sembabule and Mpigi districts. Over 20,000 rural farmers are trained annually in different sustainable agriculture practices such as organic farming, animal husbandry, integrated nutrient and pest management and fisheries management techniques. The practical nature of the trainings enables adult and low literacy farmers to easily comprehend. Animal improvement at the Centre enabled neighbouring farmers to access improved high yielding animal breeds which improved their livelihoods through improved nutrition and increased incomes from milk and beef sales. Poultry improvement by crossing local and exotic chicken increased egg and meat production resulting into improved incomes for the beneficially farmers. The Centre also introduced new cash crops such as vanilla and improved coffee varieties which enabled farmers to increase their incomes and transform their livelihoods. The Centre mobilized and strengthened organic farmer groups in Masaka district to form Masaka Organic Processors Cooperative Society Ltd. which is promoting group production and marketing of their produce. This cooperative has been certified and secured an export market to sell organically grown fruits in Sweden.

environmentally friendly innovations using cheap and locally available materials. The major enterprises demonstrated include sustainable banana production, SWC, agroforestry, agronomic practices, apiary, vegetable growing, orchards, biogas production, animal management and fish farming.

Within these enterprises, the Centre demonstrates integration of a wide range of climate smart innovations and many useful sustainable organic farming techniques are seen in action. The integrated farming ensures that on-farm products are used including livestock manure for biogas and compost, animal urine for pest control and liquid manure, weeds and kitchen waste for compost, runoff water for irrigation and domestic use, organic pesticides

Improved banana management demo with CSA practices at St. Jude family training centre

CHALLENGES	• Lack of tenure security over their farmlands discourages women to invest in the costly CSA interventions. • Lack of extension services, particularly climate resilient advisory services and climate information to support decision making. • Long distance to markets affects profitability of their enterprises. • Limited access to quality certified agro inputs.
OPPORTUNITIES	• Existence of the training centre which offers farmers free access to knowledge, skills and other materials to enhance productivity of their farming enterprises.
LESSON LEARNT	• Group production and marketing of produce enables farmers to bulk and negotiate for better prices for their produce

2.2.2 Conservation Agriculture and Innovative Piggery Production Mukono District

Mukono Youth Farmers' Association is a youths' group located in Bugereka village, Makukuba parish, Nabbale sub- county in Mukono district. The group was formed in response to the challenges of low agriculture production and increasing poverty resulting from the adverse impacts of climate change, particularly reduced soil fertility and prolonged dry spells common in the sub county. The major economic activities of the group members is crop and livestock farming, with maize, beans, groundnuts, cassava, coffee and oranges as major crops, and piggery as the major livestock. The group has 30 members all of whom are practicing various CSA practices, especially Conservation Agriculture (CA) to increase crop resilience to the adverse impacts of climate change and increase incomes. The group was trained by Mukono ZARDI (ATAAS SLM Project) in various CSA technologies and supported to establish CA garden during 2017 (a) and (b) seasons. The steps followed in establishment of CA gardens are outlined in Annex II. They were also trained in piggery using the Indigenous Micro Organissms (IMO) technology.

KEY PRINCIPLES OF CA

- Minimum soil disturbance to the extent possible.
- Maximum soil cover to the extent possible.
- Rotating and/or mixing cereals with legumes.

After all the basins in the garden are fully covered with soil, a stick is used to prick planting holes in the basins. Three clean early maturing and high yielding maize or 6-8 bean seeds such as maize Longe 10 or NABE 17 bean variety is evenly planted in each basin and loosely covered with soil. The whole garden is thereafter sprayed with herbicide to kill off all the grass. As the grass is drying, the crop is

Permanent planting basins for maize growing under CA

CONSTRUCTION OF IMO PIG PEN

- The pig pen is erected, inside of pen dug to depth 0.5 m.
- Subsequent 20 cm layers of branches and sticks, maize stover. coarse wood shavings, fine wood sshavings are put in the pen.
- Pigs introduced into the pen
- A 20 litre tin of maize bran is poured into a drum of water and thoroughly mixed.
- A litre of IMO is poured into the drum and thoroughly mixed.
- The IMO solution is left for two weeks for micro-organisms to multiply and then ready for use.
- IMO is evenly sprayed on beddings twice a week to digest any faeecs and urine, leaving a clean and odorless environment.

germinating. After germination, the garden is fully mulched to conserve water in the soil and suppress weed growth..As a principle of CA, cereals are rotated with legumes to reduce pest infestation and better nutrient management. This is of course accompanied by proper agronomic practices.

Permanent planting basins for maize growing under CA

Conservation agriculture practices dramatically increased maize and bean yields. The youths reported getting maize yield increases of 80% and up to 100% for beans during the first year, meaning increased income and profitability of their enterprises. The use of PPBs ensured precise nutrient placement, improving soil moisture retention and availability of nutrients within the rooting zone. The rotting mulching materials gradually improved soil fertility, water holding capacity and other soil physical properties thereby increasing resilience of the garden to the adverse impacts of prolonged dry spells. The dry season land preparation costs and peak labour requirements are lower than with conventional systems. The PPBs also harvest and conserve water protecting the soil against erosion and washing away of plant nutrients and encourage infiltration of water into the soil.

Prior to adding the IMO to the pig's pen, the big pig feacal clods are removed and the small ones are ploughed into the

beddings. The IMO is sprinkled in the pen twice a week and the piggery bedding is turned to ensure even distribution of the IMO. The IMO digests all the wastes produced by the pigs leaving no smell in the pen. The pigs are given IMO to drink in order to deworm and control other digestive tract parasites. The system leads to production of healthy and fast growing pigs which fetch premium market price. Sometimes the pigs feed on the beddings cutting on food intake by up to 30% saving the farmers on feed costs. The IMO technology generates high quality manure from animal dung. The beddings are also periodically removed and put into gardens as quality manure to improve crop yields, food security and income of members and the adopting communities.. The youths are also earning income from the sale of piglets and IMO.

CHALLENGES	• High initial labour requirements for CA and construction of the pig pen. • Need for change of mindset of policy makers, extension officers and farmers from the traditional farming systems. • Insecure land tenure among majority of farmers especially women and youths, • .Limited availability of crop residues for mulching and pig bedding. • Difficulty in getting genuine farm inputs.
OPPORTUNITIES	• The youths are hard working and willing to learn and open up to new ideas. • Collaborative linkages with partners (MAAIF SLM Project, Mukono ZARDI and the DLG) enabled the youths to acquire inputs for the SLM interventions. • Availability of a ready market for pig meat and piglets.
LESSON LEARNT	• Partnerships are necessary for strengthening technical and managerial capacity to enhance adoption of CSA practices and improve group cohesion. • Strengthening tenure security of women and youths, who are the majority of small scale farmers, is critical to success of CSA programmes. • Crop-piggery integration enhances farm productivity as the pigs provide manure to improve crop yields while the crop residues provide animal feeds

2.2.3 Innovative Community Irrigation project in Mubende district

Tukwatire Wamu Farmers Group is located in Lugala village, Kitenga sub-county, Mubende district. The group was formed in 2013 and has a membership of 23 farmers, 15 women and 8 men. The group often experienced land degradation and drought challenges which negatively impacted on crop production, leading to low yields, low household incomes, extreme poverty and family conflicts. In order to adapt to the adverse weather effects, the group supported by C-Care in 2015 to implement an irrigation project. The project targeted vegetable production during the dry seasons when most farmers are out of business.

The group was initially provided with a water pump and a network of irrigation pipes to set up a demonstration garden. The garden was used as a training ground where a number of CSA technologies were demonstrated. Members were thereafter provided with irrigation systems on cost sharing basis. They also contributed local materials, including mulches and labour for field operations. They started growing vegetables on their individual gardens under irrigation.

The first season harvests after establishing the irrigation system were much more than those before and the sales fetched very high prices for all members. Since then, there was tremendous improvement in vegetable production both for home consumption and sale throughout the year.

A demo drip irrigation system for vegetable growing in Mubende district

CSA TECHNOLOGIES PRACTICED

- Drip irrigation.
- Contour bunds/ water trenches.
- Planting grass bunds along contours.
- Planting improved seed.
- Mulching the vegetable demo garden.
- Applying cowdung or poultry manure.

One of the group members who grew one acre of cabbage and tomatoes said "I used to think my children were dull but when I started earning from dry season farming with irrigation, I got money and changed them from UPE School to a private school. These days they are among the best pupils in class". Another farmer observed "with the irrigation project, we produce when other farmers have nothing to sell and we determine our own prices earning high profits".

C-Care taught members about group dynamics, records keeping and group marketing. All members from the 23 households making up the group, including men, women and children, are benefitting from the project. They actively participate and provide labour for field activities. Presently, the group members bulk and sell their produce that include vegetables (Cabbages, spinach, egg plants), onions, passion fruits, tomatoes, pumpkins and carrots as a group. After selling their produce, the members share the income according to how much produce each contributed. They also deposit part of the earnings into their group

account from which members borrow to improve on their farming Using the income from their project, the group members contributed and bought more land for the group and planted over 5 acres of eucalyptus trees.

At the household level, the project improved cohesion of the member families, enhanced decision making and improved household food and nutrition security. Margaret Lutaya, a group member said "I managed to harvest over 700kg of beans from my piece of land in Kawangalo village in Bukuya sub-county and can now ably pay school fees for my daughters". Previously, Mrs. Lutaya was farming but getting very poor harvests and had pressure of paying school fees for her children. Farming as a group enabled the farmers to bulk their produce making it easy to look for market and have a better bargaining power to sell at a higher price.

CHALLENGES	• High cost of pesticides to spray the vegetables. • High labor costs to dig the SwCstructures in the gardens.
OPPORTUNITIES	• Availability of collaborating partners enabled the group to access irrigation equipment. • Availability of ready market during the dry season when other farmers are out of season.
LESSON LEARNT	• Involvement of all family members in the farming activities enables pooling of household labour and imely execution of field activities getting higher yields. • Involvement of husbands adds value as the family looks for appropriate solutions to farming challenges together, which improves harmony and equity in sharing earnings from the farm.

2.3 South Western Highlands Agro Ecological Zone

This Zone covers Kigezi region and is comprised of six districts, namely, Kabale, Kisoro, Rukungiri, Kanungu, Rubanda and Rukiga and a total population of 1,376,774 people (655,000 male and 721,774 female). The economic activity of the local communities is mainly crop farming, with some farmers also keeping livestock, especially goats. The landscape is characterized by steep hills and the vegetation is mainly montane grasslands mixed with scattered woodlands. The major food crops include bananas, beans, maize, sweet potatoes, sorghum and millet while Irish potatoes, tea, coffee and wheat are the major cash crops. The zone is one of Uganda's most important Irish potatoes producing areas. Kachwekano ZARDI is the resident NARO's research institute mandated to conduct research and develop agricultural technologies suitable for the zone.

The zone experiences extreme weather conditions characterized by prolonged dry seasons, increasing temperatures and heavy rainfall resulting into intense soil erosion and landslides on hill slopes and flooding of low lying areas during the rainy seasons. The rainy seasons are increasingly getting shorter and unpredictable and the increasing temperatures have led to increased pest and disease incidences which have greatly impacted on the health of communities affecting agricultural productivity. In this zone, CSA mapping was conducted in Kabale district and the climate change adaptation and mitigation efforts focused majorly on soil and water conservation and afforestation.

2.3.1 Climate Resilient Irish Potato Tubers Production by Kachwekano ZARDI

Irish potato farming has since 2000 been one of the major cash crops grown in the Southwestern Highlands of Uganda (Kigezi region). However, farmers started registering yield losses as a result of unpredictable weather, erratic rainfall and pests and diseases that adversely affected the crop. In order to rejuvenate irish potato production in the zone, Kachwekano ZARDI in collaboration with the International Fertilizer Development Centre (IFDC) implemented a project to develop, multiply and distribute improved irish potato varieties to farmers. The project established 17 screen houses in which they conducted research and developed improved early maturing, disease resistant and high yielding Irish potato varieties.

After production of the improved foundation seed, the ZARDI set up seed multiplication and demonstration gardens of improved irish potato varieties on selected farmers gardens.. Within the demonstration gardens, they integrated CSA technologies, which included making bench terraces, digging contour bunds across the garden at 10m intervals and applied fertilizers. They also dug ridges around the irish potato tubers and irrigated the crop during the dry seasons.

Mr. Eli Mushabe in his demo garden with CSA interventions (left); Some of the harvest from his garden (right)

The bench terraces controlled soil erosion, the contour bunds improved water harvesting and infiltration into the soil while the fertilizers improved soil productivity and increased yields, The heaps of soil dug around the irish potato stems encouraged production of more tubers while irrigation during the dry seasons increased soil moisture around the rooting zone The CSA technologies increased the crop's resilience to the adverse impacted of climate change that commonly occur in the zone during the dry seasons. This has enabled the institute to produce and distribute to farmers over 200,000 tones of Victoria and Kath pot Irish potato varieties so far.

CHALLENGES	• Increasing demand for planting materials from many more farmers. • Inadequate funding to invest in the production of Early Generation Seed (EGS) which could solve the problem of inadequate quality declared seed. • Continued use of inferior seed from home saved stock and/ or seed bought from local markets.
OPPORTUNITIES	• Existence of committed farmers to host demo gardens; • Presence of committed partners e.g. KaZARDI, DLGs, Calitas Uganda, Excel Hort Consult, Self Help Africa, ISSD, OWC,/NAADS to support seed multiplication and distribution.
LESSON LEARNT	• Establishment of more multiplication and demo gardens with CSA interventions will popularise improved irish potato production. • Presence of committed partners enhances dissemination of new technologies.

2.4 Northern Agro Ecological Zone

The Northern Agro Ecological Zone is divided into two broad sub-regions, namely Acholi and Lango. The zone hosts NARO's Ngetta ZARDI. The main economic activities are crop and livestock farming with maize, millet, cassava, sweet potatoes, beans, peas, sunflower, groundnuts, cotton and tobacco as the major crops while dairy and dual-purpose indigenous cattle, goats, pigs, poultry and sheep are the major animal enterprises. Use of oxen for mechanized agriculture is commonly practiced to reduce labour and drudgery of farming.

The zone is characterized by one long rainy season during May to September and a prolonged dry season from November to March, which is characterized by high temperatures that cause loss of the savanna vegetation. The resulting land degradation is intensified by seasonal bush burning and indiscriminate tree cutting for charcoal, timber and firewood production. This leaves the land exposed to agents of land degradation, particularly soil erosion, and the adverse impacts

of climate change. However, the affected local governments have intensified measures to minimize vegetation loss, including community sensitization on land degradation, increasing taxes on charcoal and timber, and provision of tree seedlings to farmers at subsidized prices.

2.4.1 Improved Maize Production using Conservation Agriculture in Otuke District

This maize demonstration garden was set up 9n Ogor sub-county, Otuke district in northern Uganda. The garden was established to demonstrate SLM practices that also contribute to improving resilience of the farming system to climatic shocks. Otuke district has a unique challenge of being mostly flat with low agriculture productivity potential due to poorly drained soils that get waterlogged for most of the rainy season making growing of cereals and legumes such as maize, beans and peas difficult. The district also usually experiences prolonged dry seasons lasing for more than 4 months causing famine, pests and diseases, food and nutrition insecurity and low household incomes due to poor crop harvests. To demonstrate how to successfully grow cereals and legumes on such soils, the ATAAS/SLM project based at Ngetta ZARDI supported the farmers to establish a maize demonstration garden for CA and other climate resilient technologies suitable for the zone. The garden benefitted the farmers in a number of ways.

Establishment of a maize demo garden under CA practices

The farmers slashed the bush and dug PPBs during the dry season. The basins were 35cm long, 15cm wide, and 15-20cm deep. The distance between basins in a row was also 35cm while that between rows was 75cm. Contour bunds were measured and dug at regular intervals of about 20m. The basins were then halfway back-filled with top soil and a soda bottle-top of DAP or a handful of manure was evenly applied and the basins fully covered with soil. A stick was then used to prick planting holes in each basin and three maize (or 6-8 bean) seeds planted in each basin and loosely covered with soil. The whole garden was thereafter sprayed with herbicides to kill off all the weeds. As the weeds were drying, the maize crop was germinating. After germination, the whole garden was mulched with grasses. At knee height, the maize was top dressed with urea and the garden later weeded by spraying with a herbicide or lightly using a hand hoe.

The farmers acquired practical skills in application of CSA and SLM technologies to improve crop production and yields. The basins helped to concentrate plant nutrients and harvest and store adequate soil moisture in therooting zone to support plant growth during the dry season. The contour bunds drained away excess water during the rainy season and conserved sufficient water in the soil to adequately support crop growth to maturity. The fertilizers added plant nutrients and the grass mulch conserved soil moisture minimizing the impacts of mid-season droughts, halting soil erosion and improving soil health. During the following season, the farmers rotated maize with beans to ensure balanced nutrient utilization and break pest and disease life cycles.

The farers reported yield increases of more than 100% during the first planting season of 2017 compared to what they were getting previously. The tremendous yield increase was attributed to the impact of the CSA and SLM technologies employed in establishment of the demonstration garden. The host farmer benefitted from the income from the sales and other farmers adopted the technologies the following season.

SLM team members inspecting the demo garden

CHALLENGES	• Limited availability and high cost of CSA implements and other inputs. • Lack of CSA advisory services. • Lack of knowledge of CSA by the farmers and extension officers.
OPPORTUNITIES	• Availability of collaborating partners enabled the farmer to freely acquire implements and other inputs to successfully establish the demo garden.
LESSON LEARNT	• Application of SWC practices and soil fertility improvement tremendously improves crop yields. • Dry season land preparation enables the use of idle labour and early planting to benefit from the first rains.

2.5 Western Highlands Agro Ecological Zone

This Zone extends across 3 Agricultural Production Zones (APZs) namely, Western Savannah Grasslands, Pastoral Rangelands, and Highland Ranges. It covers seven (7) districts, namely, Kyegegwa, Kyenjojo, Kabarole, Kamwenge, Kasese, Bundibugyo and Ntoroko, and hosts Rwebitaba ZARDI. The major economic activities in the zone are crop farming and tourism; The major crop enterprises include bananas, maize, beans and sorghum as food crops and coffee, and tea as the major cash crops. The tourist attractions include Mt. Rwenzori, Queen Elizabeth National Park, Kilembe mines, Lakes George and Edward, and Kazinga Channel.

The CSA mapping exercise was conducted in 4 districts, namely, Kabarole, Kasese, Kyenjojo and Ntoroko. The major climate change challenges identified during the study include heavy rainfall and hailstorms, floods, landslides, increased

incidence of pest and diseases, and loss of crops, animals and people. The storm water causes intense soil erosion, destruction of infrastructure (houses, roads and bridges) and siltation of low lying areas. Droughts are also common in the Pastoral rangelands and savanna grasslands. These climate change effects have negatively impacted on livelihoods of the local communities leading to reduced crop yields, food insecurity, famine, internal displacement and high poverty levels among the local communities.

2.5.1 Use of Municipal Compost Manure to Improve Food Production in Kasese district

Kasese is one of the fast growing urban cetres in Uganda. The town has a high population which generates a lot of wastes resulting into waste management challenges due to lack of appropriate waste disposal facilities. The indiscriminate dumping of wastes around the town caused unsightly areas, offensive odours and GHG emissions from the rotting wastes. This challenge made Kasese to be selected as one of the municipal councils to implement the World Bank funded Municipal Solid Waste Management Project. The project involves collection and sorting of solid wastes into biodegradable organic, plastic, metal and glass waste components. The organic waste component is used to make compost manure while the other components are disposed off separately.

The unsorted wastes are brought to the treatment site and mixed with cow dung and leachate to encourage decomposition. After 4-7 days, the wastes are mixed using a wheel loader and sorted to remove non-biodegradable components like plastics, polythene bags, metal and glass. The biodegradable component is then mixed with more leachate and heaped to encourage faster decomposition. After 2 to 3 weeks, the compost is spread out on trays and air dried. The dry compost is passed through a shredder and packed into 20 kg bags ready for sale. A 20 kg bag of compost is sold at UgX 2,000/=. Compost manure was used to enhance mango growing in Kasese district. The compost was applied in the planting holes and contour bunds dug in the plantation at 10-20m intervals, depending on the slope.

Mr. Baluku, a prominent mango farmer from Kasese district explained the benefits he has gained by using the compost on his mango garden. He said "compost application improved soil fertility and productivity of my mango plantation. Before I started applying the compost, my mangoes took 5 years to start yielding and fruits were small weighing 0.2 – 0.3 kg. When I applied the compost, the mangoes took 2.5 to 3 years to start yielding and the fruit size increased to 0.5 – 1.5 kg". He added "when the mango trees were still young, I would sometimes intercrop them with ground nuts, beans and soya beans to boost my family's food security, provide soil cover and earn some income to pay school fees for my children".

Another farmer, Mr. Masika from Kidodo village said that he had given up on vegetable growing because of the poor soil fertility and the high cost of buying inorganic fertilizers to apply to the vegetables. He attended a sensitization meeting by the extension staff on use of municipal compost as manure to

promote vegetable production. "I was encouraged to grow vegetables around my home and advised to use compost manure from Kasese waste plant. I bought a 20kg bag at 2000/= and the compost improved the yield of my vegetables and now I harvest and sell them throughout the year".

Compost manure increased resilience of crops to the impacts of climate change in a number of ways. It improved soil health, including soil structure, aeration, water holding capacity and held plant nutrients against leaching. The compost also added plant nutrients to the soil, conserved soil moisture and suppressed weed growth when he used it to mulch his garden. In this way, compost use increased the crop's resilience to climate change impacts, particularly drought, and tremendously improved crop production and yields. Furthermore, compost production reduced the amount of wastes reaching the disposal sites reducing the GHG emissions from the waste dumps.

Soild waste composting plant (left) and young vegetable garden fertilised with compost manure (right)

The improved mango yields translated into increased incomes and the farmer was now able to meet his household needs without much stress. He bought more land and wanted to expand his plantation. The farmer achieved nutrition security as his family members fed on the fruits which translated into reduced expenditure on family health Use of compost improved the quality and size of mango fruits enabling them to fetch higher prices than before. The contour bunds harvested and conserved rain water in the soil, while the crops planted in the young mango trees maintained soil cover reducing soil erosion. In addition, the mango trees contributed to environment modulation by improving vegetation cover and absorbing GHGs from the atmosphere. The branches that are regularly trimmed off are a sustainable firewood source, which reduces over-reliance of the farmer on natural vegetation that causes environmental degradation.

CHALLENGES	• Compost is required in large quantities if it is to provide adequate nutrients on a large scale. • Compost is bulky and expensive to transport over long distances. • Sometimes compost may be contaminated with undesirable components such as heavy metals which are harmful to the environment.
OPPORTUNITIES	• Presence of the municipal solid waste composting facility offers sustainable availability of the compost cheaply.
LESSON LEARNT	• Compost use should be encouraged owing to its long term beneficial attributes which improve crop productivity and the general soil health.

2.5.2 Improved Coffee and Banana Production in Kyenjojo District

Mr. David Kisembo is a renowned coffee and banana farmer from Busasa village, Bugaki sub-county in Kyenjojo district. He faced several weather related challenges that affected his coffee and banana plantations. The dry seasons had become more severe which led to withering and drying of his coffee trees and loss of vigour of the bananas. The drought also caused flower abortions and premature ripening and drying of coffee berries. The farmer received training and adopted CSA interventions which made his farm more resilient to the adverse impacts of climate change leading to increased productivity and yields of coffee and bananas.

The farmer said "I grew coffee and banana and kept livestock but faced challenges of drought during the dry seasons and hailstorms during the rainy season which destroyed my crops and caused pest and disease outbreaks". He added "I realized that the productivity of my coffee and banana plantations was steadily declining and sought assistance from Rwebitaba ZARDI and the district agriculture office. We were mobilized and trained on establishing SWC structures (digging contour bunds), mulching and application of cowdung manure in the trenches and integration of leguminous agroforestry trees like calliandra and leucaena. I also sprayed the coffee plantation with pesticides to control pests and diseases, and uprooted, chopped and buried BBW affected banana stools".

BENEFITS OF CSA INTERVENTIONS

Mr. Kisembo further narrated "within one year of adoption of the CSA interventions, banana production from my 25 acre plantation increased from 75 to 150 bunches per week and the bunch sizes more than doubled. The coffee yield from my 50 acre fairly young plantation increased from 7 to 75 bags during the second harvesting season. These yield increases are attributed to the beneficial effects of the contour bunds which harvested rain water and enabled it to percolate into the soil, mulching of the plantations which led to soil moisture retention for longer periods, and the manure poured into the trenches improved soil fertility.

Visitirs learning about improved coffee management from from Mr. Kisembo's

income from the coffee and banana sales benefitted the farmer in a number of ways. He purchased 20 more acres of land and is expanding his coffee plantation, and established a dairy cattle zero grazing unit and is selling milk to the nearby dairy. The farmer also established a tea nursery and sells the seedlings to OWC for distribution to farmers. He is planning to buy a pump and irrigate his plantations during the drought periods so that he can produce throughout the year. He also noted that his farm benefits all community members as many farmers from within and outside the sub-county regularly visit his farm to get advice on better coffee and banana management practices.

CHALLENGES	• Pest and disease incidences (coffee wilt disease in coffee and BBW in bananas) increase during the dry season. • Flower abortions and immature drying of coffee berries causing production losses. • Scarcity of manure and mulching materials and when available, they are very expensive.
OPPORTUNITIES	• Presence of other sector actors such as OWC and the DLG provides knowledge, skills and inputs which enhance the farmers capacity to improve crop productivity.

LESSON LEARNT	• Establishment of contour bunds and manure application are pivotal to sustainable coffee and banana production in Uganda

2.5.3 Climate Smart Vegetable Growing at Mobuku Irrigation and Settlement Scheme

Mobuku Irrigation and Settlement Scheme is a Government initiative established to support low income communities to earn a living through vegetable and fruit growing. The scheme was divided into a number of blocks managed by different associations each with membership of youths, women and men. The different associations grow a variety of crops, including water melon, mangoes, tomatoes, onions, kale, spinach, green pepper, hot pepper, maize and livestock rearing, among others. The scheme has a number of climate related challenges, particularly prolonged dry spells, soil degradation, pests and diseases, river bank erosion and flooding of gardens during the rainy season.

Chillies grown under CSA at Mobuku Irrigation and Settlement Scheme

Basaijakweyamba Farmers' Association is one of the community groups farming on the scheme with members specialized in growing hot pepper for export market. The association has membership of 30 households. The members received technical support from MAAIF and had their irrigation system renovated. They were trained on growing hot pepper throughout the year under irrigation to avert the effects of drought during the dry seasons. They were also taught to use fertilizers, pesticides, improved high yielding varieties and grow improved pastures. The members also dug a network of water distribution channels in their gardens with control gates to regulate the water-flow to different sections of the gardens.

BENEFITS OF CSA INTERVENTIONS

As a result of application of the above-mentioned interventions, the farmers reported increased productivity and yields of hot pepper resulting from improved soil fertility and better management practices. The network of irrigation channels enabled the crops to receive enough water during the dry season and draining away excess water during the rainy season. This enabled the crops to have adequate soil moisture which enable the farmers to grow the crop and getting sustained harvests irrespective of seasons. They got yield increases from 10 to 50 metric tons of high quality hot pepper per season for export market. This increased the incomes of members and improved their livelihoods and welfare. Members were able to pay school fees for their children on time and were able to meet hospital bills for their sick children. Some members

reportedly bought land outside the scheme and are constructing houses for their families. One member reported that he set up a shop business for his wife in Kasese town

The Association attracted a number of partners to support and enhance their farming enterprise. MAAIF provided technical support, including research, pest control, formation of cooperative and market linkages. They also provided training and some materials and equipment, including improved seed, hoes, forked hoes, wheel barrows and cold storage facilities. These strengthened capacity of the Association to produce and bulk with other associations and keep their produce for a long time awaiting transportation to Entebbe International Airport for export. Other partners like Belgian Technical Cooperation (BTC) helped with renovation of dams, irrigation and drainage channels, mechanization and capacity building of the members in irrigation technology. These partnerships have gone a long way in developing and strengthening the Association which has eventually registered as a separate entity.

CHALLENGES	• Frequent flooding during heavy rainstorms destroys gardens leading to total crop loss or low quality pepper which does not meet export market standard. • Increased disease incidences during rainy seasons requiring frequent spraying of the crops which becomes expensive to the farmers. • The long distance to the airport sometimes affects the timely delivery and quality of the produce reaching the export market.
OPPORTUNITIES	• Availability of a ready export market enables farmers to grow and sell their vegetables throughout the year. • Availability of partners in the sector enables the association members to acquire the necessary skills and equipment to enable them to implement CSA practices.
LESSON LEARNT	• Irrigation agriculture has a very high potential to adapt to climate change impacts and can enable farmers to grow and harvest produce throughout the year. • Farming for export requires an efficient value chain system which ensures timely production and delivery of high quality produce to the market.

2.5.4 Innovative Mixed Farming in Bunyangabu district

Mr. James Balinda is a prominent mixed farmer in Kibiito Town Council growing bananas, passion fruits, potatoes, coffee, vegetables and rears dairy cattle. His bananas, coffee and other crops were severely affected by unpredictable weather patterns, with prolonged dry seasons lasting up to four months and shorter and violent rainy seasons. In 2017, most sub counties of Bunyangabu district experienced a violent rainy season with intense rainstorms destroying over 5,000 gardens. Mr. Balinda was among the farmers who experienced total crop failure and lost his livestock especially goats. Reealising the magnitude of the loss he incurred, the farmer sought advice from the District Agriculture Office and Rwebitaba ZARDI. He was among the group of farmers who were trained by SLM/ MAAIF project in various improved land management practices. Following the training, he dug SWC structures, mainly contour bunds, applied manure in the trenches, mulched the banana and coffee plantation, and integrated agroforestry trees in the farming system.

Mr. Balinda said *"I used to grow crops without integrating SWC practices and got poor yields. My gardens were also losing water quickly during the dry season"*. He added *"After receiving training, I adopted the CSA technologies and since then, productivity of my gardens improved. For example, during June-August 2018 season, I sold over 400 bunches of bananas at farm price of 13,000= which gave me over 5 million"*. Mr. Blazio Businge a neighbouring coffee and banana farmer also said that he used to face climate related challenges such as drought, pests and diseases and violent rainstorms which ravaged his gardens. After digging contour bunds, applying manure and mulching the banana and coffee gardens and controlling BBW disease, his yields more than doubled.

Through the collaboration with partners including Bunyangabu DLG, ADP, OWC, Rwebitaba ZARDI and SLM project in MAAIF, the farmers received various support from the partners. For example, ADP trained them in compost making using animal wastes, banana peels and other crop residues. The project also supported group marketing by establishing a banana collection centre which improved market price and provided farmers with improved sweet potato vines. OWC provided them with improved banana suckers while Bunyagabu DLG and Rwebitaba ZARDI through ATAAS/SLM project provided the farmers with agricultural inputs and trained them in various climate resilient agricultural technologies, including digging SWC structures, mulching, manure application and agroforestry, among others.

SWC interventions in Mr. James Balinda's banana plantation

Mr. James Balinda reported that the contour bunds harvested rain water and enabled it to sink slowly into

the soil. Mulching the plantation improved soil moisture retention which reduced the drought impacts on his gardens. The manure applied in the trenches increased soil fertility, banana yield and bunch sizes while it also improved the yield and quality of coffee berries He observed that the agroforestry trees and hedgerows planted in the coffee and bananas improved soil fertility, reduced wind speed, provided firewood for his household and improved the general environment around his farm.

Mr. Blazio Businge also noted that his farm benefits his immediate family through provision of food for domestic consumption and income from banana and coffee sales which he uses to pay school fees for the children and meet other household needs. Mr. Balinda said he used the money to buy more land to expand his banana plantation and meet hospital bills and other domestic requirements. Both farmers reported improved household food security and better harmony and welfare of their family members.

CHALLENGES	• Digging contour bunds was labour intensive and costly using hired labour. • Scarcity of grass for mulching the gardens and he collects it from far away which makes it expensive. • Pests and diseases lead to drying of coffee trees and bananas affecting their yields.
OPPORTUNITIES	• Presence of other actors who advise farmers on possible CSA practices.
LESSON LEARNT	• Collaborative linkages with other actors is instrumental in building capacity of farmers to successfully manage and improve productivity of their farmlands.

2.5.5 North Rwenzori Plantation Forest in Ntoroko district

North Rwenzori Plantation is a regional tree centre established by the National Forestry Authority (NFA) to promote a tree planting and afforetation in western Uganda. The Centre covers Itojo, Karugutu and Masandana sub-counties in Ntoroko district and Kasitu and Burondo sub-counties in Bundibugyo district. The Centre was established after realizing the dwindling tree cover in western region as a result of rampant deforestation for charcoal, timber, firewood and land conversion to arming activities. This prompted NFA to set up the centre to promote Pinus caribaea, Trminalia superba and Cedrela odorata tree planting in the western districts of Ntoroko, Kabarole, Kamwenge, Bundibugyo, Kasese and beyond. The Centre also set up its own woodlots to increase tree cover and demonstrate to local communities the best practices for forest management and conservation.

The Centre received tree seeds and other support from NFA and the centre staff established and managed the nurseries until when the tree seedling were ready for transplanting. The Centre collaborates with several partners, including OWC, Rwebitaba ZARDI, the regional DLGs and Rwenzori United Farmers Association, among others. These partners provide some materials and participate in community mobilization and sensitization on best practices and benefits of collaborative forest management.

ADVERSE WEATHER IMPACTS DUE TO DEFORESTATION

- Increased temperatures.
- Prolonged dry spells.
- Unpredictable rainfall.
- Shorter and erratic rainy seasons.

The Centre established 150 hectares of Pinus caribaea, Trminalia superba and Cedrela odorata woodlots on Ngisi Block 1 to rehabilitate the degraded hilly landscape. Large contours bunds/ big trenches were dug at a spacing of about 30 metre intervals depending on the slope. Planting holes 1 ft wide and 1 ft deep were dug at a spacing of 10 ft by 10 ft followed by planting of the seedlings. Where possible, grass was maintained to provide ground cover for controlling soil erosion before tree establishment. Thinning of the seedlings was done at 6 months while pruning was carried out after one year. Crooning was done to produce fast growing and pest, disease and drought resistant seedlings. Firelines 30 ft wide were opened up to separate different woodlot sections and fire gangs were formed to guard the forest against wild fires.

CSA INTERVENTIONS UNDER WOODLOTS

- Large contour bunds - harvest water runoff preventing gully formation down the landscape.
- Large planting holes and grass cover - harvested runoff and encouraged water infiltration into the soil.
- Firelines - avoid burning of the entire plantation in case of wild fire outbreak.
- Fire gangs - urgently respond and put out any fire outbreaks.

Section of a landscape planted with pine woodlot in Ntoroko district

The Centre offers employment to local community members involved in tree nursery management and providing security to the woodlot against wild fires and encroachers. The woodlot contributes to the national tree cover, provide habitat for biodiversity and provide sinks for GHGs, contributing to reduction of atmospheric GHG concentration in the atmosphere and mitigating climate change impacts.. At maturity (15-20 years), the woodlot provides timber which gives income to the Centre and the local communities. All community members participating in collaborative forest management

(men, women and youths) benefit from the arrangement. Over 250,000 tree seedlings are distributed to more than 166 tree farming communities in Ntoroko, Kabarole, Kamwenge, Bundibugyo and Kasese districts per season.

The woodlot has significantly contributed to environment modulation by providing a conducive microclimate. Generally, there are higher chances of rainfall on the landscape planted with the woodlot than the surrounding areas. In addition, the tree roots help to bind together the soil particles creating a stable soil structure. The roots break the soil clods improving water percolation and reducing water runoff and soil erosion in the woodlot. The woodlot also provides non timber products such as honey production and the tree prunnings harvested for firewood by the neighbouring communities. Furthermore, the deep rooting system helps to capture leached plant nutrients from deep soil layers back to the top soil through leaf fall improving soil fertility and organic matter in the top soil layer.

CHALLENGES	• Torest fires which are sometimes maliciously lit destroying the trees. • Difficult to quickly climb steep slopes to extinguish fire in case of outbreak. • Pest and disease outbreaks which damage and sometimes deform the trees. • Abrupt weather change when the woodlot is harvested affecting farming activities in the surrounding areas.
OPPORTUNITIES	• Opportunity for Collaborative Forest Management. • Willingness of communities to provide land for woodlots. • Collaboration with other partners (OWC, ZARDI, regional DLGs, etc).
LESSON LEARNT	• Collaborative Forest Management ensures survival of the forest to maturity since communities have a stake and guard the woodlots against forest fires and encroachers. • Integration of SWC structures prevents land degradation, especially when the forest is still young with limited tree cover.

2.5.6 Commercial Tea Growing in Kyenjojo District

Kyenjojo district experiences unpredictable weather patterns, with prolonged dry seasons and erratic and violent rainstorms during the rainy season. The prolonged dry seasons lead to decline of soil moisture, increased pest and disease incidences and sometimes withering of crops.

On the other hand, the violent rainstorms cause intense soil erosion, flooding and silting of low lying areas, destruction of crops, death of animals, loss of property and internal displacement.

Mr. David Kisembo a prominent tea farmer from Busasa village, Bugaki sub-county had his tea plantation adversely affected by the above mentioned climate change impacts. The prolonged dry seasons caused moisture stress leading to reduction in yield and quality of tea leaves.

Mr Kisembo narrated *"The CSA interventions tremendously increased my tea production and yields. Since I adopted the better land management practices, income from my enterprise more than doubled. Due to increased tea market, I expanded the tea acreage to over 100 acres. Soil erosion has been effectively controlled in the plantation as the water is harvested by the contour bunds and allowed to sink into the soil". He added "the inorganic fertilizers applied improved soil fertility which tremendously increased yields. I have also established a commercial tea nursery and during the previous rainy season I supplied over 300,000 tea seedlings to OWC programme"*. He also observed that integrating agroforestry with conservation practices enabled him to overcome the adverse impacts of climate change as the trees act as wind breaks, provide shade and improve soil fertility.

The violent storms with hailstones during the rainy seasons caused intense soil erosion on the hill slopes and reduced the quality of tea leaves, affecting yields and income from tea sales. The farmer sought advice from Rwebitaba ZARDI and Kyenjojo District Agriculture Office and was trained in a number of CSA practices, including digging contour bunds, application of inorganic fertilizers and integration of agroforestry.

A section of Mr. Kisembo's tea plantation

He said that with improved land management, tea his yield tremendously increased which transformed his life as he is now seen as a model farmer in the district. The income from tea sales more than doubled, which enabled him to buy a truck he uses to transport the seedlings and bought more land to expand his farm. The farm offers employment to many youths in the area. He also pays school fees for his children without hassle and has made several investments in Kyenjojo town. He underscored the importance of the collaboration with Rwebitaba ZARDI and Kyenjojo DLG who provided him with skills in improved land management, and OWC programme that provided market for his tea seedlings. He noted that he regularly receives visitors from within and outside the district who come to learn about improved tea management which has made him proud of his enterprise. The tea farmers in the district formed a cooperative society and have managed to build their own tea factory (Mabale Growers Tea Factory), which provides a ready market to the

CHALLENGES	• Labour shortage causes delayed plucking of tea leaves leading to low quality tea. • Lack of a tea regulatory body for a fast growing sector with many new players. • Limited tea research and advisory services on better management practices. • Limited availability of quality tea inputs on market (such as fertilizers). • Market speculators affect tea production and marketing. • Digging SWC structures (contour bunds) in tea plantation is labour intensive and costly.
OPPORTUNITIES	• OWC offers ready market for the tea seedlings. • Establishment of a cooperative society enables members to access credit from financial institutions. • Tea factory provides members with ready market for the tea leaves.
LESSON LEARNT	• Farmers working together enables them to pool resources and invest in other income generating projects (coffee factory by the cooperative members). • Collaborative linkages with partners such as OWC, the ZARDI and the DLG enable the farmers to acquire relevant skills which improve their farming enterprise.

2.6 Lake Albert Crescent Agro Ecological Zone

Lake Albert Crescent AEZ is located in western Uganda and covers five (5) districts, namely, Hoima, Masindi, Buliisa, Kibaale and Kiryandongo. The zone covers two farming systems that is Banana, Millet, cotton system and western Banana, coffee Cattle system. The zone hosts Bulindi ZARDI, which conducts agricultural research and dissemination of appropriate technologies adaptable to the zone. The major economic activity in the zone is crop farming, with bananas, maize, cassava, millet, sorghum, beans and groundnuts as the food crops and cotton and coffee as the major cash crops. Livestock keeping is also practices to a lesser extent.

The zone experiences widespread land degradation and biodiversity loss through deforestation which is a result of encroachment, charcoal burning, tobacco curing and lack of forest law enforcement. This resulted into unpredictable weather patterns, prolonged dry seasons and land degradation, particularly soil erosion. Oil exploration in the zone

is a major economic activity, which unfortunately came along with a number of environmental challenges, including biodiversity loss, land degradation and contamination of the environment from poor disposal of oil byproducts. All these contribute to the adverse impacts of climate change experienced in the zone.

2.6.1 Promoting Improved Cassava Varieties in Hoima District

Cassava is one of the major food and cash crops grown in the zone. Traditionally, farmers were growing local cassava varieties which yielded poorly and susceptible to diseases, especially cassava mosaic disease. The cassava would also rot in the field before maturity forcing farmers to sell their crop cheaply in order to avoid total loss in the field.
To address this challenge, Bulindi ZARDI multiplied and distributed to demonstration farmers in Bulindi sub-county improved cassava variety which is early maturing and drought and disease resistant.

CSA INTERVENTIONS UNDER WOODLOTS

- Improved drought tolerant, pest and disease resistant, early maturing, high yielding varieties.
- Digging contour bunds for SWC.
- Agronomic practices.

The demonstration farmers were also provided with extension services which included digging contour bunds for soil and water conservation and appropriate agronomic practices.

An improved cassava demo garden in Hoima district

The improved varieties yielded cassava which is not bitter and lasts long in the garden after maturity, unlike the local varieties which used to rot before maturity. Improved cassava varieties were found to be highly adaptive and improved on productivity and incomes of farmers.
A demonstration farmer from Bulindi suc-county reaped a number of benefits from cassava growing. The resistance of the improved cassava to drought and diseases enabled him to get high yields which were translated into increased income from sale of the produce. In addition, the attribute of cassava staying in the garden for long after maturity without rotting enabled the farmer to harvest at peak demand and sell the crop at high price enabling him to earn better income. Sometimes the farmer sun-dried the cassava, stored it and later added value by making cassava flour which he sold at higher prices during times of high demand. The demonstration farmer also got income from sale of planting materials after harvesting the crop. He boasted of the multiple income sources from growing a single crop.

CHALLENGES	• Intensive labour to add value to cassava (peeling, splitting and drying the cassava in the sun everyday). • Disease attach on cassava (mosaic and brown streak diseases)
OPPORTUNITIES	• Availability of relevant actors (Bulindi ZARDI and Masindi DLG) enabled the farmer to acquire the right cassava variety.
LESSON LEARNT	• Case underscores the importance of selecting the right crop varieties that are adaptive to the impacts of climate change

2.6.2 Climate Resilient Ochard: A Case of Biizi Multiple Farm in Masindi District

Biizi Multiple Farm is on a 15 acre piece of land located in Biizi village, Nyangaya Division, Masindi municipality. The farm was started by Mr. John Winter Bagada in 2011 as an alternative income generating activity after realizing that the soils and climate of the area could not adequately support growing of annual crops. The climate of the area consists of unpredictable weather patterns, with extended dry spells while the rainy seasons have violent thunderstorms which cause land degradation through soil erosion. The farm grows improved mango varieties that are resistant to pest and diseases. The mangoes were planted at a spacing of 8.m by 8 m and various CSA technologies integrated.

The contour bunds harvested and conserved soil moisture improving resilience of the mangoes to the prolonged dry spells. The manure poured in the trenches improved soil fertility and the mulching improved water conservation in the soil. These interventions increased mango production which made the farm to start a fruit processing cottage industry that packs mango juice trading as Eden Juice. The juice is sold to shops and supermarkets in nearby urban centres such as Masindi, Hoima and other neighbouring towns. The cottage industry has tremendously improved the income of the proprietor, who is now a renowned entrepreneur in the region. He has set up a number of other businesses and constructed buildings in the neighbouring towns.

CSA TECHNOLOGIES APPLIED

- Contour bunds (20 m intervals) - for soil and water conservation.
- Cowdung manure – soil fertility improvement.
- Mulching garden for SWC.
- Prunning – Removal of ecess branches
- Spray with pesticides (or use pheromones) – Control pests and diseases

A mango orchard planted by Biizi Multiple Farm

The mango tree prunnings provide firewood for the factory which reduces dependency on natural vegetation and deforestation that endangers the environment. The mango trees contribute to absorption of GHGs from the atmosphere thereby mitigating on carbon dioxide concentration in the atmosphere. In addition, the mango trees improve the local climate and the decaying leaf-fall provides mulch that improves soil fertility. Farmers from within and neighbouring villages adopted mango growing and are selling their harvests to a ready market at the cottage industry.

CHALLENGES	• High cost of digging SWC structures. • Limited knowledge and management of improved mango cultivars. • Poor quality of fruits from out grower farmers resulting from pest and disease damage.
OPPORTUNITIES	• Availability of the cottage industry which provides a ready market for the mangoes.
LESSON LEARNT	• Value addition to the mangoes by the cottage industry improves the market value and profitability of the enterprise for the farmers. • The factory provided a ready market for the produce, which interested other farmers to adopt the same enterprise.

2.6.3 Integrated Soil and Water Conservation in Panyandoli Camp, Kiryandongo District

Panyandoli Resettlement Camp is located in Bweyale Town Council, Kiryandongo district. The camp was set up in 2010 for resettlement of Internally Displaced Persons (IDPs) from over 600 households in Bududa district in Eastern Uganda. The camp is located in the central cattle corridor and experiences unpredictable weather patterns, with prolonged droughts and shortened rainy seasons. The resettled people are mainly crop farmers growing maize, beans, groundnuts, vegetables and sorghum. Each household was given only one hectare (2.5 acres) of land which limited their farming activities.

The camp was previously occupied by refugees who left the area severely degraded, depleted of vegetation cover

CSA TECHNOLOGIES APPLIED

- Digging contour bunds (fanya chiini and fanya ju) for soil and water conservation.
- Planting elephant grass bunds for soil erosion

and developed hard pans which adversely affected its productivity making it unsuitable for agriculture. Therefore, farming on these soils resulted into low crop yields leading to food insecurity, hunger, and extreme poverty among the resettled communities.

control.
- PPBs for water harvesting and conservation.
- Fertilizers or manure for soil fertility improvement.
- Mulching garden for SWC.
- Proper agronomic practices.
- Integrated pest and disease management.

Realising this challenge, the camp was identified by the MAAIF-SLM project and the District Agriculture Office as a land degradation hotspot which required urgent rehabilitation to enable the IDPs achieve food security and live decent livelihoods. The SLM project and the sub county agriculture extension officer trained the IDPs on rehabilitation of the degraded lands and improved farming practices. The farmers established maize and beans demonstration gardens under SLM and CA practices that addressed the impacts of climate change.

Farmers digging PPPBs for maize growing; and farmers planting napier grass to stabilize the soil bunds

As a result of application of the improved land management practices, the farmers achieved tremendous yield increases. The contour bunds and grass bunds controlled soil erosion in the gardens while the PPBs harvested and conserved rain water in the rooting zone and broke the hard pans. Mulching of the gardens improved the soil's water holding capacity and reduced moisture evaporation from the garden, while the fertilizers applied in the planting basins improved soil fertility around the rooting zone. These interventions improved the crop's resilience to the prolonged dry spells, increased yields sustainably. The maize yield increased from average of 0.25 t/ha before to 3.75 to 5 t/ha after adoption of the CSA practices.

A maize demo garden established by farmers in Panyandoli IDP camp

The increased yields improved food and nutrition security and incomes of the farmers leading to better livelihoods. The IDPs who had resorted to working in the neighbouring ranches to earn a living returned to their land holdings after realizing that the CSA interventions led to better crop yields. The farmers were mobilized and formed a SACCO under which they bulk and sell their harvest at a better price. One of the farmers pointed out that he is now able to take his children to school without much stress and is planning to open up a shop in Bweyale trading centre.

CHALLENGES	• Intensive labour required to dig the PPBs and the contour bunds. • Limited availability of crop residues for mulching. • Lack of access to credit. • Difficulty in getting genuine farm inputs.
OPPORTUNITIES	• Availability of collaborating actors such as Bulindi ZARDI and Masindi DLG enabled the farmers to acquire CSA knowledge and skills as well as inputs for CA.
LESSON LEARNT	• Improving soil fertility and conserving water in the soil are pivotal to improving and sustaining yields and incomes of farmers. • When farmers have no alternative, they will find a way to make the best use of the locally available materials to sustain their livelihoods.

2.7 Eastern Highlands Agro Ecological Zone

The Eastern Highlands AEZ comprises of two sub regions, namely, Bugisu sub region (Mt. Elgon highlands) and the mainly lowlands of Busoga sub region. The zone hosts Buginyanya ZARDI. The Mt. Elgon highlands are characterized by a fragile ecosystem with steep slopes and rocky terrain which require sustainable management and conservation. The major crops produced in the highlands sub region include Arabic coffee, bananas, irish potatoes, fruits and vegetables. On the other hand, Busoga sub-region mainly produces maize, sweet potatoes, cassava, fruits, sugar cane, rice, sorghum and millet.

Owing to encroachment of the highlands with unsustainable farming practices (such as rampant deforestation and depletion of vegetation cover) and continuous cultivation of lowlands, a number of climate related challenges have

affected the zone. These include intense soil erosion, landslides, flooding, loss of soil fertility, busting of river banks, and destruction of roads and bridges. These have resulted into crop and animal losses, food and nutrition insecurity, death of humans and animals, as well as internal displacement and migrations of the local communities.

2.7.1 Conservation Farming in Namutumba District

Alibawo Nalibona Cooperative Society is located in Bulange Sub County, Namutumba district. The cooperative started in 2004 with membership of 30 farmers. The farmers were growing maize, beans and groundnuts, but getting low crop yields as a result of poor soil fertility coupled with the impacts of prolonged droughts that are common in the district. The members were mobilized by MAAIF and Namutumba DLG to start farming using CA practices. The group received training and established demonstration gardens to equip farmers with CA practical knowledge and skills.

The use of PPBs and riplines increased resilience of the crop to the adverse weather conditions, particularly the prolonged droughts. The basins and riplines harvested and stored soil moisture for long periods. The fertilizer or manure added in proximity of the plant roots in the basins/ riplines was efficiently utilized which improved crop production and yields. The farmers planted early at the onset of the rainy season and benefitted from the early rains. They also harvested early and benefited from the high prices for their produce during off season. The farmers boasted of tremendous yield increases of up to 100% compared to what they were getting previously, which increased their household incomes and improved their livelihoods.

Youth digging PPBs preparing to plant maize under Conservation Agriculture

The farmers adopted CA using the PPBs and Riplines. Land preparation was done by slashing followed by digging the basins or making riplines using the ox ploughs. The basins were 35 cm long, 15 cm deep and width the size of the hoe. The spacing between basins in a row was 35 cm wand the distance between rows 75 cm. The riplines were also 75 cm apart and i5 cm deep. The farmers also dug contour bunds across the garden at a spacing of 15-29meters for SWC.

After digging the basins, they were half way back-filled with top soil and DAP fertilizer (or a handful of manure) evenly poured into each basin and fully covered with soil. A stick was used to prick planting holes into the basins. Each basin was planted with 3 maize seeds or 6-8 bean or groundnut seeds. The seeds were loosely covered with soil and the whole garden sprayed with a herbicide to kill off all the grass. After seed germination, the entire garden was mulched with maize stover or grass. Weeding was done by spraying the garden with herbicides and use of the hoe was avoided to minimize soil disturbance.

A cost benefit analysis of maize grown under CA from Namutumba district was done (see Annex I) and results showed more than doubling of maize grain yields. Similar yields was achieved by members of Alibawo Nalibona Cooperative Society, who in addition to minimum tillage practices, used improved high yielding seed varieties and integrated agroforestry. As a result, food production, household income and food security amongst participating households improved. The continuous application of fertilizers or manures within the basins or riplines improved soil fertility over time and the rotting mulching materials improved soil organic matter leading to overall improvement in soil productivity and crop production.

A farmer from Bulange sub county, Namutumba district infront of his CA maize garden

CHALLENGES	• Lack of CSA extension services. • Limited availability of mulching materials. • Initial intensive labour required to dig the basins. • Low farm gate prices for their produce during the harvesting season.
OPPORTUNITIES	• Availability of collaborating institutions enabled the cooperative members to acquired CSA skills.
LESSON LEARNT	• Early land preparation during the dry season enables exploitation of idle labour. • Continuous application of CA builds-up soil fertility over time and restores agricultural production in the long run.

2.7.2 Enhancing orange production using Conservation Agriculture in Kamuli District

Balimi Network for Developing Enterprises in Rural Agriculture 2000 (BANDERA 2000) is a community based organization (CBO) based in Nalimawa village, Nawanyago Sub County in Kamuli district. The group members were previously farming individually and affected by a host of challenges related to climate change in the district. They were producing oranges but the fruits were tiny and affected by yellow spots due to prolonged dry spells and pest attack in the field. They also grew bananas, coffee, maize and beans on a smaller scale. The farmers were mobilized by MAAIF and trained in various CSA practices, and formed the group in 1995.

The climate related challenges affecting the farmers were low soil fertility and unpredictable weather conditions in the district. The rainy seasons had become shorter and irregular while the dry seasons were getting longer and more severe, leading to severe soil moisture stress and withering of crops. The group members established a model orange orchard at Mrs. Betty Tigawalana's farm where other members came to learn about improved orange production using CSA practices.

CSA INTERVENTIONS PRACTICED

- Minimum tillage.
- Contour bunds and the L-bridge.
- Mulching the garden.
- Sometimes planting legume cover crops.
- Planting agroforestry and indigenous trees.
- Zero grazing dairy cattle.
- Water harvesting (tarpaulin-lined underground tank).and small scale irrigation.
- Biogas system.

The minimum tillage practices reduced soil disturbance (turning and churning) which minimized soil moisture loss. The L-bridge harvested roadside rain-water runoff diverting it into the garden and enabling it to infiltrate into the soil. The contour bunds harvested runoff water minimizing soil erosion and encouraging water infiltration into the soil. Mulching of the garden avoided direct sunshine on the soil surface improving water conservation and increasing soil fertility on rotting. The legume intercrops provided soil cover and nitrogen fixation improving soil fertility. The integration of zero grazing animals and biogas production provided manure which was poured in the trenches for spoil fertility improvement and environment conservation by avoiding GHG emissions from manure. The indigenous trees were important for environmental protection.

Sustainable orange production, agroforestry and biogas system by Bandera 2000 group

The above CSA interventions increased the quantity of fruit harvests and improved on the quality of the fruits. The ochard became resilient to the adverse impacts of climate change as it produced very juicy fruits, with three oranges filling up a glass when squizzed. Productivity of the ochard increased, the premature ripening and falling of fruits was minimized and most of the oranges were harvested. This improved and stabilized the household income and food and nutrition security of the demo farmer. The farmer confessed that with the income from oranges, she is able to pay school fees for her children without difficulty and has set up a business in Nawanyaago town using the income from her oranges.

CHALLENGES	• High temperatures during the drought periods. • Limited CSA extension support. • Scarcity of mulching materials. • Lack of a ready market for the oranges. • High cost of pesticides for pest control.
OPPORTUNITIES	• Presence of collaborative partners (MAAIF and Kamuli DLG) enabled BANDERA 2000 members to acquire knowledge and some implements that enabled the group to successfully improve productivity of the orange orchard.
LESSON LEARNT	• Orange farming is a profitable enterprise provided that management practices that improve soil fertility, moisture retention and pest and disease control are adopted.

2.8 West Nilre Sub-Agro Ecological Zone

West Nile is a sub-region under the Northern Uganda AEZ that stretches from Acholi and Bunyoro sub-regions to the borders of the Democratic Republic of Congo and South Sudan. It includes nine districts of Adjumani, Arua, Koboko. Maracha, Moyo, Nebbi, Pachwach, Yumbe and Zombo. Agriculture is one of the major economic activities with mixed cropping as a common practice. The major crops grown include cassava, beans, groundnuts, sweet potatoes, sesame, tobacco, sorghum, rice, maize, soya beans and finger millet. In addition, apiary and livestock are important enterprises though the latter is limited by tsetse fly infestation.

The sub-ergion is seriously affected by unpredictable climate related challenges, with short and erratic rainy seasons and prolonged dry spells. These have contribute to increased pest and disease incidences, thunderstorms, frequent floods along River Nile banks, prolonged droughts, and mid rainy season dry spells. However the local authorities recently initiated a number of initiatives to mitigate climate change, which include developing and enforcing deterrent ordinances; investing in alternative income sources; awareness creation and sensitization on environmental stewardship; establishment of tree nursery beds for promotion of tree planting and demarcation of wetland boundaries.

2.8.1 Innovative Soil and Water Conservation in ADRA Village, Nebbi District

The Adventist Development and Relief Agency (ADRA) established a model village in the highlands of Erussi sub-county, Nebbi district. This village was established to address climate related challenges which negatively affect crop production and livelihoods of the local farming communities, especially women and youths. The challenges include intense water runoff down the hill-slopes causing soil erosion and formation of gullies, soil degradation and siltation of wetlands and other water bodies. This negatively impacted farming leading to poor crop yields, food and nutrition insecurity, famine and poor livelihoods.

ADRA hired youths from the community to dig the large contour bunds on hill slopes while women dug contour bunds in the gardens. They thereafter dug planting basins 35cm long, 15 cm wide and 15 cm deep. The spacing between the basins in a row was 35cm and that between rows 75cm. After completion of the entire garden, the basins were halfway backfilled with top soil and one soda bottle top of DAP or a handful of manure spread evenly in each basin. The basins were then fully covered with soil. A stick was used to prick three holes for planting maize or 6-8 seeds of beans planted per basin and loosely covered with soil. The entire garden was then sprayed with a herbicide to kill off all the grass and germination, the garden was well mulched with grass. At knee height the maize was top dressed with urea and weeding was done using herbicides or loosely with a hoe.

A remarkable number of women embraced and adopted the demonstrated interventions as they witnessed a remarkable increase in maize and beans yields. They also reported a significant reduction in soil erosion down the hills and improved water retention in the contour bunds. The PPBs also harvested and stored rain water in the rooting zone.

CSA INTERVENTIONS

- Digging contour bunds
- Agroforestry
- Conservation farming using PPBs
- Fertilizer application
- Integrated pest management
- Large contour bunds on hill-slopes to trap the intense runoff and enable the water sink into the soil.

A section of the degraded ADRA landscape being rehabilitated by the community (left); and a well managed maize garden under CA grown in the same area (right)

The fertilizer added increased soil fertility and the mulching improved water retention in the soil, which increased resilience of the crops to the extended dry spells. This increased the productivity and yields, which ultimately improved food security, household incomes and livelihoods of the farming communities. Some farmers reported having invested the income in other enterprises. One farmer bought a plot and is constructing a residential house. Another farmer reported to have set up a shop in the nearby trading centre out of the income from maize sales.

CHALLENGES	• Limited availability of CSA advisory services, • Intensive labour required to dig the basins. • Unreliable market for the produce in the nearby trading centre. • Lack of access to improved seeds which are not easily available in the nearby trading centres. • Lack of access to credit since they do not have collateral.
OPPORTUNITIES	• Integration
LESSON LEARNT	• Contour bunds and planting basins halt soil erosion and improve resilience of the crops to the adverse impacts of climate change.

2.8.2 Development of Climate Resilient Commercial Aquaculture in Arua District

Ecomungusi Fish Farming Project is located in Manibe, one of the sub-counties worst affected by unpredictable weather patterns in Arua district. The sub county experiences prolonged dry spells and short rainy seasons affecting productivity of most farming enterprises, including fish farming. During the dry seasons, the fish pond water temperature increases while during the rainy season, the temperature decreases impacting negatively on fish productivity.

In order to minimize the impacts of adverse weather patterns on fish farming, the farmer planted improved fruit trees (Apple mangoes) alongside the fish ponds to expand the water catchment by the trees providing shade around the fish ponds. The farmer was extensively trained in aquaculture by Abi- ZARDI and Makerere University aquaculture technical team. The farm produces highly nutritious fish locally called Angara which is a very good source of protein and is recommended for lactating mothers and infants.

Planting fruit trees on the fish farm enhances mitigation and adaptation of fish to the climate change impacts in the area. The mango trees play a positive role of recharging aquifers within the vicinity of the fish ponds thereby maintaining uniform water levels in the fish ponds. The trees also provide shade moderating temperature and reducing water evaporation thereby creating a conducive environment around the fish ponds, particularly during the dry season. The grass planted around the fish ponds traps any soil that would be transported by water into the fish ponds minimising water turbidity and siltation of the ponds.

Some of the fish ponds for Ecomungusi Fish Farming Project in Arua District

As a result of the above climate smart interventions, the fish ponds maintain relatively uniform water levels and temperature throughout the year. The water in the ponds is also clear since the soil that would be transported by runoff water into the ponds is trapped by the grass. The trees provide shade which modulates the scotching temperatures during dry seasons As a result, there is increased production and yield of the Angara fish. The farmer is training other fish farmers in the region earning an additional income. Furthermore, the mangoes harvested provide alternative source of livelihood at the times when fish is not yet mature.

CHALLENGES	• The seasonal temperature fluctuations in the fish ponds negatively impacts on the productivity of the fish ponds as the fish take long to mature and the fish sizes remain small leading to reduced fish production • High cost of fish feeds
OPPORTUNITIES	• Availability of a ready fish market in Arua town.
LESSON LEARNT	• Successful fish farming requires maintenance of uniform pond water temperature throughout the year to avoid productivity losses due to temperature fluctuations in the ponds

2.8.3 Climate Resilient Apiary-Agroforestry Integration in Pakwach District

Pakwach district is located in the low lying plains of northwestern Uganda on the western side of Lake Kyoga. A significant part of the district lies within the Albert Nile basin. The district is prone to the adverse impacts of climate change, with short and erratic rainy seasons and long dry seasons. This is partly attributed to the rampant deforestation that has taken place in the district during the previous decade. The trees were mainly cut for timber, charcoal, firewood, brick burning and opening up fertile virgin land for agriculture.

Realising the adverse impacts of climate change on their livelihoods, the local communities decided to take urgent action to revegetate their landscapes by conserving the natural vegetation and planting agroforestry trees to reverse the glaring land degradation in the area. Pakwach sub-county being in a basin has its leeward side lying in a rain shadow receiving very little rainfall and is dry most of the time.

A farmer from Pakwach district inspecting the community bee hives

The farmers established a community tree nursery and hired a few community members to manage the nursery. The community divided themselves into groups and dug

contour bunds across the hills slopes to halt the runoff and control soil erosion. They also planted grass bunds along the contours to trap soil being washed down the slopes. The farmers planted extensive areas with agroforestry trees and conserved the remnants of the natural tree species. When the trees started flowering, the community integrated apiary as a way of diversifying their income sources, providing pollinating bees and improving natural resource management.

A bee hive strategically sited to enhance conservation of the indigenous natural Vegetation

The community has registered a string of benefits from tree planting. The general environment has improved as the area is getting more rainfall than it used to have previously. Soil erosion along the hill slopes has been halted by the contour bunds that were dug on the hill slopes. In addition, the bees help to effectively pollinate the mangoes making them yield highly making the farmers reap a lot of income from sale of mangoes, honey and other bee products. There is also improved nutrition among the communities as they consume the fruits and bee products. Furthermore, the owners of the plantation trees will also soon start reaping income from The natives have greatly appreciated the value of tree planting owing to a diversity of benefits accrued. The community has agreed and is implementing a "you cut one tree, you plant ten of them" as a way of promoting environment conservation within the community.

CHALLENGES	• Transportation of the tree seedlings up the hills and digging planting holes on the rocky terrain were very labour intensive. • Transportation of harvested fruits down the hill without damage was labourious. • Stealing of mangoes from the plantations by youths is rampant. They throw stones at the mango trees dropping raw mangoes causing income loss to the farmers.
OPPORTUNITIES	• Integration of bees increased mango yield and income to the farmers
LESSON LEARNT	• Integrating tree planting with other enterprises is very beneficial as it brings a variety of benefits including economic, environmental and nutritional, all of which contribute to the livelihoods and well being of communities.

2.8.4 Improved Cassava Production in Pakwach District

Mr. Geoffrey Andama is a progressive cassava farmer from Amisi village, Vurra sub-county, Pakwach district in West Nile sub region. The farmer was growing cassava but his production was severely affected by the unpredictable weather, especially shortened rainy seasons and prolonged dry spells. This was compounded by the increased disease incidences especially cassava brown streak and cassava mosaic.

To address these challenges, NARO/ AbiZARDI in collaboration with Pakwach DLG established improved cassava demonstration and multiplication plots on selected farmers gardens. Mr. Andama was selected as one of the participating farmers and he established a 30 m by 40 m demo garden in 2017a season. The demo garden was managed by the farmer with supervision of sub-county agriculture extension officer. The farmer planted NAROCAS1, NAROCAS2 and NACE19 cassava varieties. He dug fanya chini and fanya ju contour bunds and water drainage channels, and planted lemon grass on the heaped soil forming grass bunds.

Mr. Andama narrated *"…. the CSA practices I applied on my garden tremendously improved my cassava production. The knowledge and advisory services I acquired from the ZARDI scientist and the sub-county agriculture extension officer enabled me to put in place effective soil and water conservation interventions".* He added that *"the contour bunds harvested and conserved water in the soil and prevented soil erosion in the garden. The grass bunds halted soil erosion, prevented silting of the garden and the repellants kept away cassava mosaic disease carrying vectors. The timely implementation of agronomic practices such as timely planting and weeding also improved the cassava productivity. The improved varieties were tolerant to drought, resistant to pest and diseases and high yielding, which increased my cassava production and yields".*

The income from the tuber and stem sales encouraged the farmer to start commercial cassava growing. Mr.Andama expanded his cassava garden to 6 acres out of which he harvests 30 to 40 bags of cassava tubers per acre.

Improved cassava demo garden established by NARO in Vurra sub-county, Pakwach district

This improved his household food security and increased income from his farming enterprise. He acquired a milling machine in 2019 and is buying and milling cassava into flour which he sells at a higher price.

The farmer supplies both raw cassava and the flour to schools and traders in the nearby urban centres, with a 100kg bag selling at 70,000/=. He is also in advanced stages of establishing business linkages with Nile Breweries so that he supplies the factory with cassava flour used in brewing. The farmer also sells cassava stems to other farmers through OWC, earning even more money than that from cassava flour. During the previous season,

the farmers bulked their cut cassava stems and sold through OWC 4,800 bags at 45,000 per bag. The farmer also has constructed a rental building in Ongivu peri urban setting and earning additional income.

CHALLENGES	• Fluctuations in price. • Water logging and siltation of cassava gardens in low lying areas during rain seasons. • Attack on the garden by stray animals (domestic and wild) and unemployed youths who steal cassava.
OPPORTUNITIES	• The crop is easy to grow and not labour intensive to manage. • There is a ready market for the stems under OWC as planting materials. • Cassava, as a staple crop in the district has ready market locally. It can be consumed in many forms (cassava posho, cassava porridge, fried cassava, and cassava chips). • Cassava has a variety of other uses including raw material for the brewing industry, making local potent brew (enguli) and as a source of starch.
LESSON LEARNT	• Although farmers look at cassava as a food crop, it has a big potential for income generation. Its production is cheap, easy to manage and has a ready market as it can be put to a variety of uses.

2.9 North Eastern Semi Arid Agro Ecological Zone

The Zone is located in Northeastern Uganda and covers eight districts in the Teso sub region and seven in the Karamoja sub region. The zone hosts Nabuin ZARDI, which generates and disseminates appropriate crop varieties and livestock breeds, and offers advisory services on climate resilient technologies suitable for the zone. The zone is segregated into three farming systems, namely, pastoral, agropastoral and crop production systems. The main economic activity for the pastoral system is keeping indigenous livestock, with transhumance as a common practice during drought periods in search of water and pastures. The agropastoral system involves both crop and livestock farming while the crop farming system predominantly involves crop production.

Karamoja sub region lies in the semi arid part of the country and is severely affected by the impacts of climate change and variability. The sub region experiences prolonged droughts, high temperatures, unreliable rains, flush floods, intense soil erosion and dust storms. This has leads to severe land degradation, food insecurity, famine, malnutrition, and extreme

poverty. Teso sub region also experiences prolonged dry spells, moderately high temperatures and frequent flooding during the rainy season, partly as a result of runoff water from Karamoja sub region. Other climate related challenges include vegetation loss due to tree cutting and bush burning; soil erosion; overgrazing; and limited water for both domestic use and production.

2.9.1 Climate Smart Citrus Production in Serere District

Olupe Fruit Growers Association is a farmers group located in Olupe parish in Serere district. The association is involved in growing citrus fruits which are sold to Soroti Fruit Factory located in Soroti district. One of the association members, Mr. Robert Ogaro owns a 10 acre citrus farm which he planted 10 years ago. The farm performs its own budding of seedlings to avoid importing diseases from citrus nurseries outside the farm.

The farm experiences climate related challenges especially the 2017 drought that lasted for more than 6 months. The drought caused serious water stress causing withering of the citrus trees, premature ripening and dropping of fruits and flower abortions. This was followed by a violent rainy season that caused intense soil erosion and flooding of low lying areas. These extreme weather events were accompanied by serious outbreak of citrus pests and diseases such as fruit flies, leaf spot, gummosis, and sweet orange scab which led to reduced fruit quality and fruit and flower abortions. In addition, the poor soil fertility of the farm led to poor fruit quality. The farmer was supported by the Otuke DLG and CARE to integrate CSA technologies which increased productivity of the orchard.

CSA INTERVENTIONS

- Contour bunds dug – water harvesting and SWC.
- Mulching - moisture conservation around the trees.
- Soya bean cover crop – SWC in rest of garden
- Pesticides - spray pests
- Proper spacing 3m x3m.
- Foliar fertilizers – improve crop productivity
- Rain water harvesting – harvest water for irrigation
- Irrigation – Avail soil moisture during dry season.

Mr. Robert Ogaro's citrus plantation in Serere

The CSA interventions have benefitted the farmer in a number of ways. The contour bunds helped with water harvesting and infiltration into the soil. Mulching around the citrus trees minimized moisture evaporation and improved water conservation in the soil around the citrus trees. The soya bean intercrop provided soil cover which increased soil moisture conservation and improved soil fertility through biological nitrogen fixation. These interventions tremendously increased

citrus production and yields. The farmer benefitted from the increased income from the sale of citrus fruits to Soroti fruit factory, which has enabled him to make other investments like setting up business in Soroti town. The citrus trees also play a key role in environment management, including climate modulation and absorbing GHGs from the atmosphere contributing to of climate change mitigation.

CHALLENGES	• Seasonal flooding during the rainy season which sometimes leads to drying of citrus trees due to lack of air in the soil. • Plantation is sometimes affected with pest and disease attacks affecting quality of the oranges.
OPPORTUNITIES	• Presence of Soroti Fruit Factory which provides a ready market for the oranges.
LESSON LEARNT	• Where there is a ready market for the produce, farmers will make all the effort to improve productivity of their farming enterprises in order to earn income from the available market.

CHALLENGES AFFECTING CLIMATE SMART AGRICULTURE IN UGANDA

- Limited access to and utilization of climate information by farmers: Utilization of climate information is known to considerably improve agricultural management and livelihoods for farmers, and is therefore crucial for effective implementation of CSA interventions. However, utilization of climate information by farmers has been limited bythe lack of packages responding to their information needs and limited capacity to access and utilize ICT to benefit from a wide range of climate information sources.

- Limited climate advisory services: Strengthened climate advisory services are required to provide support to farmers on how to respond appropriately and cope with the changing climate conditions. Extension workers and farmers organization lack adquate information, knowledge and tools (packages) on CSA technologies, practices and approaches needed.

- Low coverage of Agricultural financial services – The high cost of CSA inputs, technology equipment and services coppled with the weak economic base of the majority smallholder farmers and the increasing climate risk call for financial services to scale up adoption of CSA. Financial organisations providing agricultural credit services for inputs,equipment and services have a low coverage especially in rural agricultural areas and offer credit at high interest rates not conducive for agricultural borrowing.

- Low coverage of Agricultural Insurance Services – One of the CSA strategies to mitigate involves risks and uncertainties in agriculture is Agricultural Insurance. The study, however, observed that agricultural insurance services were not available leaving farmers liable to loss and damage due to climate change.

- Limited marketing infrastructure – Farmers especially in rural areas receive low prices for produce due to the poor storage and transportation infrastructure and lack of access to markets and marketing information. The study found that most farmers stored and marketed produce individually through middlemen. There were few organized group/cooperative with bulking and transportation facilities to access good markets.

- Limited scope of application for CSA – The majority of actors promoting and practicing CSA have focused their application of CSA on field production practices rather than covering the entire value chain including (pre-production planning, production, post harvest handling, storage, value addition and marketing).

- Limited access to CSA extension services - Government and Non- Governmental Extension service providers are rarely accessible to farming communities and are inadquately equiped to extend CSA related advisory services. The study found few dedicated and knowledgable extension service personnel providing CSA Advisory services to farmers.

- Gender disparities – Land and resource ownership and controlsystems in rural agricultural communities do not favour women and youths hence limiting their access land, inputs, skills and credit needed for adoption of CSA practices and technologies as well as shared benefits. Many of the agricultural extension initiatives have not integrated measures to increase gender equity in participation, access to inputs, financial services and skills and benefit sharing between female and male as well as youth and adult actors.

- Limited collaboration of CSA actors at various levels – Effective CSA implementation requires a multi-displinary and integrated approach at all levels. The existing National collaborative arrangement between line ministries and other stakeholders in climate change and agriculture "the CSA National Taskforce" was found to be limited and requiring capacity strengthening. Similar CSA platforms exist in some districts but are dependent on projects for support, These CSA platforms are not institutionalized.

- Change of mindset of farming communities – The majority of farmers are so much used to the traditional farming practices to the extent that it is difficult to change their mind set to climate resilient agricultural production systems. They view CSA interventions as externally driven additional burden which is costly and can be done away with in their traditional farming systems.

LESSONS LEARNT FROM CSA IMPLEMENTATION IN UGANDA

(i) Inter-institutional collaboration and building effective partnerships between various actors, (farmers, Government ministries, local governments, CSOs, private sector and academia) greatly enhance adoption and upscaling of CSA interventions. The different partners bring a wealth of knowledge and resources which improve the farmers' capacity to implement CSA interventions.

(ii) Farmer access to climate and weather information can greatly facilitate informed decision making regarding CSA production. Provision of real time climate and weather forecasts in simple and easily understood formats will enable farmers to use the information to make rational farming decisions.

(iii) Local farming communities and other CSA actors are aware of climate change impacts on agriculture but the complexity and associated cost of mitigation and adaptation interventions is impeding sustainable adoption of CSA. The initial high cost of CSA technologies is prohibitive to its adoption by the majority of small scale farmers.

(iv) There are few scattered CSA initiatives which are planned and implemented on a piece meal basis. Effective CSA adoption and upscaling can only take root with a well planned multisector national CSA programme that involves all key actors at the national, sub national and community levels.

(v) Successful implementation of CSA can only be achieved through its integration into the value chain development of agricultural commodities including value addition and establishing market linkages for better prices.

(vi) Farmer access to agricultural credit and other financial services greatly enhances adoption of CSA initiatives. Access to credit reduces the burden of the farmers to access financial resources to procure the necessary agricultural inputs.

(vii) Women and youths are the majority of small scale farmers, but their involvement in CSA initiatives is limited by lack of tenure security over their farmlands. Therefore, building capacity and strengthening their tenure security is critical to the successful implementation of CSA programmes.

(viii) Strong farmer organizations can easily promote and sustain CSA initiatives. Group members can pool labour and resources to achieve certain outputs, and can bulk their produce to have a stronger bargaining power for better prices.

(ix) Large scale national level promotion and adoption o f CSA is the best way to salvage agriculture from the vulnerabilities of the sector to the adverse impacts of climate change in Uganda.

(x) Water for production increases farm production especially for the quick maturing crops-vegetables. However, the irrigation technologies are expensive for the rural small-scale farmers requiring subsidies from government and development partners.

OPPORTUNITIES TO ENHANCE CSA IMPLEMENTATION IN UGANDA

These SDGs offer opportunities to acquire resources from global initiatives to promote actions to combat climate change and land degradation, including promoting CSA initiatives. Sustainable Development Goal (SDG) 13 calls on Governments to take urgent action to combat climate change and its impacts; while SDG 15.3 "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world".

At the regional level, there is the Africa Climate Smart Agriculture Alliance (ACSAA), an initiative to scale-up CSA in order to benefit small-scale producers and contribute to the overall goal of ending hunger by 2025. The Comprehensive African Agriculture Development Programme (CAADP) encourages partner states to extend the area under and reliable water control systems, and contribute to addressing the impacts of climate change on agriculture.

At the national level, Government put in place a number of policies and plans in support of CSA development and implementation. The National Climate Change Policy (2015), the National Agriculture Policy (2013), the NAPA, the NAP Agr, the ASSP (2015/16 – 2019/20) and the USIF-SLM (2018-2030) all identify climate change as a key challenge impacting negatively on agriculture development and have explicitly elaborated coping strategies, including promoting CSA interventions.

Government also prepared a National CSA Programme outlining its vision and objectives. The programme also presents the result areas, components, outputs and priority action areas for promoting CSA in Uganda. Some components of the programme are already being implemented in eastern Uganda and the lessons learnt will be used to upscale CSA countrywide.

A number of institutions including government ministries, departments and agencies (MDAs), NGOs, CBOs, the private sector, faith based organizations and individual farmers are promoting different CSA technologies in different parts of the country. These provide a foundation for large-scale adoption of CSA implementation in Uganda. Hence, building partnerships and collaborative linkages with these actors would enhance adoption and upscaling of CSA interventions countrywide.

Government recently revamped the agriculture extension system and recruited sub-county agriculture extension officers in most of the districts across the country. This offers a great opportunity to integrate CSA into the extension system and provide advisory services on the climate resilient technologies to farmers.

The presence of ZARDIs in all Zones provide opportunity to undertake research and generate climate resilient technologies and practices responding to the local climate change impacts. In addition, the Production and Marketing Departments in the DLGs offer great opportunity for dissemination and upscaling of CSA technologies and practices among farming communities countrywide.

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- Uganda has a favourable enabling legal and policy environment for promoting CSA. Most of the natural resources related laws and policies integrate strategies to address climate change and its impacts on agriculture, offering a fertile ground for promoting CSA initiatives.

- Climate change is viewed as a cross cutting issue requiring to be addressed using a multisectoral approach. As such, both national and sub national institutions should work together to address climate change issues affecting agriculture that fall within their mandates. This will ensure comprehensive and sustainable implementation of CSA in the country.

- There are various stakeholders on the ground with a wealth of CSA knowledge and experience. These stakeholders can be used as building blocks for large scale adoption and upscaling of CSA practices in all the Zones across the country.

- Based on the stakeholder mapping results, there are few CSA initiatives which are poorly planned and resourced. This calls for better coordination and resource mobilization for large scale CSA implementation in order to realize impact among the participating communities and the general environment.

- Climate Smart Agriculture initiatives are presently implemented without any regulatory framework. It is important to formulate a guiding policy framework to regulate CSA implementation as more actors are joining the sub sector.

6.2 Recommendations

- Climate Smart Agriculture is globally recognized as the farming system to respond to climate change but is usually not reflected in government policies, plans and budgets. There is need to integrate CSA into policies, strategies, plans , programmes and budgets of agriculture and other natural resource based sectors in order to adequately address the impacts of climate change on agriculture in Uganda.

- There is need to improve access to weather and climate information to enable farmers make informed decisions on when to prepare land and plant crops. Furthermore, there is need to improve quality and reliability of weather information (by providing real time weather forecasts) accompanied by provision of climate advisory services in order to improve agricultural planning and decision making in response to climate change impacts.

- Most farmers in Uganda practice traditional farming methods without use of soil productivity enhancing interventions leading to consistent decline in farm yields over time. Within this era of climate change, there is need to change the mindset of farmers through training, retooling and demonstration of how CSA can help farmers to consistently maintain or increase crop yields to be able to feed the ever increasing human and animal population on a dwindling land resource.

- Adoption of CSA has additional cost implications which require strong institutional support to enable farmers have access to financial services. This can be achieved by working with financial institutions to provide appropriate financial products, such as low interest credit and agriculture insurance, to facilitate farmer transition to CSA.

- To realize the full potential of CSA, access to reliable markets is essential. Hence, there is need for establishment of partnerships along the value chains that improve market linkages and offer stable and better prices to producers.

- Access to agricultural information is key to successful adoption of CSA. Therefore there is need to strengthen early warning systems to increase farmer access to timely information regarding climate change impacts such as droughts, floods, pest and disease epidemics and other natural disasters and provide advisories for mitigation or adaptive interventions.

- Government should strengthen technical capacity of district and sub county agriculture extension officers to deliver CSA extension services. The required skills, among others, include crop fertilizer requirements and use of the field soil test kit to establish soil fertility status (see Annex III). This should be achieved through provision in-service tailor made short courses and equipping the extension officers with tools to deliver on CSA such as training manuals and handbooks to guide them in provision of extension services to the farmers.

- Government should strengthen engagement and partnerships with the private sector to support and build their capacity to establish agroprocessing industries. This will provide reliable market for agricultural produce which will motivate farmers to invest in climate resilient farming systems and also enhance value addition through agroprocessing to achieve better prices for local and export market.

- There is need for a multisector approach in the implementation of CSA. Line ministries including MAAIF, MWE, MEMD, MLHUD and MTIC should work together through the Inter Ministerial Cooperation Framework to address issues of climate change on agriculture that fall within their mandates. This will ensure comprehensive and sustainable implementation of CSA in the country.

THE CATALOGUE OF CSA ACTORS – WHO IS DOING WHAT AND WHERE

Category	CSA Actors	CSA Interventions	Districts of Operation	AEZ/ZARDI	Contact
International NGOs	Agency for Cooperation and Research in Development (ACORD) Mbarara	Sustainable agriculture, SWC practices (contour bunds, grass bunds, mulching), water diversion channels, agroforestry, water harvesting, irrigation, training of farmers.	Mbarara, Isingiro, Ntungamo	South Western Rangelands/ Mbarara	John Najuna +256 701 047940
	Netherlands Development Organisation (SNV) – Western Regional Office	Tick control, pasture improvement and conservation, breed improvement, water for production, biogas production and provision of subsidies on CSA equipment	Mbarara	South Western Rangelands/ Mbarara	Paul Kimbugwe TIDE Project +256 772 441 146 pkimbugwe@snv.org
	Oxfam – works through partner organizations (eg. PELUM Uganda. ESAF, COPACSO, CEFORD, IFRAD, CIDI	Food security, SWC, water harvesting, irrigation, CA, marketing and value chain development, gender equity, agronomic farming practices, natural resource management, CSA pasture seed systems	Yumbe, Gulu, Amolatar, Katakwi	North Eastern Semi-Arid/ Nabuin; Northern/ Ngetta	Jackson Muhindo Resilience & Climate Change Coordinator Tel:+256 414390500 Mobile: +256 772922399/ +256 752922399 Jackson.Muhindo@ oxfam.org
	International Rescue Committee (IRC)	Line planting, early and timely planting, mulching, use of quick maturing varieties in crops, irrigation, trainings farmers in crops and livestock management, market linkage to potential buyers and VSLA saving scheme.	Nakapiripirit, Amudat, Napak, Moroto	North Eastern Semi-Arid/ Nabuin	Harriet Anena +256 775 593 083

	World Vision Uganda	Energy saving technologies, environmental conservation in schools, CA, water harvesting, irrigation, apiculture, kitchen gardening, seasonal weather forecasts, SWC, Agroforestry, organic farming	Oyam, Omoro, Gulu, Agago, Kiboga, Kikuube, Kakumiro, Kagadi, Rakai, Nakasongola, Butambala, Tororo, Busia, Bigiri,Soroti, Amuria, Mbale, Butalejja, Buikwe	North Eastern Semi Arid (Nabuin), Northern (Ngetta), South Western Rangelands (Mbarara), Lake Victoria Crescent (Mukono), Eastern Highlands (Buginyanya)	Immaculate Luwedde Sekitto Technical Programme Manager Resilience and Livelihood World Vision Uganda Immaculate_Sekitto@wvi.org isekitto@hotmail.com Tel:256 752652841
	CARE International Uganda	Small household irrigation, water harvesting, dissemination of weather forecasts from UNMA, mulching, bee keeping, shea nut processing, integrated soil management studies, agronomic practices, eco based value addition and marketing, financial inclusion, integrated risk management approaches (disaster risk reduction, climate change adaptation and ecosystem management and restoration, wetland management and restoration	Otuke district	Ngeta ZARDI	Anguparu Monica +256 758379874 or 782379874 Monica.Anguparu@care.org

	Catholic Relief Services Uganda	Ridges, minimum tillage, agronomic practices, promoting early maturing varieties, improved Varieties,farmyard Manure, agroforestry, intercropping, mulching, irrigation, SWC/ contour bunds, crop rotation, micro water harvesting, IPM, bio-pesticides	Moroto, Napak, Nakapiripirit, Nabilatuk, Abim, Kasese, Bunyangabu, Ntoroko and Bundibugyo	North Eastern Semi-Arid/ (Nabuin)/ Western Highlands (Rwebitaba)	John Bruce Nabimanya, Manager vanilla/ Coffee, Programs P.O. Box 30086, Kampala, Uganda +256 771 401759
National NGOs	Albertine Interventions For Development	Terracing, mulching, trench construction and promotion of energy saving technologies.	Bundibugyo, Kabarole, Kasese, Kyegegwa, Kyenjojo, Ntoroko	Western Highlands/ Rwebitaba	Thomas Ahurra MORE Programmes Director +256 772 089 096
	Caritas Kasese	Terracing, soil conservation and double digging	Kasese	Western Highlands/ Rwebitaba	Sumba Baguma +256 772873545
	Foundation For Urban and Rural Advancement (FURA)	Tree planting, promotion of improved seeds, swamp restoration, mulching, pruning and trench construction	Bundibugyo, Kasese, Ntoroko	Western Highlands/ Rwebitaba	P.0 Box 544, Kasese, +256 483 445689, +256 783 842917, +256 779 032557 furauganda@gmail. com
	Africa 2000 Network Uganda	Mulching, use of organic and artificial fertilizers, mixed farming, terracing, minimum tillage, crop rotation, agricultural extension services, establishment of demo sites and supply of farm inputs.	Kabale, Kanungu, Kisoro, Rubanda, Rukiga	South Western Highlands/ Kachwekano	+256 772 908 470

	C-Care Uganda	Kitchen gardening, soil and water conservation techniques, growing early maturing and tolerant varieties of pastures and crops, contour trenches and enterprise mix.	Mubende	Lake Victoria Crescent/ Mukono	Monah Turyahikayo +256 703 588 853
	Caritas Moroto	Kitchen gardening, soil and water conservation techniques, growing early maturing and tolerant varieties of pastures and crops, contour trenches and enterprise mix.	Moroto	North Eastern Semi-Arid/ Nabuin	Anna Grace Nakoru - Happy Cow Project +256 782560207
District NGO	Ibanda District Farmer's Association	Training members bin climate change agriculture and pasture cultivation and promotion and provision of drought tolerant crop varieties	Ibanda	South Western Rangelands/ Mbarara	Christopher Kafura Secretary +256 772 453476
	Ibanda Women's Guild	Mulching, commercial tree planting, rain water harvesting and training members on climate change adoption and management	Ibanda	South Western Rangelands/ Mbarara	Mollen Kamugisha Guild Secretary +256 782316555 mollenkamugisha @gmail.com
CBO	Kazo Dryland Husbandry Agro-Pastoralists' Association (KDHAPA)	Early maturing crop varieties, Growing of nitrogen fixing trees and crops, cultural cultivation and conservation and promote biogas use, range land management	Kiruhura	South Western Rangelands/ Mbarara	Erison Tumusiime Chairperson +256 783 976368 erisontumusiime @gmail.com
	Kyamatongo Farmers Group	Mulching, mixed cropping, irrigation, intercropping, variety selection andadvisory services	Sheema	South Western Rangelands/ Mbarara	+256 784 215 008

	Ruhabo Bakyara Twimusane	Terracing, mulching, mixed cropping, hybrid seeds, intercropping, band farming, training farmers and establishing demonstration sites	Ntungamo	South Western Rangelands/ Mbarara	+256 784 306 550
	Sheema Community Integrated Development Organization (SCIDO)	Mulching, minimum tillage, agroforestry, renewable energy, cooking stoves, organic fertilizers, demonstration sites, training and input supply	Sheema	South Western Rangelands/ Mbarara	+256 775 514 407
Farmers	Kenneth Muginya	SWC, water harvesting, irrigation, water retention ditches, organic fertilizers, pest and disease control, improved varieties	Mbarara	South Western Rangelands/ Mbarara	Kenneth Muginya +256-702-037310
	David Kisakye	Mulching, maximum plant cover, minimum tillage, use of herbicides, ripping using animal traction, seed selection and extension services	Namutumba	Eastern Highlands/ Bugunyanya	David Kisakye +256 754650287
	Richard Musenero	Minimum tillage using planting basins rippers, mulching, indigenous tree planting, soil and water conservation structures, water and soil conservation, breeding and promoting new crop varieties, bio gas production, advisory services, marketing and technology promotion	Kamuli	Eastern Highlands/ Bugunyanya	
Private sector	Biogas Solutions Uganda	Biogas plants, training farmers in biogas production	Mbarara	South Western Rangelands/ Mbarara	Kasibante Julius Mbarara Representative +256 702 420770

	David Kisembo	Contour bunds, mulching, manure and inorganic fertilizer application to coffee, banana and tea Agroforestry and mulching	Kyenjojo	Western Highlands/ Rwebitaba	David Kisembo +256 703401920, +256 783356500
	James Nagoro	Use of fertilizers, provision of farm inputs and medium scale irrigation	Kasese	Western Highlands/ Rwebitaba	Ministry of Agriculture Mubuku +256 753 789775
Research	Mbarara ZARDI	Conservation agriculture, contour bunds, agro-nomic SLM practices (mulching, maturing, crop rotation), terraces, agroforestry, small scale water harvesting (roadside run off water harvesting),	Isingiro, Kiruhura, Mbarara	South Western Rangelands/ Mbarara	John Sendawula Zonal SLM Specialist +256 753 487788
	Rwebitaba ZARDI	Soil and water conservation agriculture, agroforestry, afforestation, drought tolerant crops, permanent planting basins, terracing, trench construction and training of farmers	Bundibugyo, Kabarole, Kamwenge, Kasese, Kyegegwa, Kyenjojo, Bundibugyo and Ntoroko	Western Highlands/ Rwebitaba	Josephine Nakanwagi Zonal SLM Specialist P.O Box 96, Fort Portal. +256-754-208901
	Rubona Stock Farm	Preparing silage, irrigation, preparation of silage and use of manure	Bunyangabu	Western Highlands/ Rwebitaba	Nissan Kabahingi +256 701810014
	Kachwekano ZARDI	Mulching, contour ploughing, use of artificial fertilizers, use of screen houses, breeding early maturing and resistant crop varieties, backyard gardening, research, establishment of demonstration sites and marketing	Kabale, Kanungu, Kisoro and Rukungiri	Southwestern Highlands	Dr. Vettes Kalema Zonal SLM Specialist +256 486 426406

	Mukono ZARDI	Generation & dissemination of CSA technologies, improved crop varieties, SWC practices, dry season livestock feeding, tree planting, CA, adaptive trials, training and institutional capacity building and training	Mukono, Masaka, Mubende	Lake Victoria Crescent/ Mukono	Fred Tabalamule SLM Specialist +256-706-066104 +256-772325660
	Bulindi ZARDI	Mulching, contour bands, permanent basins, quick maturing hybrids crops, irrigation, banana coffee technology, seed multiplication, seed and plant implement distribution and sharing of information	Kiryandongo, Masindi, Hoima, Buliisa, Kagadi, Kakumiro, Kibaale	Lake Victoria Crescent/ Mukono	Fred Tabalamule SLM Specialist +256-706-066104 +256-772325660
	Abi ZARDI	Dissemination of improved varieties of crops, soil and water conservation practices, dry season feeding for livestock, tree planting, adaptive trials, training and institutional capacity building on issues of conservation and which species to adapt and demonstration	Arua, Nebbi, Zombo, Maracha, Koboko, Yumbe, Moyo, Adjumani	West Nile/ Abi	Dr. Sadik Kassim +256 772 673 458

Government	Ntoroko DLG	Planting indigenous trees along the river, agroforestry, promotion of early maturing crop varieties, terracing, Integrated Pest Management (IPM), crop rotation, mulching and agricultural extension services (NAADS)	Ntoroko	Western Highlands/ Rwebitaba	District Agricultural Officer +256 774 031910
	Mubende DLG	Soil and water conservation, high yielding varieties, cover cropping and mulching	Mubende	Lake Victoria Crescent/ Mukono	Fredrick Kisakye District Agricultural Officer
	Mukono DLG	Minimum tillage, crop rotation, contour ploughing, breeding, indigenous microorganisms, use of planting basins, trainings, provision of farm inputs	Mukono	Lake Victoria Crescent/ Mukono	+256-773-000122
	Masindi DLGt	Conservation farming system, agroforestry, use of organic manure, hybrid seeds, fruit tree growing (grafted oranges and mangoes), coffee production, extension services and exchange visits and exposures	Masindi	Lake Albert Crescent/ Bulindi	Lawrence Tusiimomuhangi +256-772-663763
	Nebbi DLG (Extension)	Fanya chiini fanya juu contour bunds, soil and water conservation, tree planting, pastures production, artificial insemination, training, establishing demonstration sites	Nebbi	West Nile/ Abi	Dr. Okwi +256 772635397

	Pakwach DLG *Extension)	Mulching, promotion of improved crop varieties, fanya chini fanya juu, ox ploughing, provision of farm inputs, area commodity enterprise and training	Pakwach	West Nile/ Abi	Olayo Michael +256 773 363313
	Nakapiripirit DLG	Mulching, terracing, use of contours, irrigation, artificial insemination, improved seed varieties, extension services and marketing	Nakapiripirit	Northeastern Semi Arid/ Nabuin	Dr. kaltiya Dominic +256 772 335 483
	Otuke DLG	Agroforestry, terracing, irrigation, serial banking, livestock management and produce marketing	Otuke	Northern/ Ngetta	+256 782510546
	Serere DLG	Use of artificial and natural manure, soil erosion control measures, tree planting, quick maturing and tolerant varieties, water harvesting, irrigation, artificial fertilization, training farmers, providing information on the weather and advisory services	Serere	Northeastern Semi Arid/ Nabuin	+256 782613544
	North Rwenzori Plantation (Karugutu)	Improved tree varieties through crooning, training and farm support services	Ntoroko	Western Highlands/ Rwebitaba	Muhesi Ezron Forestry Supervisor
Faith Based Organisations (FBOs)	Kigezi Diocese (Water Department)	Mulching, Conservation agriculture, manure application, seed selection, minimum tillage, training of farmers, establishment of demonstration sites and vulnerability assessment services	Kabale	South Western Highlands/ Kachwekano	+256 702 020 550

REFERENCES

GoU, 2015 Government of Uganda. Second National Development Plan (NDP II) 2015-2016 Pp. 315.

MAAIF, 2013. Ministry of Agriculture, Animal Industry and Fisheries. National Agriculture Policy. Pp. 38.

MAAIF, 2015. Bureau of Ministry of Agriculture, Animal Industry and Fisheries. Agriculture Sector Strategic Plan 2015/16 – 2019/2020. Pp. 100.

MAAIF, 2018. Ministry of Agriculture, Animal Industry and Fisheries. National Adaptation Plan for the Agriculture Sector. Pp 84.

MAAIF, 2018. Ministry of Agriculture, Animal Industry and Fisheries. Ugada Strategic Investment Framework for Sustainable Land Management 2018 – 2030. Pp. 209.

MAAIF and MWE, 2017. National Irrigation Policy: Agricultural Transformation through Irrigation Development.

MWE, 2007 Ministry of Water and Environment. National Adaptation Programmes of Action.

MWE, 2015 Ministry of Water and Environment. National Climate Change Policy, pp. 53.
UBOS, 2019. Uganda Statistics. Statistical Abstracts 2019 pp 347.

LIST OF ANNEXES

Annex 1: Cost: Benefit Analysis of Conservation Agriculture

This cost:benefit analysis is based on the study conducted to establish a methodology for monitoring piophysical and socioeconomic impacts of CSA activities in the districts of Bugiri, Busia, Budaka, Namutumba and Buyende in Uganda (MAAIF, 20`4). The study was conducted in a drought-affected season. The analysis shows the capital outlays for the various CSA practices for maize presented below:

Csa practice	Maize under traditional system (from 2.9 ha)	Maize under CA
Spraying with herbicide to clear land (UGX)	285,000	723,000
Digging SWC structures (contour bunds) (UGX)		598,000
Digging PPBs (UGX)		3,014,500
Ploughing (UGX)	455,000	
Seed purchase and application (UGX)	760,600	2,327,500
Soil back filling/ scooping and fertilizer application (DAP) (UGX)		468,000
DAP fertilizer purchase and application (UGX)	43,500	2,879,000
Herbicide spraying (UGX)	12,000	
Pesticide application (UGX)	2,000	357,000
Urea fertilizer purchase and application (UGX)		1,589,500
Manual weeding (UGX)	1,519,000	803,000
Manure application		238,000
Spraying with paraquat		234,000
Napier grass bunds		90,000
Total costs	3,077,100	13,321,500
Total harvest (kg)	4,000	93,287.3
Yield per ha	1,396.1	4,240.3
Percentage yield increase		203.7%

The analysis shows more than doubling of yields for maize grown under CA (203.7%) compared to that grown under the traditional system. This confirms the need to promote CA as a CSA practice rather than encouraging the farmers to continue using the traditional farming system. Similar results have been achieved for beans, ground nuts and other annual crops grown under CA.

Annex II: Establishment f a Conservation Agriculture garden

FUNDAMENTAL PRINCIPLES OF CA/CF
PRIMARY PRINCIPLES

- Minimise tillage (soil disturbance) to the extent possible
- Maximise soil cover to the extent possible
- Rotate cereals with legumes

SECONDARY PRINCIPLES

- For all farmers establish permanent planting zones/ basins
- Control weeds with minimum use of the hoe, including the use of herbicides

COMPLIMENTED WITH ESSENTIAL CA ENHANCERS (WHICH ARE HOWEVER NOT CA!)

- Good agronomic practices
  - Timely planting
  - Proper plant spacing
  - Effective weed control (with and without herbicides)

- Use of improved external inputs – Timely planting
  - Improved seeds
  - Judicious use of fertilisers
  - Judicious use of pesticides
  - Agro-forestry – Fertiliser trees, fodder, fruit, live fences, wind breakers, [Faidherbia Albida; Baobab; Grevillea; Shrubs]

Steps in CA garden establishment

Early season land preparation

- Carry out bush clearing by slashing.
- Measure and dig contour bunds
- Dig permanent planting basins (PPBs) or make riplines if using livestock – during dry season.
- The basins are 35 cm long and 15-20 cm deep and width is size of hoe. Distance between basins in a row is also 35 cm and that between rows is 75 cm
- Loosen the soil at the bottom of the basin.
- Backfill the basin with top soil to half depth.
- Apply the fertilizers or manures (one soda bottle top of DAP or a handful of FYM) in each basin
- Fill the basin with soil to the top.
- Using a stick, prick evenly spaced holes in the basin (3 for maize; 6-8 for beans)
- Plant the seed in the holes and cover loosely with soil.
- Spray the entire garden with herbicides to kill of any weeds.

- If available, mulch the entire garden with grass or maize stover after germination.
- Weed the crop using herbicides or loosely with a hoe if herbicides are not available.
- When maize crop reaches knee height, top dress with urea around the maize rooting zone.

Annex III: Establishing Contour Bunds

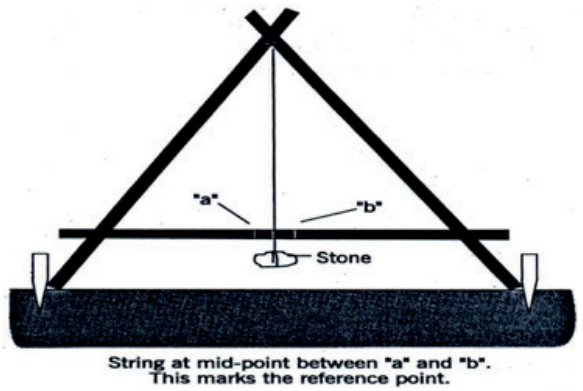
Two methods are commonly used (i) using the A-Frame; (ii) using the Spirit/ Line Level

1. USING THE A-FRAME

How to construct and mark an A-Frame

MATERIALS

- 2 strong sticks, each 6 ft long
- One stick, 4 ft long
- Three 2-inch nails
- About 4 ft of strong string
- A fist-sized stone
- Two pegs about 2 ft long



String at mid-point between "a" and "b".
This marks the reference point.

Method

Step 1 – Cross the two 6-ft long sticks at the top and nail them together securely.
Step 2 – Nail the 4-ft-long stick across the other two to form the letter "A".
Step 3 – Tie a string to the top of the A-Frame and let it hang down below the crossbar.
Step 4 – Tie a fist-sized stone to the end of the string below the cross bar. Now the A-Frame is almost complete, but before it can be used to mark contours, a point must be found on the crossbar which will indicate when the two legs are in level position.
Step 5 – Stand the A-Frame upright and drive a peg into the ground next to each leg of the A-Frame.
Step 6 – With a pencil, chalk or charcoal, mark the point (point 1) where the string settles without touching the crossbar of the A-Frame.
Step 7 – Turn the A-Frame so that the placement of the legs is reversed and the left leg is now put where the right leg had been. Leg one touches the second peg and leg two touches the first peg.

Step 8 – Id the ground is level, the string will settle in the same position as in step 6. Now move to step 10. If the string does not settle in the same position as in step 6, mark the new point (point 2) where the string settles without touching the crossbar.

Step 9 – Put a third mark (point 3) halfway between points 1 and 2. This is the point on the crossbar which will indicate when the two legs are in level position.

Step 10 – Using a panga or knife, make a permanent mark by cutting a notch at the level position.

Step 11 – When the weighted string hangs directly in the front of the cut notch, the two legs are in a level position.

Now the construction of the A-Frame is complete and it is ready to be used to mark contours in sloping land

How to construct and mark an A-Frame
To determine the location of contours using an A-Frame, do the following:

Step 1 – Study the area of your field which you want to construct contour barriers. Start at the highest point (upper boundary) of your field. The A-Frame should only be used when the ground is firm, e.g. in the dry season when the legs of the A-Frame do not enter the soil.

Step 2 – First, Cut a supply of pegs. These are used for making level lines where contour barriers will be constructed.

Step 3 – Drive the first peg (peg 1) at the upper most edge of the field. You will begin marking the contour lines at this point.

Step 4 – Place one leg (leg 1) of the A-Frame just above peg 1. Adjust the other leg (leg 2) until the string settles at the position of the notch without touching the crossbar.

Step 5 – When the string settles at the position of the notch, drive another peg (peg 2) into the ground just above but touching leg 2 of A-Frame.

Step 6 – Now lift the A-Frame and move it along, placing it so that Leg 1 of the A-Frame is put at peg 2.

Step 7 – Lift the A-Frame again putting leg 1 at peg 2. Adjust leg 2 until the string settles at the position of the notch without touching the cross bar as in step 4 above. Drive another peg (peg 3) just above but touching leg 2 of the A-Frame.

Step 8 – Continue with the exercise across the slope up to the end of the field. Now you have a line – A contour of pegs across the field.

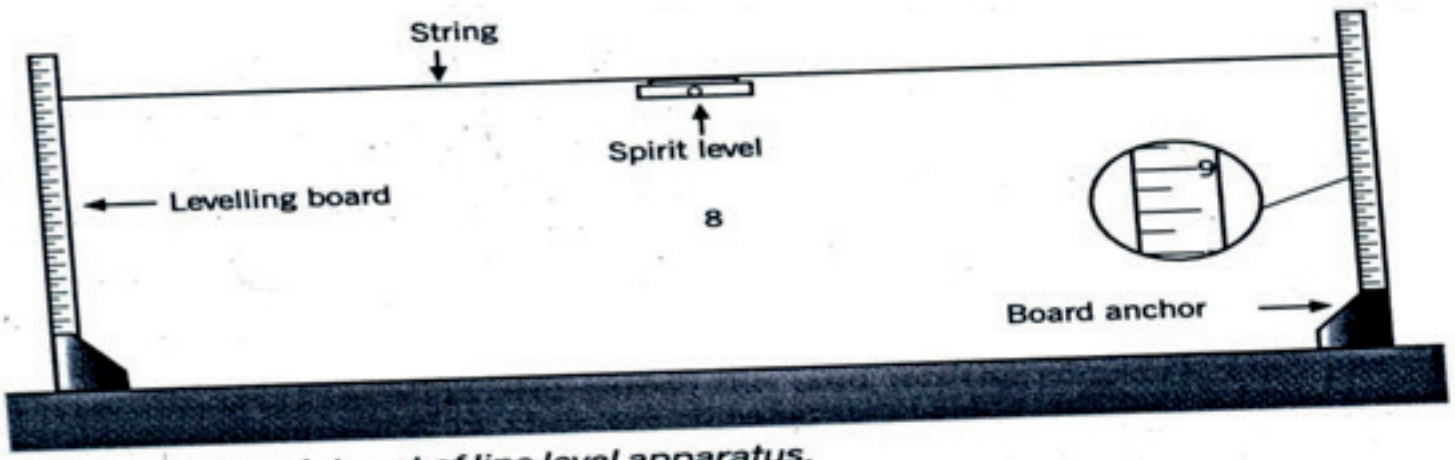
Step 9 – Adjust the pegs which are not in line with the others to make a smooth curve.

2. USING THE SPIRIT/ LINE LEVEL

Materials

- Two sticks (leveling boards) each 1.5 m high.

- The boards are graduated in 5 cm intervals, starting with zero from the top of each board.
- A triangular piece of wood is attached to the bottom of each board to prevent it from sinking into the ground.
- The boards should be made from good material that does not bend or break easily. An allowance of about 5cm is added at the top of the boards for handling – making the boards 1.55 cm high.
- A cotton or nylon string 11 m long.
- A SWC spirit level. This is a flat instrument about 5 cm long containing a tube of liquid with an air bubble



A complete set of line level apparatus.

in it. It also has hooks for suspending it on the string.

Measuring contours using the spirit level

(a) Put the string at the zero mark on both sticks.
(b) Starting from the top of the slope on one side of the field, put a peg to serve as the starting point to measure the contour across the slope.
(c) One person should hold one of the sticks (ranging rod) firmly at the peg while a second person by the spirit level which hangs at mid point (5 m) of the string directs the third person stretching the second stick o move up or down hill, while keeping the string straight.
(d) When the air bubble in the spirit level settles at the cantre of the glass, the two points are at the same level and a peg is put at that point
(e) The first person holding the stick at the starting point then moves to the second peg and the person holding the second peg moves on across the slope to another point ahead.
(f) The process is repeated for the entire length across the slope.
(g) On reaching the end of the field, the pegs are realigned to make a smooth curve of the contour.
(h) After measuring the distance between contours, the process is repeated for the next contour until the entire field is covered.

Locating the distance between contours

It is important that a farmer knows how to locate contour positions on the farm for purpose of soil erosion control or SWC. SWC barriers established along contours reduce the speed and distance over which water flows, thus reducing its ability to erode the position of contours is determined as follows:

Step 1 – Drive the first peg in the ground (at the uppermost boundary of your field) at a point of the first contour. The position of this peg is now our reference point.

Step 2 – Move down backwards with your arm stretched horizontally at shoulder level until it becomes level with your reference point above. Drive a peg at this point. This is a starting position for locating the contour.

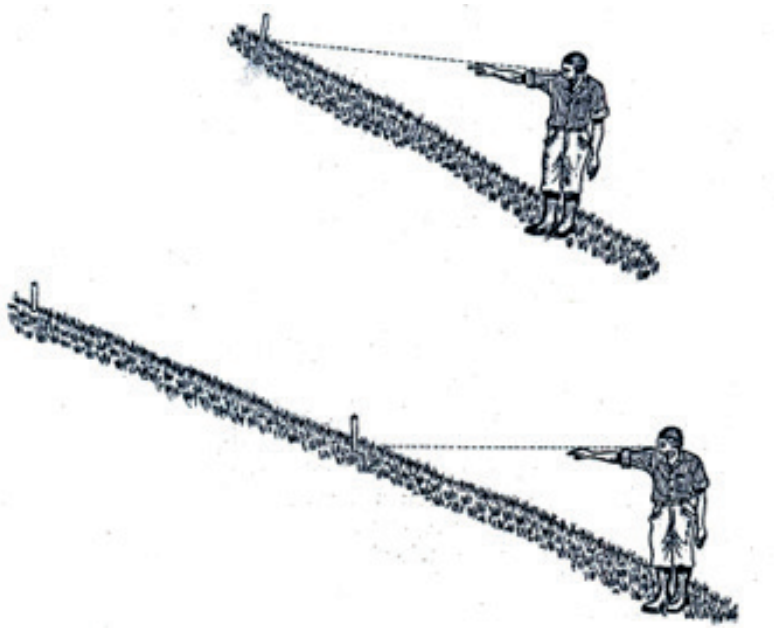
Step 3 – Repeat the same exercise to locate the next position where another contour will be marked using the peg above as reference. This is done until you get to the lower boundary of your land.

Step 4 – Using an A-Frame, locate and mark contours starting at the reference points. (see card 2-2 on how to use an A-Frame to establish contours.).

The interval or distance from one contour to another will depend on the steepness of the slope.

LOCATING DISTANCE BETWEEN CONTOURS

- Depends on steepness of the slope –distance short on steep slopes and long on gently sloping land
- If contours are too close, the slope is very steep and land should not be used for annual crops as soil erosion will be severe.
- Generally; distances should be 10m for land with slopes between 30-20%, about 20m for slopes of 20-12% and 30m for slopes of less than 12%
- Eye- level method can be used to quickly locate the distance between contour positions for the SWC structures with ease.



3. Digging contour bunds

After measuring and locating the contour line, dig the contour bund following the steps below:

Step 1 – Dig a trench 15-20 cm wide and 20 – 30 cm deep depending on the steepness of the slope.
Step 2 – Heap the excavated soil on the lower side of the trench forming a fanya chini contour bund or on the upper side forming a fanya ju contour bund. Fanya chini contour bunds are usually dug on the upper end or within the garden to harvest and allow erosion water from higher areas to collect and settle into the trench and sink slowly into the soil. In contrast, fanya ju contour bunds are usually dug within or on the lower end of the garden to hold runoff and trap soil and nutrients that may be contained in the runoff.
Step 3 – After every 10 m interval, a tie band 10 – 15 cm wide is made to separate different sections of the contour bund. The tie band enables water to overflow to other sections of the contour when one section fills up.
Step 4 – A suitable grass species such as elephant grass, chloris gayana or agroforestry hedge row of calliandra or leucaena is planted on the soil bund to stabilize the heaped soil along the contour. The grass bund may eventually be fed to livestock or used to mulch the garden.

Annex IV: Introduction to Soil sampling and testing

Soil sampling – Involves taking a representative soil sample in a field

Soil sampling methods;

- Random sampling
- Line sampling
- Systematic sampling

Factors to consider when taking soil sample;

- Topography
- Vegetation cover
- Unique features
- Crop to be grown

Field Soil Test Kit – Is a mobile tool containing reagents used to test 5 soil fertility parameters;

- Nitrogen,
- Phosphorus,

- Potassium,
- Soil pH, and
- Organic matter
- Crop to be grown

The soil test kit can test average 50 soil samples.
Cost Shs. 350,000/= from the Department of Agricultural Production, Makerere University.

Importance of Soil testing;

- Establish soil nutrient levels.
- When to apply fertilizers.
- What kind of fertilizers are required for a particular crop and field.
- How much fertilizers are required in a field.

Soil Test Kit Vs Laboratory Analysis;

- Mobile.
- Cheap.
- Easily stored.
- Obtain results in less than 20 minutes.
- Less technical skills required.

OXFAM

For more information, please contact

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