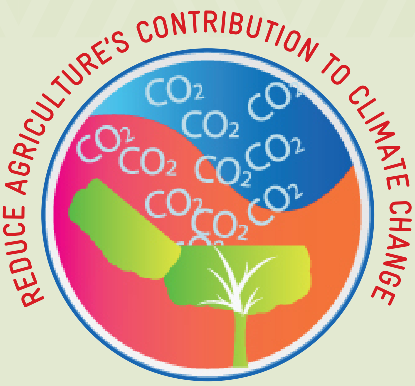
CLIMATE SMART AGRICULTURE

TRAINING MANUAL

WHAT IS CSA?

NATIONAL FOOD SECURITY AND DEVELOPMENT GOALS



A Reference Guide for Agricultural Extension Agents in northern Uganda

Rural Development Programme (PRUDEV)- Promotion of Climate Smart Agriculture Project (ProCSA)

EUROPEAN UNION

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Republic of Uganda

Implemented by: giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Uganda Landcare Network

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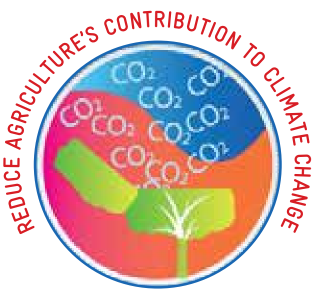

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This guide is not prescriptive but meant to inspire field extension workers and other practitioners into exploring by using applicable combinations of methods and tools

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FOREWORD

Climate change is a fundamental concern for Uganda and northern Uganda in particular because of its effects on the agriculture sector which is a mainstay for rural households. The most frequent climate risk that has affected farmers across northern Uganda has been prolonged dry spells with consequences of heat and water stress leading to reduced crop yields. The shifting onset of rains is also posing challenges to farmers with unpredictable rainy seasons making it difficult to plant in time. This puts farmers in a vulnerable position, jeopardizing food security for many.

Climate Smart Agriculture (CSA) is an approach to overcome existing barriers in achieving food security, adaptation of agriculture to climate change and mitigation of greenhouse gas (GHG) emissions. CSA is a key aspect for Uganda in achieving its national commitments summarized in the National Determined Contribution (NDC) towards achieving the goals of the Paris Climate Change Agreement.

The GIZ - Rural Development Programme (PRUDEV) is a bilateral programme of the Ugandan government and the German Federal Ministry for Economic Cooperation and Development to improve the agriculture-based development of the rural economy in selected regions of northern Uganda with its main implementing partners being the Ministry of Local Government and the District Local Governments. Part of the PRUDEV programme is the European Union (EU) co-funded "Promotion of Climate Smart Agriculture" (ProCSA) Project that focuses on strengthening the rural population against the effects of climate change through climate-smart agriculture (CSA). The ProCSA project promotes the application and adoption of gender-responsive climate-smart agricultural practices among smallholder farming communities.

The selected cooperatives /farmer groups are located in the following districts: Amolatar, Dokolo, Oyam, Lira, Agago, Kitgum, and Napak. GIZ together with Uganda Landcare Network (ULN) have developed a CSA Training Manual as a tool to guide local master trainers and community-based trainers in teaching farmer groups and applying CSA practices.

The training manual is a detailed module, giving options to trainers and farmers to select appropriate practices depending on their knowledge, interest, and local agroecological conditions.

ACKNOWLEDGEMENT

Uganda Landcare Network (ULN) working closely with Kampala and Gulubased GIZ teams, acknowledges a range of partners, institutions and individuals for their active participation in the development of the CSA training manual, targeting seven (7) districts in three (3) subregions in northern Uganda, namely Acholi, Karamoja and Lango. Local government authorities led by district technical teams of the seven districts of Amolatar, Dokolo, Oyam, Lira, Agago, Kitgum, and Napak provided the vital baseline information including opportunities of ensuring the manual fits in the district plans for relevance and ownership.

Writing the manual was participatory led by key individuals specifically Dr. Drake N. Mubiru, Dr. Willy Kakuru, Dr. Grace Nangendo, Mr. John Bosco Okaya, Mr. Benard Twinomugisha and Ms. Jalia Namakula. A cadre of field-based trainers contributed substantially to the manual development and validation – these include Mr. Bosco Ocan, Mr. Walter Odur, Mr. Lawrence Ogwal, Ms. Caroline Angwench, Mr. Uthan Okoth, Ms. Monica Ruth Acan and Mr. Isaac Awany.

Forty-six (46) Community-Based Trainers from the seven target districts actively participated in the entire process with enthusiasm and added a lot of value to the manual specifically to ensure that it is customized to local conditions.

ULN key staff of Dr. Joy M.B. Tukahirwa, Mr. Mathias Wakulira and Mr. Rick Kamugisha, working with the GIZ – Rural Development Programme (PRUDEV) - Promotion of Climate Smart Agriculture (ProCSA) team, is highly appreciated for managing ably the entire process of the manual development. We also acknowledge and appreciate Slick Republic Limited for the design/layout of the manual.

Finally, the Government of Uganda (GoU) is acknowledged for the enabling policy environment together with the funding support from the German Federal Ministry for Economic Cooperation and Development (BMZ) as well as the European Union (EU).

ACRONYMS AND ABBREVIATIONS

AEATREC	Agricultural Engineering and Appropriate Technology Research Centre
APZ	Agricultural Production Zone
BBW	Banana Bacterial Wilt
BCTB	Black Coffee Twig Borer
CA	Conservation Agriculture
CBSD	Cassava Brown Streak Disease
CFCs	Chlorofluorocarbons
CIAT	International Centre for Tropical Agriculture
CMD	Cassava Mosaic Disease
CWD	Coffee Wild Disease
CSA	Climate Smart Agriculture
GALS	Gender Action Learning System
GDP	Gross Domestic Product
GHGs	Green House Gases
GIZ	German Society for International Cooperation, Ltd.
GoU	Government of Uganda
GLS	Grey Leaf Spot
FAO	Food and Agriculture Organization
IFPRI	International Food Policy Research Institute
IK	Indigenous Knowledge
IPCC	Intergovernmental Panel on Climate Change
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MSV	Maize Streak Virus
NARO	National Agricultural Research Organization
NASA	National Aeronautics and Space Administration
NDC	Nationally Determined Contribution
NLB	Northern corn Leaf Blight
NSOER	National State of the Environment Report
OM	Organic matter

ProCSA	Promotion of Climate Smart Agriculture
PRUDEV	Rural Development Programme
SAIMMCO	Soroti Agricultural Implements and Machinery Manufacturing Company
S&WC	Soil & Water Conservation
SLM	Sustainable Land Management
UBOS	Uganda Bureau of Statistics
ULN	Uganda Landcare Network
UNFCCC	United Nations Framework Convention on Climate Change
WOCAT	World Overview of Conservation Approaches and Technologies
UNDP	United Nations Development Programme
2WT	Two Wheel Tractor

ORGANIZATION OF THIS MANUAL

The training manual is arranged in 8 modules as follows:

Module I	Climate science and climate change
Module II	Agricultural production and climate change
Module III	Climate Smart Agriculture (CSA) Concept and pillars
Module IV	Gender Action Learning System (GALS) methodology
Module V	Community-based Natural Resources Action Planning
Module VI	Climate Smart Agriculture (CSA) Solutions and Practices
Module VII	Blending Indigenous knowledge and Science to Maximise Benefits
Module VIII	Scaling CSA

The introduction elaborates the background and objectives of the manual.

Module I introduces trainees to climate science i.e. weather vis-à-vis climate; the elements of weather and elaborates on climate variability and change. It further discusses the causes of global warming (the greenhouse effect), which is a precursor to climate variability and change. Participants are introduced to the gaseous composition of the atmosphere and how human activities have altered this natural composition leading to an elevation of the greenhouse gases. The module is concluded with a case study giving an outlook on climate change and its manifestation in Uganda.

Module II: In this module, participants are made to appreciate the contribution of the agricultural sector to the economy of the country. Participants are also introduced to food security and how climate change affects the four dimensions of food security. They are further made to appreciate that when climate change impacts agricultural production it does not only affect food security at the micro-level but also affects the economy of the country at the macro level. A discussion is also made about the challenges farmers face along the commodity value chains, which aggravate the effects of climate change.

Module III introduces trainees to the concept of climate-smart agriculture (CSA) with an elaboration of the three pillars of CSA (i.e. productivity (food security), adaptation (resilience) and mitigation. Participants are made to appreciate what makes a practice/technology climate-smart and are made to identify CSA practices/technologies in their local areas, by teasing out the functions of the practices/technologies as related to the three pillars.

Module IV introduces the gender action learning system (GALS) methodology. The methodology elaborates on gender mainstreaming, which is the process of integrating a gender equality perspective into the development process at all stages and levels.

Module V is to enable participants to understand and appreciate the importance and process of community-based natural resource action planning. It is also intended to make participants aware that the participatory approach to community-based natural resource action planning is based on a set of principles that redefine the roles of individuals and communities in local planning. The module uses a combination of theoretical and hands-on training with tangible outcomes such as community resource maps, matrices, and action plans. In addition, there are less tangible outcomes, such as the development of community dynamics, commitment to the decisions that have been made, and the fairness of the decision-making procedures.

Module VI introduces the climate-smart agriculture practices and technologies. For ease of communication and training, the practices and technologies are grouped into six categories according to their functions in agricultural production. Participants are made aware that although the practices/technologies are communicated separately; they are not independent of one another and are advised that for best results they should be combined to address the issues at hand.

Module VII is intended to make participants appreciate the importance of indigenous knowledge (IK) in development programs and to underscore the synergies between IK and science. By the end of this module, participants would have been made aware that IK is neither archaic nor primitive, but a formidable set of technologies and practices, which when blended with science maximize benefits

Module VIII is intended to introduce to participants cost-effective approaches for scaling up CSA in the region and the different tools used in the scaling process. It also elaborates on the actions required for creating and strengthening an enabling environment essential for effective scaling.

INTRODUCTION

Background

The GIZ – Rural Development Programme (PRUDEV) is a bilateral programme of the Government of Uganda and the German Federal Ministry for Economic Cooperation and Development. The programme aims at improving the agriculture-based development of the rural economy in selected districts of northern Uganda with its main implementing partners being the Ministry of Local Government and the District Local Governments. The selected districts include Amolatar, Dokolo, Oyam, Lira, Agago, Kitgum, and Napak.

Part of the PRUDEV programme is the European Union co-funded "Promotion of Climate Smart Agriculture" (ProCSA) Project that focuses on preparing and strengthening the rural population against the effects of climate change through Climate Smart Agriculture (CSA). The ProCSA project promotes the application and adoption of Gender-responsive climate-smart agricultural practices among smallholder farming communities.

GIZ contracted the Uganda Landcare Network (ULN) to develop a CSA training manual as a tool to guide local master trainers and community-based trainers in teaching farmer groups and applying CSA practices. The Uganda Landcare Network is an association of individuals and institutions committed to the principles, philosophy and practice of land care in Uganda. Uganda Landcare Network had previously worked with the World Overview of Conservation Approaches and Technologies (WOCAT) to document Sustainable Land Management (SLM) and CSA practices and technologies implemented in northern Uganda. WOCAT is a global network on SLM that promotes the documentation, sharing and use of knowledge to support adaptation, innovation and decision-making in SLM.

Objectives

Uganda submitted its first Nationally Determined Contribution (NDC) in 2015 to the United Nations Framework Convention on Climate Change (UNFCCC) through which is committed to reducing approximately 22% of national GHG emissions in 2030 compared to business-as-usual of 49 million $MtCO_2eq$. The adoption of climate-smart agricultural practices is crucial to the achievement of Uganda's Nationally Determined Contributions. It is equally important as a vehicle through which to increase agricultural production in northern Uganda and thus reduce widespread poverty in the region. Several CSA initiatives have been launched by the Government of Uganda (GoU) in the past years with support from international stakeholders, particularly in the areas of research, piloting and outreach. However, the adoption rate of CSA techniques by farmers remains low, and unsustainable agricultural practices resulting in land degradation and reduced productivity are very rampant in the region. Key challenges include farmers' limited knowledge of CSA practices and low capacity of the national agricultural extension service.

This reference manual aims to address these challenges by providing local master trainers and community facilitators with a comprehensive set of tools to empower farmers to make climate-smart production decisions, adopt CSA practices and install demonstration plots.

MODULE I: CLIMATE SCIENCE AND CLIMATE CHANGE

Understanding weather in relation to climate, and climate change and its effects	
Estimated duration	60 minutes
Module guiding questions	This module aims at giving definition and examples of Weather and Climate and Climate Variability and Climate Change, making the trainer and trainees understand and respond to the following questions: a. What is weather vis-à-vis climate? b. What is the difference between climate change and natural climate variability? c. What are the causes of climate change?
Session Objective	• Make participants appreciate the differences between weather and climate, and between climate variability and change while applying the terms to their locations. • At the end of the session, participants should be able to: a. Identify the different weather elements b. Distinguish the difference between weather and climate c. Distinguish the difference between climate variability and change d. Appreciate the natural composition of the global atmosphere e. Appreciate the causes of climate change
Preparation	• Prior knowledge and information on the elements of weather/climate • Prior knowledge and information on climate variability and change • Charts with information on weather, climate, climate change and climate variability
Materials/resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Pieces of paper for the trainer/trainees to state: a. Elements of weather in their local language (Luo/Akaramojong) [check the English equivalents] b. Extreme weather events in the local area
Session type and delivery methodology	• Presentations • Plenary discussions • Group work to discuss seasonal calendars for different commodities and how they are affected by climate change • Field visits to some areas where impacts of climate change on the agricultural sector can be observed
Take home and follow up	• Weather differs from climate • Climate variability is a natural phenomenon whereas climate change is human-induced • Greenhouse gases (GHGs) e.g. CO_2, CH_4, N_2O, CFCs are the major causes of climate change • Human activities such as the burning of vegetation/biomass, fossil fuels, deforestation, and landuse change cause an increase of GHGs • Effects of climate change include extreme weather events such as heatwaves, floods and flooding, extended droughts • Impacts of climate change include human/livestock poor health (morbidity) and death (mortality), crop failure, famine, etc.

Background to assist the Trainers

Introduction

There is nothing on this earth that has remained unchanged. Everything changes. Weather changes all the time. There is a time when it is hot, cold, warm, cloudy, misty, clear sky, windy, still air and so on. Indeed local languages are awash with terms that describe the different weather situations. However when it is outside what has traditionally been known from past generations, oral history has always special comments including giving names for remembering such unusual situations (e.g. *enjala ani amuwade a katebe* a Luganda phrase meaning severe famine; *enkuba okufuudemba* meaning incessant rainfall) If such situations persist for a long time they will have an impact on the population in terms of food availability (famine: food insecurity), which can lead to displacement or migrations of people to a more stable place particularly during those days before the land became titled and changed ownership from the community to private.

Traditional farming methods, which have evolved overtime based on the understanding of the local people and the prevailing weather conditions are not expected to operate appropriately in a drastically changed climate often manifested in unpredictable weather patterns. It is therefore important for the trainers and the farmers to understand a little more of what climate change is from a basic science point of general knowledge in order to appreciate the Climate Smart Agriculture practices, methodologies and farming techniques.

The training is aimed at building the capacity of farmers to increase crop, livestock, fisheries and forestry production and productivity through use of improved practices and technologies, thus building resilience to shocks associated with climate change.

Session I: Weather and Climate

What is weather?

Weather is the state of atmospheric conditions at a particular place and time. The most common aspects of weather are felt by everyone during the course of a day or night and include sunshine, temperature, rain, humidity, wind, and cloudiness.

Weather can change within a very short period of time, even within the same day.

Common elements of weather
- Sunshine
- Temperature
- Rain
- Humidity
- Wind
- Cloudiness

What is climate?

Climate is the set of weather conditions prevailing in an area over a long time, typically three consecutive decades (IPCC, 2007). Several factors contribute to the definition of climate, including long term averages of temperature and rainfall, but also the type, frequency, duration, and intensity of weather events such as heatwaves, cold spells, storms, floods and droughts.

When the elements of weather are measured systematically at a specific location for several years, a record of observations is documented from which averages, ranges, maximums and minimums for each variable can be computed and this then constitutes the climate of that location.

Session II: Climate change and variability

The planet's climate has been constantly changing over geological times, with significant fluctuations of global average temperatures. However, this current period of warming is occurring more rapidly than ever before. The warming has been accompanied with unprecedented extreme weather events such as droughts, heatwaves, floods, landslides, etc. Climate observers are in agreement that humankind has caused most of the last century's warming by releasing heat-trapping gases, commonly referred to as greenhouse gases (GHGs), for example, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) [Box 1]. The main source of the GHGs is the burning of fossil fuels (oil, coal and gas), for example, through lighting, heating and cooking; and transportation either by air, rail, road, or water. The other avenues by which GHGs are released are intensive and extensive agriculture to meet increasing food demand, which is often accompanied by deforestation; and landuse change, especially from forest to cropland, among other activities.

Box 1: Major greenhouse gases

The Earth's atmosphere contains a number of greenhouse gases, in different concentrations:

Water vapour (H_2O) is water that evaporates from the sea, lakes, rivers and the soil surface, and what is transpired by plants and often felt as humidity. Human activity makes little direct contribution to the large amount of water vapour or clouds in the atmosphere.

Carbon dioxide (CO_2) can be found in nature produced by volcanoes. It is emitted by human activities including transport and energy production based on combustion engines burning fossil fuels such as coal, mineral oil, gas. All animals exhale it through respiration, as do plants at night when they are not photosynthesizing. It also enters the atmosphere through the decay of organic matter, deforestation, burning vegetation and certain industrial processes such as cement-making.

Methane (CH_4) enters the atmosphere when produced by livestock, as well as by microbes in the soil and in water, such as in flooded rice fields. It is released when wetlands, marshes, swamps, bogs and peat lands are dried.

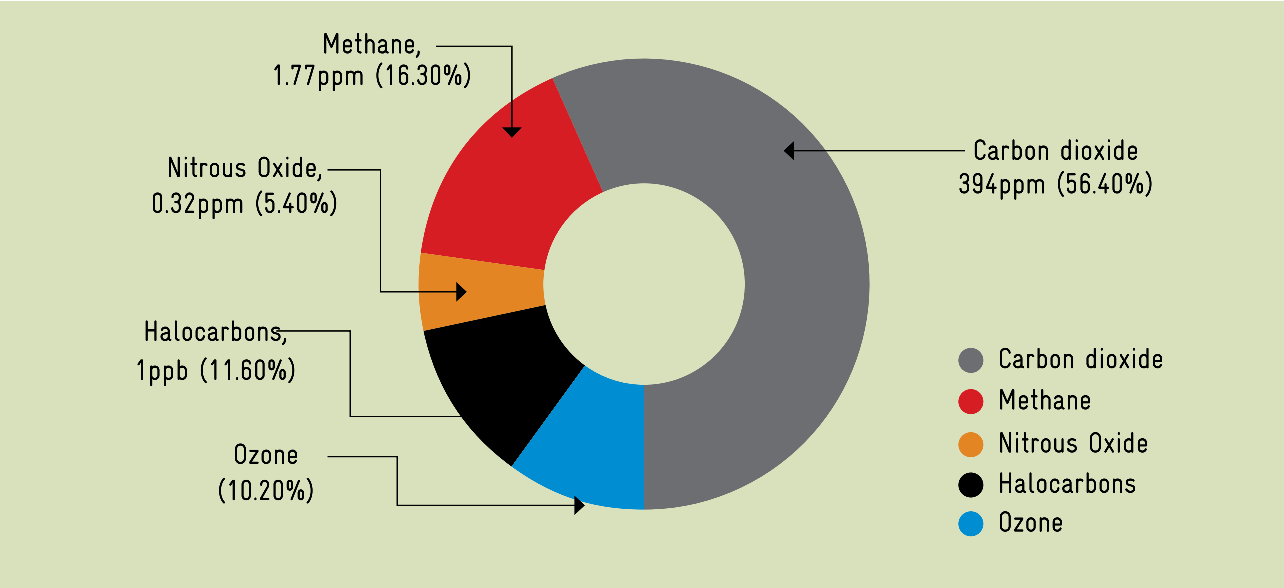
Nitrous oxide (N_2O) is produced by farming, including organic and synthetic fertilizer applications, industrial processes and burning fossil fuels.

Fluorinated gases (F-gases) are made by humans and used in refrigerators, air-conditioners, foams, cosmetics and fire extinguishers.

Green House Gas	Abundance in the atmosphere	Global warming potential (GWP)
Carbon dioxide (CO_2)	By far the most common anthropogenic* GHG (accounts for ¾ of total emissions) – biggest overall effect	1
Methane (CH_4)	Sunlight converts the CH_4 molecules to CO_2 after about 12 years	28
Nitrous oxide (N_2O)	Lasts about 121 years	265
Fluorinated gases	May last thousands of years	6,500

*Anthropogenic = human induced

Percentage of different GHGs in the Atmosphere



Reportedly, GHGs are at the highest levels they have ever been over the last 800,000 years. This rapid rise is a problem because it is changing the planet's climate at a rate that is too fast for living things to adapt to and causing extreme weather events such as severe and extended droughts, floods, landslides, etc., which have caused low crop and livestock productivity and in extreme cases total crop failure and livestock deaths; infrastructure damage; morbidity and mortality among humans, all exerting economic and socio-political effects to humankind.

Climate Variability

Climate variability is a term that is used to refer to all the variations/changes in the climate that last longer than individual weather events. For example today it may rain heavily (20mm of rain) in the morning; then a day later it rains in the evening receiving 60mm. This gives an indication that the rain received in a season may vary on a daily basis. The average of rains received this year may be less than those received the previous year and can be different in subsequent year(s) (Figure 1).

This observation may also apply to winds, temperature and other weather conditions. All these variations apply to a ten year period (Decade) and therefore contribute to the average weather conditions. If such variations continue happening for at least 30 years and have affected the average weather conditions to produce a big difference (e.g. in temperature) then the change may be described as "Climate Change" (Figure 2).

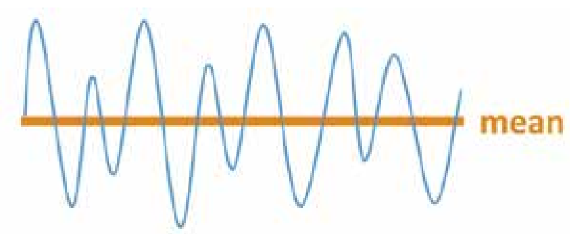


Figure 1: Climate: Variability around a steady mean (Source: FAO, 2018)

Climate variability is the natural fluctuation within the climate, including swings above and below the mean state and other parameters. It reflects the different weather conditions over a day, month, season or year.

Climate Change

The Earth's climate has always been changing due to natural causes that include volcanic activities and oscillations in the planet's rotational and orbit cycles. However, scientists have been measuring trends to higher average global temperatures that are happening much faster than observed previously and that cannot be attributed to natural causes. Instead, scientists conclude this longer-term warming is anthropogenic, meaning it is caused by human activities.

For this reason, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "change of climate that is attributed directly or indirectly to human activities, which alter the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time".

The natural composition of the global atmosphere by volume:

- Nitrogen (N_2) – 78.09%
- Oxygen (O_2) – 20.95%
- Argon – 0.93%
- Carbon dioxide (CO_2) – 0.04%
- Small amounts of other gases

According to the United States of America National Aeronautics and Space Administration (NASA), Climate Change is "a broad range of global phenomena created predominantly by burning fossil fuels, which add heat-trapping gases to Earth's atmosphere. These phenomena include the increased temperature trends described by global warming, but also encompass changes such as sea-level rise; ice mass loss in Greenland, Antarctica, the Arctic and mountain glaciers worldwide; shifts in flower/plant blooming; and extreme weather events."

Globally, millions of people are already suffering from the catastrophic effects of extreme disasters exacerbated by climate change, including severe and extended droughts, floods and landslides in sub-Saharan Africa; devastating tropical storms sweeping across southeast Asia, the Caribbean, and the Pacific; and devastating heatwaves accompanied by wild fires, snowstorms and extreme winter in temperate regions as a result of warming Arctic weather fronts.

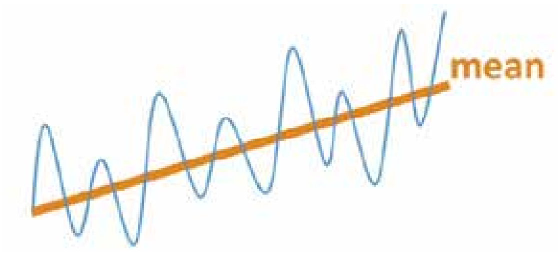


Figure 2: Climate change: Conditions trend and the mean changes (Source: FAO, 2018)

Climate change refers to any permanent change in climate over time (change in mean, frequency, and magnitude).

Climate change vis-à-vis variability – climate variability averages out as climate over years in a steady state (same mean) whereas climate change averages out to a changing trend (changing mean) over decades

What are the main sources of greenhouse gases?

- Human activities play an important role in the emission of greenhouse gases.
- The amount of carbon dioxide released by each country depends on the type and share of its main economic activities.
- Therefore, the shares of carbon dioxide emissions are different across the regions of the world.
- The latest estimates of emissions from human activities totaled more than 46 billion metric tonnes of greenhouse gases, expressed as carbon dioxide equivalents, representing a 35 per cent increase over the previous decade

The list below gives an idea of what other human activities can bring about climate change:

- Clearing land and burning plant biomass/vegetation for farming, which exposes the soil and releases carbon stored in the soil into the atmosphere;
- Burning of wood in form of firewood or charcoal, which releases the carbon normally stored in the trees into the atmosphere;
- Cultivation practices that turn and expose the soil to release carbon stored in the soil into the atmosphere;
- Poorly managed manure that leads to more biogas (methane) escaping into the atmosphere;
- Overstocking of livestock, this leads to land degradation and hence causes soils to emit GHGs;
- Inefficient energy use in the poultry value chain that leads to increased carbon emissions to the atmosphere;
- Indiscriminate use of agro-chemicals, which interferes with maintenance of a sustainable ecosystem;
- Fishing in depleted waters which requires more fuel per kilo landed hence increasing GHG emissions.

Greenhouse Effect

The greenhouse effect comes about when the gases form a blanket in the atmosphere, which does not allow heat, generated by the earth's surface when the sun's rays are reflected off its surface, to go back higher/deeper into the atmosphere. This heat is trapped and overtime it causes the temperatures to rise. The rise in temperature will lead to global warming. Figure 3 illustrates how the greenhouse effect comes about.

Climate change effects are not limited to where the cause of change comes from. Thus, wind blowing over the Sahara Desert will generate dry conditions in northern Uganda; pollution from factories in Kampala will affect other parts of Uganda, through changing weather patterns.

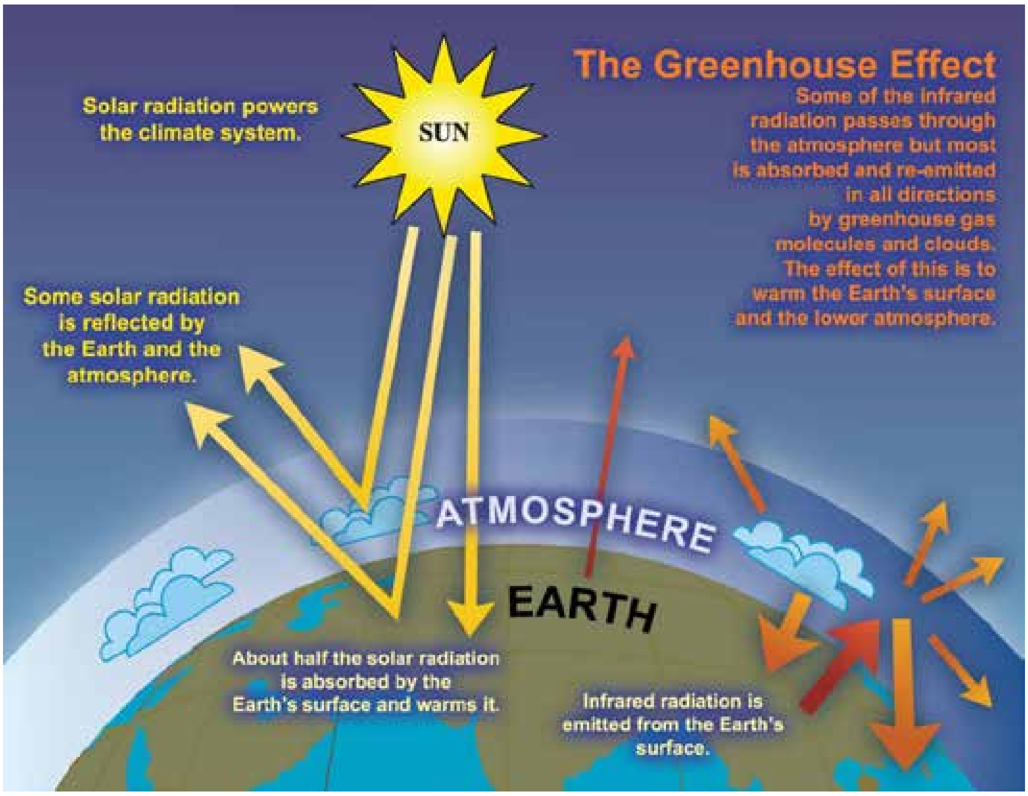


Figure 3: The greenhouse effect. [Source: IPCC 2007]

However, everyone has to be prepared to operate within the changing climate. That flexibility to operate and farm using techniques that will help the farmer to either maintain same yield or increased production levels, with actions that increase resilience of the farmer and ecosystems and targeted at reducing emission of GHGs, are collectively termed "Climate Smart Agricultural Techniques"

Case study: Climate change in Uganda

Uganda experiences equatorial climate with moderate temperatures and humid conditions throughout the year. Its location across the Equator gives it two rain seasons in a year, which merge into one long rainy season as you move northwards from the Equator (GoU, 2007). The first rainy season ranges from March to June, while the second one ranges from August to November. The rainfall level ranges from 400 to 2200 mm per year. Uganda's climate can be broadly subdivided into:

i. Highland climate;
ii. Savannah tropical climate, including the lake basin climate; and
iii. Semi-arid climate.

They are further explained below.

i) Highland climate

The Highland climate has cool temperatures and moderate rainfall (mean annual rainfall of over 900mm). For instance, temperatures in Kabale can be as low as 4 degrees Centigrade. In the Rwenzori Mountains, which have a permanent ice cap, temperatures of below 0°C are experienced.

ii) Savannah tropical climate

The Savannah tropical climate, including the lake basin has moderate average temperatures of 28°C and high mean annual rainfall of over 1200mm. The tropical rainforest is found in this climate. Swamps, found mostly in this climatic zone, provide an excellent habitat for birds; the most notable being the Crested Crane. Reclaiming of wetlands has resulted in decimation of many aquatic animals and migration of the Crested Crane.

iii) Semi-arid climate

The semi-arid climate has relatively high average temperatures, ranging from 26 to 29°C in Mbarara and Moroto, respectively. However, extreme temperatures of 33 and 36°C have been recorded in these areas. The mean annual rainfall is relatively low, ranging from 887 mm in Moroto to 905mm in Mbarara. Animal rearing is the dominant activity in this climate. The high animal population has led to serious land degradation. Although the mean annual rainfall is relatively low, some drought-tolerant land grasses can still grow (GoU, 2007).

Just like elsewhere, in Uganda climate change has manifested in extreme weather events such as severe and extended droughts, flash floods and flooding, landslides, heatwaves, pests and disease outbreaks. It is estimated that 90% of Uganda's extreme weather events are as a result of climate change, especially droughts and floods. Studies (e.g. Kitutu, 2013; Hepworth and Goulden, 2008; GoU, 2007) show that 8 out of the 10 most severe floods and droughts in terms of numbers affected that have been reported since 1900 have taken place in the last 10 years. This is an indication that the number of extreme weather events in Uganda have been increasing within the recent years as shown in Table 1

Table 1: Climate change-induced hazards in Uganda between 1911 and 2020

Period	Climate change hazard		
	Drought	Landslides	Floods
1911-1920	1	1	RNA
1921-1930	RNA†	2	RNA
1931-1940	1	RNA	RNA
1941-1950	RNA	1	RNA
1951-1960	1	7	RNA
1961-1970	RNA	13	RNA
1971-1980	3	6	RNA
1981-1990	2	13	RNA
1991-2000	7	53	RNA
2001-2010	RNA	3	RNA
2011-2020	RNA	21	26

(Source: GoU, 2007 and Kitutu, 2013)
†RNA = Record not available

However, the hallmark of climate change in Uganda has been the receding snow mass on the Mountains of the Moon aka the Rwenzori Mountains (Figure 4).

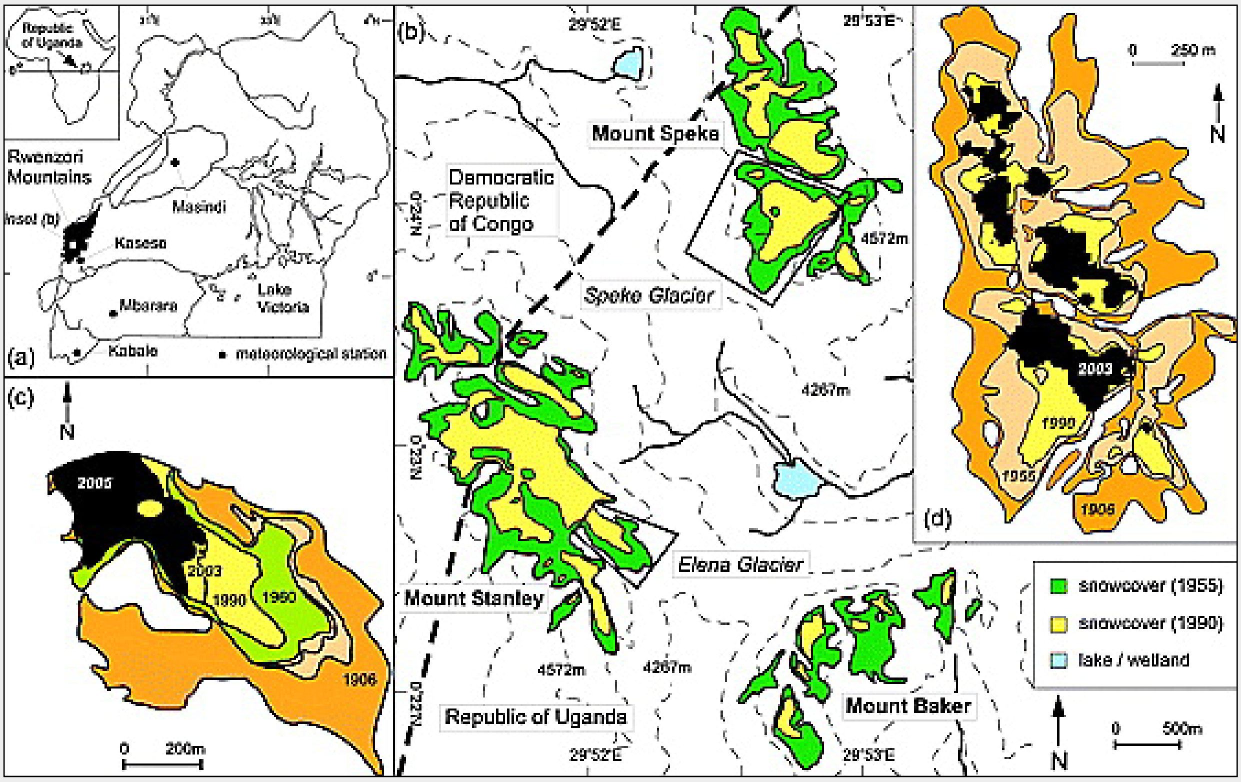


Figure 4: A figure depicting the receding snow mass on the Mountains of the Moon aka the Rwenzori Mountains [Source: Taylor et al., 2006]

Weather variables

The major weather variables that greatly affect agriculture are mainly rainfall and temperature.

a) Rainfall

In Uganda, rainfall is the most sensitive climate variable that affects social and economic activities (GoU, 2007). Figure 5 shows the mean annual rainfall distribution in Uganda. The wettest districts are located within the Lake Victoria Basin, eastern and the northwestern parts of Uganda. These areas include Kalangala, Kampala, Mpigi, Mukono, Jinja, part of Masaka and Bugiri (Lake Basin), Mbale and Kapchorwa (eastern) and Arua (northwestern). It has also been observed that falls are heavier and more violent.

This is consistent with the Intergovernmental Panel on Climate Change (IPCC) prediction that wetter areas will become wetter. The western, northern and northeastern districts are experiencing long droughts, which are becoming more frequent. The eastern region including Pallisa, Kumi, Soroti, Tororo, Busia and Bugiri receive moderate rainfall. The average long-term annual rainfall for Uganda is about 1318 mm, which is adequate to support agricultural activities. However, recent years have witnessed erratic onset and cessation of rainfall seasons.

This coupled with increasing frequency of droughts has made Uganda more vulnerable to climate change (GoU, 2007).

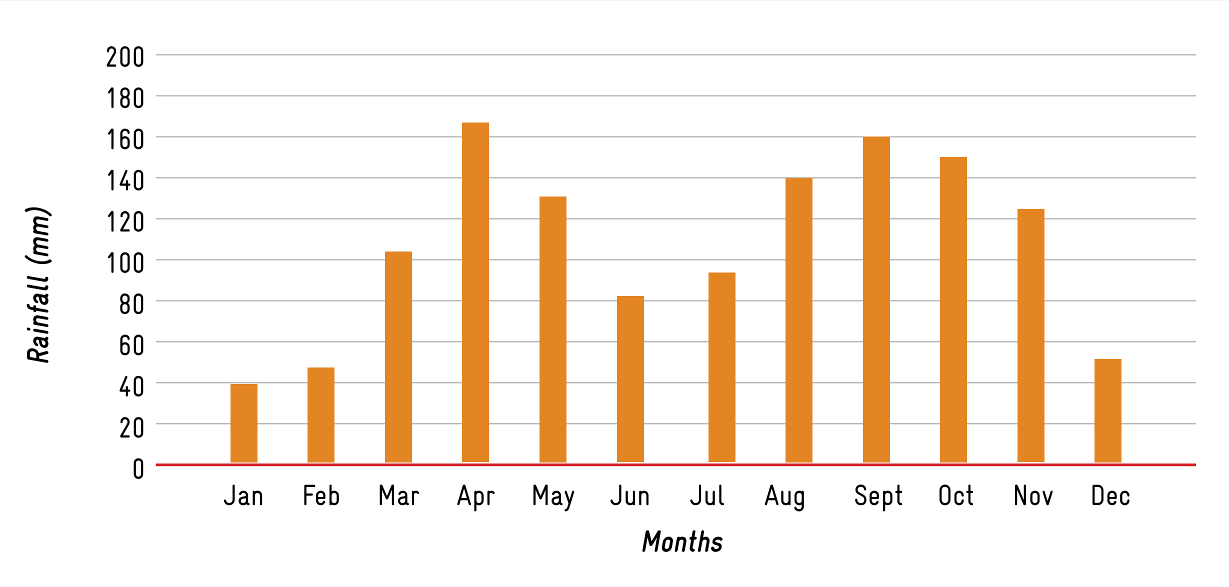


Figure 5: Mean monthly rainfall distribution from 1938 to 2012 at one of the weather stations in Uganda (Source: Authors' elaboration)

b) Temperature

Uganda experiences moderate temperatures throughout the year. The mean daily temperature is 28°C. Extreme temperatures as low as 4°C are experienced in Kabale, which is located in the western highlands (GoU, 2007). However, temperatures below 0°C are experienced on the mountain ranges of Rwenzori and Mount Elgon. Rwenzori has a permanent ice cap, which is vulnerable to global warming. Highest temperatures (over 30°C) are experienced in Gulu, Kitgum and Moroto in the north and north-eastern part of the country (GoU, 2007).

In Uganda, generally day and night temperatures have increasingly become warmer. Figure 6 shows the trend of increasing maximum temperature in Uganda since 1950.

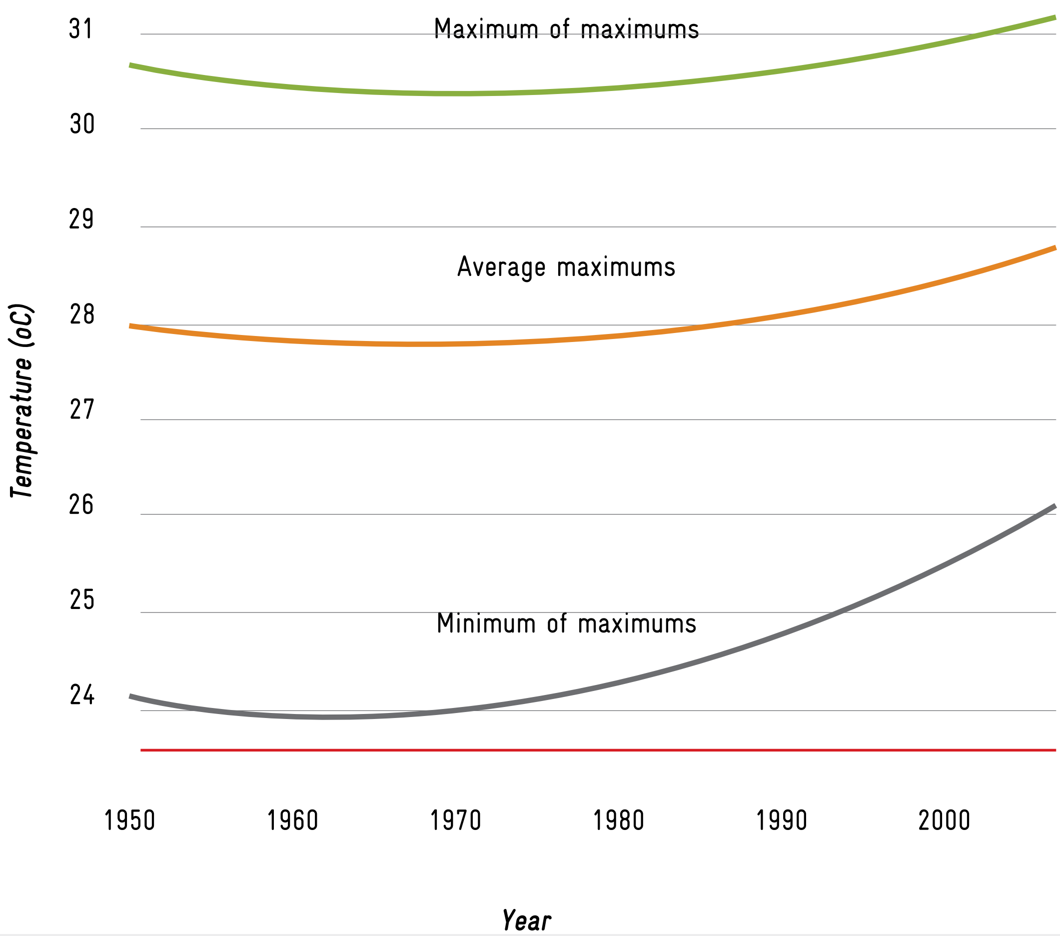


Figure 6: The trend of maximum temperatures from 1950 to 2000
[Source: Mubiru et al., 2012]

MODULE II: AGRICULTURAL PRODUCTION AND CLIMATE CHANGE

Effect of Climate change on food security and appropriate adaptation and concepts	
Estimated duration	120 minutes
Module guiding questions	a. What are the key agricultural production sectors in Uganda? b. How has climate change affected the different agricultural production sectors? c. What is food security and what are the different dimensions of food security? d. How has climate change affected the different dimensions of food security? e. What are agricultural value chains? f. What are the key impacts of climate change on agricultural value chains and how can they be addressed?
Session Objective	• To make participants appreciate the importance of climate change and how it has affected the different agricultural production sectors (Agriculture, Fisheries, Livestock, Forestry, & Water sector) • To make participants appreciate the different dimensions of food security • Identify relevant climate change impacts on agricultural value chains for selected commodities in different areas and how they can be addressed.
Preparation	• Prior knowledge and information on the different agricultural production sectors • Prior knowledge and information on food security and its different dimensions • Specific information and data on food security from Lango, Acholi and Karamoja sub-regions • Chart with examples of agricultural value chains (crop, livestock, fisheries)
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Pieces of paper for the trainer/trainees to state a. Agricultural production sectors b. Effects of climate change on the agricultural production sectors
Session type and delivery methodology	• Presentations • Plenary discussions • Group work to discuss the effects of climate change on the agricultural production sectors • Field visits to some areas where impacts of climate change on agricultural production value chain segment(s) can be observed
Take home and follow up	• The different agricultural production sectors in Uganda are: crop, livestock, fisheries, forestry, and water • Food security is when people have safe and nutritious food in the right quantities at all times • The four dimensions of food security are: availability, accessibility, utilization and stability • Agricultural production value chains have three stages: pre-production, production and post-harvest • Climate affects all stages of the agricultural production value chain

Background Information to assist the trainer

Introduction

In Uganda, the agricultural sector contributes about 24.2% to the total economy according to UBOS (2019), over 90% export earnings and employs about 70% of the labour force. Although Agriculture previously contributed as high as 64.1% (for example in 1985), it has progressively declined probably because of a diversified economy and the impact of factors that influence agricultural production.

Agricultural production fluctuates with climate variability and change particularly rainfall as most of the agriculture in Uganda is rain-fed. The variability in the rains received both in time and space (when and where it is received) affects the agricultural output. Thus climate change with its effect on all weather conditions affects the timing and intensity of rains, which ultimately affects food security and livelihoods in particular. Therefore, there is a great need to be ready to practice agriculture in a changing environment that is influenced by climate change.

Contribution of the different agricultural production sectors to Uganda's economy (UBOS, 2019)	
Crops (food & cash)	14.9%
Livestock	4.3%
Forestry	3.5%
Fisheries	1.5%
Total	24.2%

Session I: Climate Change and Food Security

Effects of Climate change on agricultural production

Climate change is expected to cause yield reductions in important food and cash crops in the long term. The direct impacts such as erratic rainfall, high temperatures and extreme events, several indirect impacts such as increased runoff and erosion rates as well as increased losses from crop pests, diseases and weeds will significantly magnify production losses. The observed shift in rainy seasons (September-November) and (March-May) and short or prolonged dry seasons in some regions distorts growing seasons, affecting the timing of planting activities by farmers. This affects the timing of field preparation and planting with negative implications on crop growth, intensification of crop diseases and pests, resulting in lower yields.

Crop production is also directly affected by heavy rains. For example, the unusually heavy rains in March 2010 caused landslides in the Bududa District of the Mount Elgon region burying three whole villages, including crops and livestock. In 2011, the district of Bulambuli was also strongly affected by landslides, which destroyed homes and crops. Landslides also frequently destroy crops and livestock in the highlands of south-western Uganda. A value chain analysis of crops most widely grown in Uganda showed that many crops are vulnerable to rising temperatures, increasing dry season and unpredictable rainfall patterns (USAID, 2013); with Arabica coffee being particularly vulnerable, while cassava is the least vulnerable. From the study, most to least sensitive crops are: Arabica coffee, Robusta coffee, rice, maize, East African Highland Banana (matooke), beans, sorghum, sweet potatoes, and cassava.

In addition, crop production in Uganda is affected by pests and diseases, whose outbreak and prevalence has been linked to climate change and variability. The most important economic pests and diseases include, Banana Bacterial Wilt (BBW); Coffee Wild Disease (CWD); Black Coffee Twig Borer (BCTB); Maize Streak Virus; Fall Army Worm; Aphids; Cassava Brown Streak Disease (CBSD) and Cassava Mosaic Disease (CMD). For example, available data shows that in the FY2016/17, the fall armyworm reduced national production by 15-30% by causing poor yields of mainly maize, sorghum and cassava.

Climate change affects crop production by reducing the area of land suitable for production. For example, beans are projected to experience the greatest decreases with an up to 70% potential decrease in areas suitable for production by 2040-2069 (Figure 7). In contrast, millet, banana and groundnut are projected to increase in suitable areas, albeit only slightly (5-10%). Further, projections show that by 2050, the value of the coffee crop could fall by half, due to contraction of the area that can support its production (as a result of a changing climate), costing the country up to USD 1,235 million. This could be a huge impact on an economy that derives up to 18% of its export earnings from coffee. Estimates of impacts on tea growing areas also indicate significant losses of up to 50% (fall in production) by 2050. An IFPRI (International Food Policy Research Institute) modeling shows potential losses of cotton production due to yield impacts in the range of 60-77% by 2050. If no action is taken on climate adaptation, Uganda could lose up to USD 1.5 billion on food crops (cassava, groundnuts, maize, millet, pigeon peas, potatoes, rice, sorghum, soybean, sugar cane and sweet potato), due to climate change impacts by 2050.

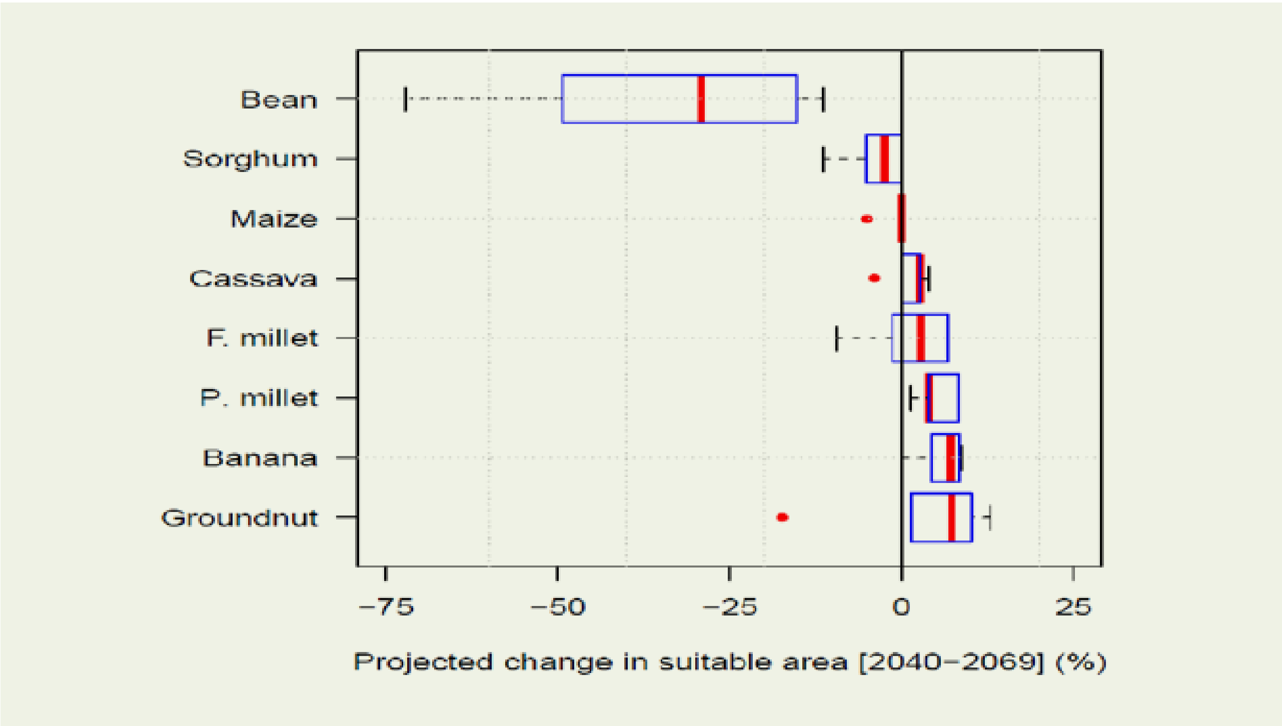


Figure 7: Percent change in a suitable area for major crops in Uganda due to climate change (J. Vargas, CIAT)

[The red line represents the average projected change and the blue box and dashed lines represent uncertainty associated with the crop modeling]

The effects of climate change on livestock production in Uganda are manifested by reductions in water and pasture availability, increased incidences of livestock pests and diseases and livestock mobility (transhumance). Increasing temperatures and warming due to climate is expected to alter the feed/water access and intake, mortality, growth, reproduction, maintenance and production of animals - all of which have a negative impact on livestock productivity (GoU, 2018).

Some areas also suffer livestock disease outbreaks of foot and mouth disease, black quarter/blackleg, tick-borne diseases, and lumpy skin which are associated with weather changes in districts like Kitgum, Agago, Pader and Lamwo, among others (IPCC, 2017).

The economic impacts of climate change to farming households through livestock diseases are diverse: farmers incur costs of disease control, treatment, and vaccination. Direct losses are associated with animal mortality, reduced milk production, and limited use of animals for traction. The total annual economic cost for diseases in cattle alone is estimated at USD 76.5 million (Taghouti Ibtissem *et al.*, 2015). In pastoral communities, drought may lead to cattle migration, which increases the risk of cattle diseases and intercommunal conflict. Studies have also shown that at temperatures higher than 30°C, heat stress leads to low production in poultry by reducing the rates at which poultry gain body weight, feed intake, carcass weight as well as the content of protein and muscle calorie. On hens, heat stress reduces production efficiency and thus egg production due to reduced food intake and interrupted ovulation. Heat stress has also been associated with low sperm count in livestock.

Capture fisheries and aquaculture are vulnerable to climate change and variability. Fisheries have critical thermal maxima and minima and cannot survive temperatures that exceed their threshold. Climate change affects fisheries in a number of ways including increasing water temperatures; extreme weather events which lead to fluctuations in water levels (floods, droughts, storms); changes in water quality parameters such as pH, conductivity and turbidity; decreasing pH, and; changes in current open water productivity patterns. Value chain analyses show that the impacts of climate change on fisheries in Uganda result from an increase in mean air temperature, changes in rainfall patterns, and an increase in extreme weather events (GoU, 2018).

Food Security

Food security is the outcome of food system processes all along the food chain. Climate change will affect food security through its impacts on all components of global, national and local food systems. "FAO's vision of a world without hunger is one in which most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat." (FAO, 2007).

> "Food security exists when all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996).

Household food security is the application of this concept to the family level, with individuals within households as the focus of concern. For this to happen in the focal region, one must have sufficient conditions for growing crops and sufficient fodder for the livestock, both of which are vital for a "food secure balanced diet" at all levels and all the time.

According to reports by the World Bank (2013), Climate change can potentially impact agricultural production and productivity through effects and impacts of:

- reducing the area suitable for agriculture,
- altering the length of the growing season,
- reducing the yield potential,
- increasing the frequency and severity of extreme events (in particular droughts and floods)
- Increasing the incidence of plant diseases.
- Pests and disease (Desert Locusts, fall armyworms and " Covid19")

The different effects and impacts will determine how much food can be produced in such unpredictable weather and climatic conditions. Effects on food production and productivity will in turn affect the capacity to access different livelihood assets (Box 2).

Box 2: Types of livelihood assets (illustrative examples)

Human capital	Household members, active labour, education, knowledge and skills
Physical capital	Livestock, equipment, vehicles, houses, irrigation pumps
Natural capital	Land, forests, water resources, grazing land, fisheries, wild products and biodiversity
Financial capital	Savings/debts, gold/jewellery, income, credit, insurance
Social capital	Family & friends networks, group memberships, socio-political voice and influence

The four dimensions of food security
- Food Availability
- Food Accessibility
- Food Utilization
- Food Systems Stability

Climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns.

Session II: Agricultural production value chains

A value chain is not an object that you can see. Rather, a value chain is simply a useful way of understanding how the world of producing, buying and selling things works. We are all part of value chains in one way or the other as producers, consumers of goods and services, processors, retailers, finance providers, etc.

A 'value chain' in agriculture identifies the set of actors and activities that bring a basic agricultural product from production in the field to final consumption, where at each stage value is added to the product

As consumers, we all eat and we all wear clothes, and so we are linked to many value chains – chains of grain crops, roots and tubers, fruits and vegetables, legumes, oils, and textiles. These chains stretch from growers to our kitchens, eating tables, clothing, and beyond.

The agricultural production value chain consists of three phases: namely pre-production, production and post-harvest. Due to climate change, food losses occur in all three phases. The agricultural production challenges experienced by farmers in the different phases of the value chain are listed in Table 2

Table 2: Agricultural production challenges experienced by farmers in the different phases of the value chain

Phase	Challenge
Pre-production	• Inability to open land on time • Lack of inputs (seed, breeds, fertilizer, farm implements/equipment, etc.)
Production	• Poor soil fertility • Inadequate soil moisture • Weed infestation • Degraded cropping and grazing land
Post-harvest	• Rudimentary harvesting methods • Inappropriate grain processing methods • Poor/lack of storage facilities • Poor/lack of processing facilities • Lack of knowledge and skills in value addition

With farmers not able to open land on time because of using rudimentary tools and inappropriate farming methods and lack of site-specific weather forecasts, valuable rainwater is lost as farmers struggle to open land and making farm decisions. This has drastic effects on crop productivity.

For instance, the current maize production, productivity, and quality have stagnated due to several biotic and abiotic factors including, pests and diseases, declining soil fertility, drought stress and inadequate extension services, among others. Average yields have remained as low as 2.2 – 2.5 MT/ha, compared to the potential of 8 MT/ha (FAO, 2020).

Annual food losses in the post-harvest phase have been estimated to amount to 17.6% for about 2.8 million metric tonnes (MT) of maize, 12.4 per cent of about 214,000MT of millet and 13.5 per cent of 230,000MT of rice produced in the country (FAO, 2020)

Some illustrations from past experiences include floods in the Teso and Lango sub-regions, which led to crop losses of cassava, groundnuts, maize and sweet potatoes which have traditionally provided food security for those areas (Figure 8[a-b]).

Figure 8(a): Food losses due to floods experienced in the Teso sub-region in 2007 (Source: NARO)

Figure 8(b): An illustration of the effects of floods (Source: Uganda Landcare Network)

When there is extended dry period beyond what is normally experienced in the region, this still leads to crop failure (Figure 9[a-b]), loss of pasture through burning and sometimes leading to local migrations in search of pasture and water, usually leading to conflicts of the affected people and host communities.

Figure 9(a): A decimated maize crop due to inadequate rainfall (Source: NARO)

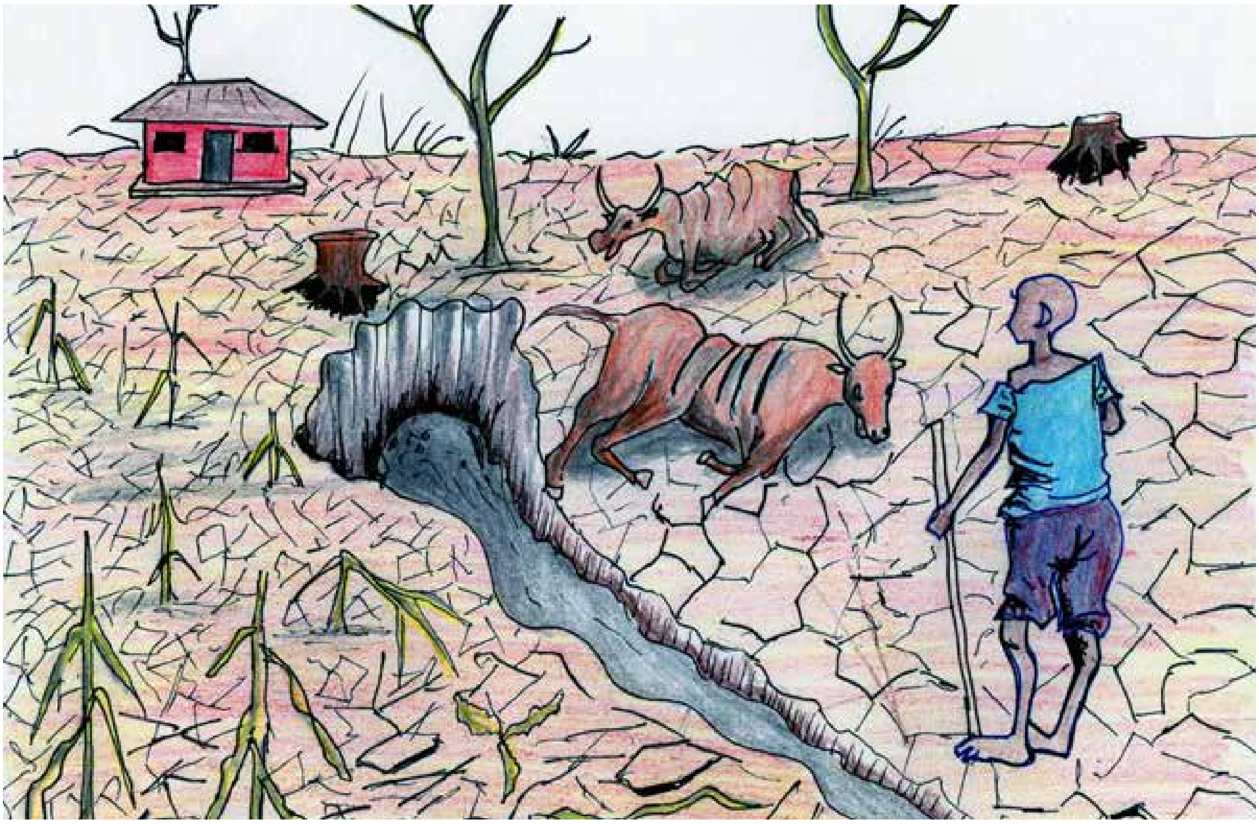


Figure 9(b): An illustration of the effects of extreme drought (Source: Uganda Landcare Network)

It is, therefore, critical for the trainers to appreciate, and make farmers appreciate that "Climate change and its impacts on food security" are real and we all have to prepare for living in the same/similar situation (s). This can only be done using means and appropriately applied technologies for Climate Smart Agricultural practices.

MODULE III: CLIMATE SMART AGRICULTURE (CSA) CONCEPT AND PILLARS

Climate Smart Agriculture (CSA) and its application for climate action	
Estimated duration	60 minutes
Module guiding questions	This module is intended to introduce to participants the concept of climate-smart agriculture. It is also intended to introduce the participants to the three pillars of CSA and the benefits of using CSA a. What is Climate Smart Agriculture? b. What makes a technology/practice climate-smart? c. Are there any practices that are climate-smart in your local area? d. What have been the benefits/experiences of using CSA practices?
Session Objective	• At the end of the session, participants should be able to articulate the CSA concept and its 3 pillars to guide application in their areas of operation. • The trainees to appreciate how CSA can improve agricultural production amidst climate change.
Preparation	• Prior knowledge and information on the CSA concept • Chart with the three pillars of CSA
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Pieces of paper for the trainer/trainees to state a. Pillars of CSA b. CSA practices c. Benefits of CSA
Session type and delivery methodology	• Presentations • Plenary discussions • Group work to align benefits of technologies/practices into the three pillars of CSA
Take home and follow up	• CSA is a means of sustainable agricultural production amidst a changing climate • The three pillars of CSA are productivity (food security), adaptation (resilience), mitigation (reduction of GHGs)

Background Material to assist the trainer

Introduction

Uganda as a country faces declining agricultural yields, which is partly attributed to climate change challenges such as unreliable rainfall, and increased frequency of prolonged droughts and floods. Climate change challenges are worsened by ecosystem degradation and conflicts. Northern Uganda is no exception to the challenges from climate change. It is also important to note that about 95% of agriculture in the region is rain-fed and therefore affected by weather variability and climate change. It is therefore of paramount importance to build the capacity of local farmers in climate-smart agricultural technologies and practices. The understanding of climate-smart agriculture has to be better appreciated by the farmers to flexibly apply the practices and principles.

What follows is an attempt to localize what the concept of SCA is in the context of agriculture in Uganda.

Session I: Climate Smart Agriculture (CSA) and its application for climate action

The CSA Concept

The CSA concept reflects an ambition to improve the integration of agricultural development and climate responsiveness. It aims to achieve food security and broader development goals under a changing climate and increasing food demand. CSA technologies sustainably increase productivity, enhance resilience, and reduce or remove GHGs. However, the implementation of technologies requires planning to address trade-offs and synergies (co-benefits and "triple-wins") between the three CSA pillars: productivity, adaptation, and mitigation.

Climate Smart Agriculture (CSA) includes farming practices that sustainably increase productivity, enhance resilience (adaptation), reduce or remove GHGs (mitigation), and enhance achievement of national food security and development goals (FAO, 2010). CSA is therefore founded on three important pillars: productivity; adaptation and mitigation.

The pillars of CSA

- Increase productivity
- Enhance resilience of communities and landscapes (adaptation)
- Reduce or remove GHGs (mitigation)

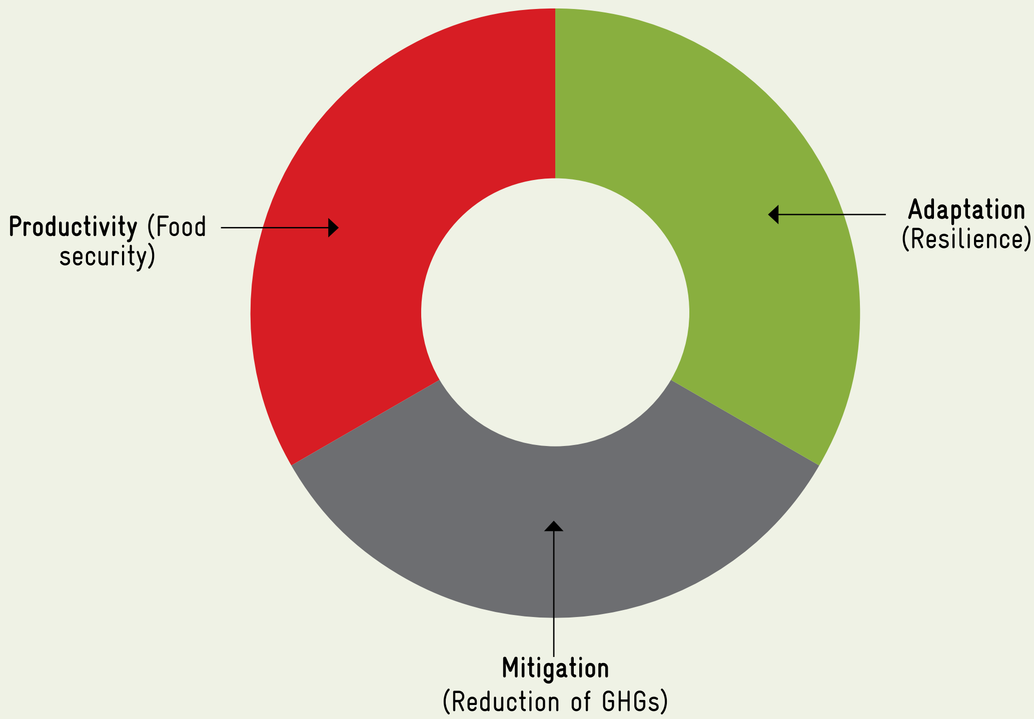
It is important to note that CSA is not a technique, a new production system or a one-size-fits-all set of practices, but rather a three-tiered action-based approach to identify existing production systems that can best respond to the impacts of climate change.

What is Climate Smart Agriculture (CSA)?

Climate Smart Agriculture is an integrated approach where agriculture is understood in a broad sense which includes crop and livestock production, forest management and fisheries (CCAFS and FAO, 2014) for food, fibre, fodder, fuel, building materials, medicinal products and water (FAO, 2010)

Climate-smart agriculture (CSA) may be defined as an approach for transforming and reorienting agricultural development under the new realities of climate change (Lipper et al., 2014). The most commonly used definition is provided by the Food and Agricultural Organisation of the United Nations (FAO), which defines CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals". In this definition, the principal goal of CSA is identified as food security and development (FAO 2013; Lipper et al. 2014); while productivity, adaptation, and mitigation are identified as the three interlinked pillars necessary for achieving this goal

The three pillars of CSA



- **Productivity:** Climate change has affected agricultural productivity by reducing crop yields, and livestock, forestry and fisheries products. Technologies and practices that can help maintain/sustain agricultural productivity amidst a changing climate are called climate-smart. Maintenance and sustenance of agricultural productivity ensures food and nutritional security of household, making it one of the pillars of CSA

- **Adaptation:** Technologies and practices used to adjust to actual or expected climate change and its effects help to enhance the resilience[1] of households, communities and landscapes to climate change, thus making adaptation another pillar of CSA. For example, soil and water conservation technologies and practices help to harvest and conserve rainwater in the soil such that even when there isn't enough rainfall agricultural production can continue with little or no disturbance; thus making the system resilient to climate change

Adaptation has been defined by IPCC as "the process of adjustment to actual or expected climate change and its effects". In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. Adjustments in form of climate change adaptation include actions in different sectors such as infrastructure, agriculture and education. In terms of adaptation measures, there are several actions that help reducing vulnerability to the consequences of climate change. Adaptation actions can be considered as either incremental adaptation (actions where the central aim is to maintain the essence and integrity of a system such as protection of swamps) or transformational adaptation (actions that change the fundamental attributes of a system in response to climate change and its impacts). Climate Smart Agriculture can be planned to promote elements of both adaptation and mitigation.

- **Mitigation:** CSA can help to reduce agriculture's contribution to climate change by reducing GHG emissions or completely removing them. Any action that helps to reduce GHG emissions is dabbed mitigation.

Some of the actions that can be taken to contribute to mitigation for climate change include, but are not limited to:

- Landscape restoration e.g. by implementing sustainable land management (SLM); this does not only increase land productivity and resilience but also helps in reducing emissions
- Reforestation

Other actions that are taken to reduce and curb GHG emissions include:

- Practicing energy efficiency
- Greater use of renewable energy
- Electrification of industrial processes
- Efficient means of transport implementation, e.g. electric public transport, bicycle, shared cars, carbon tax and emission markets.

It is important to note that measures and actions to be taken are site and time-specific. Therefore an analysis of the prevailing situation on the ground will give a sense of direction on what measures to put in place.

1 Resilience is the ability of a system to spring back/rebound/return to its original state after a negative effect

MODULE IV: GENDER ACTION LEARNING SYSTEM (GALS) METHODOLOGY

Session I: Background

Background on gender mainstreaming and the GALs methodology	
Estimated duration[2]	30 minutes
Session guiding questions	This session is intended to introduce the framework for gender mainstreaming in agricultural development programs The key guiding questions are: a. What do you understand by the term GENDER? b. What is gender mainstreaming? c. What are the strategies and methods of gender mainstreaming? d. What are the steps taken in gender mainstreaming? e. What are the approaches used to understand interactions between men and women (e.g. roles & responsibilities, decision-making, ownership and resource utilization, benefits sharing, access to inputs and information)
Session Objective	• Make participants appreciate the guiding principles in the GALS methodology in agricultural production
Preparation	• A clear understanding of what gender means • Prior knowledge and information on gender interactions vis-à-vis local contexts/experiences • Prior knowledge and information on the guiding principles of the GALS methodology (especially, participation & leadership) • Charts with illustrations elaborating the contexts of gender
Materials/resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Audio-visual aids • Pieces of paper for the trainer/trainees to state a. elements of gender in their local language (Luo/Akaramojong) [check the English equivalents] b. genders interactions in the local context
Session type and delivery methodology	• Presentations • Plenary discussions • Pictionary/gender role play
Take home and follow up	• Gender is not about sex • It is Important to mainstream gender in development programs

2 Time not inclusive of practical sessions

Training on gender mainstreaming and the GALs methodology

Gender mainstreaming is the process of integrating a gender equality perspective into the development process at all stages and levels. This is a very sensitive topic that the CSA facilitator should handle with care. It is important that during the plenary, learners are asked to share and discuss their understanding of gender and the difference between 'sex' and 'gender'. Through a brainstorming session, ask participants to write as many terms on their understanding of gender as they can. Discuss and agree on the commonly used terms and write them on a flip chart. In buzz groups, assign learner's specific terms and ask them to come up with working definitions. Share and discuss these in plenary. Having fully understood gender and its related terms, task the learners to explain their understanding of the concepts of gender mainstreaming and integration. In plenary, let the learners discuss the difference between mainstreaming and integration. The following steps are important to guide the process:

Step 1: Strategies and methods in gender mainstreaming

- Ask the learners to explain what they understand by the terms 'strategy' and 'methods' by giving an example of each.
- Let them identify any strategy and methods known to them, which are commonly used in gender mainstreaming.

Step 2: Levels of gender mainstreaming

- By using question and answer method, ask the learners to identify the levels at which gender mainstreaming is done.
- Let them give the rationale for mainstreaming gender at the different levels of testing and implementing climate-smart agriculture.
- Summarize key issues of mainstreaming gender at each level.

Step 3: The process of gender mainstreaming

- The facilitator introduces the steps in gender mainstreaming at each level.
- The learners suggest key elements at each level of the gender mainstreaming process.
- Summarize key issues on participation of women and men at each level of the mainstreaming process.

The GALS methodology is one of the fundamental tools that can be adopted to promote gender transformation and gender mainstreaming in any issue including general life planning, environment management, conflict resolution and climate change resilience.

About the GALS methodology

GALS is a community-led empowerment methodology which aims to give women as well as men control over their lives and catalyze a sustainable movement for gender justice. Women and men draw their individual visions for change, with achievable targets and road maps to move towards these visions, based on analysis of their current situation, past achievements and opportunities/strengths and challenges. The vision journey is a reflection and planning tool that enables individuals and communities to dream for a better life and develop SMART plans of how to achieve their visions. The Vision Road Journey is the basic framework tool for the Gender Action Learning (GALS3) methodology. The GALS methodology and specifically the Vision Road Journey is easy to use especially by the illiterate and semi illiterate communities as it largely uses visual diagramming and symbols to express themselves as opposed to writing.

3 GALS (Gender Action Learning System) is a community-led empowerment methodology that aims to give women and men more control over their lives and catalyse and support a sustainable movement for gender justice.

Session II: The Vision Road Journey

The Vision Road Journey	
Estimated duration[4]	120 minutes
Session guiding questions	This session is intended to address issues of gender inequality in agricultural production in regard to resources allocation, roles & responsibilities, decision-making, ownership and resource utilization, benefits sharing, access to inputs and information. The key guiding questions are: a. What is the vision road journey? b. What are the steps along the vision road journey? c. What are lessons learnt in each step?
Session Objective	• To make participants appreciate the usefulness of the vision road journey in joint households/community planning, using a gender mainstreaming lens
Preparation	• A clear understanding of household planning dynamics • Prior knowledge and information on approaches that can be used for gender mainstreaming in the local context • Prior knowledge and information on the vision road journey • Illustrations/charts of any available case scenarios on the vision road journey
Materials/resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Audio-visual aids [song on the steps] • Pieces of paper for the trainer/trainees to draw a. The vision road journey in the local context (language -(Luo/Akaramojong), situation) [check the English equivalents] b. Case scenarios
Session type and delivery methodology	• Presentations • Plenary discussions • Pictionary/gender role play • Interactive drama • Group work
Take home and follow up	• The opinion/vision of each and every household/community member is of importance • The road vision journey is drawn to show where one wants to be, where they are now, and the different stages they go through to achieve the desired vision • The road vision journey can be used at the household and community level • The road vision journey shows the importance of the different gender groups working together to successfully reach a desired vision • A shared vision regardless of the differences in the household paves way for success. • The road vision journey is a necessary tool to guide transformational development

4 Time not inclusive of practical sessions

The Vision Road Journey has 6 major steps as illustrated in Figure 10

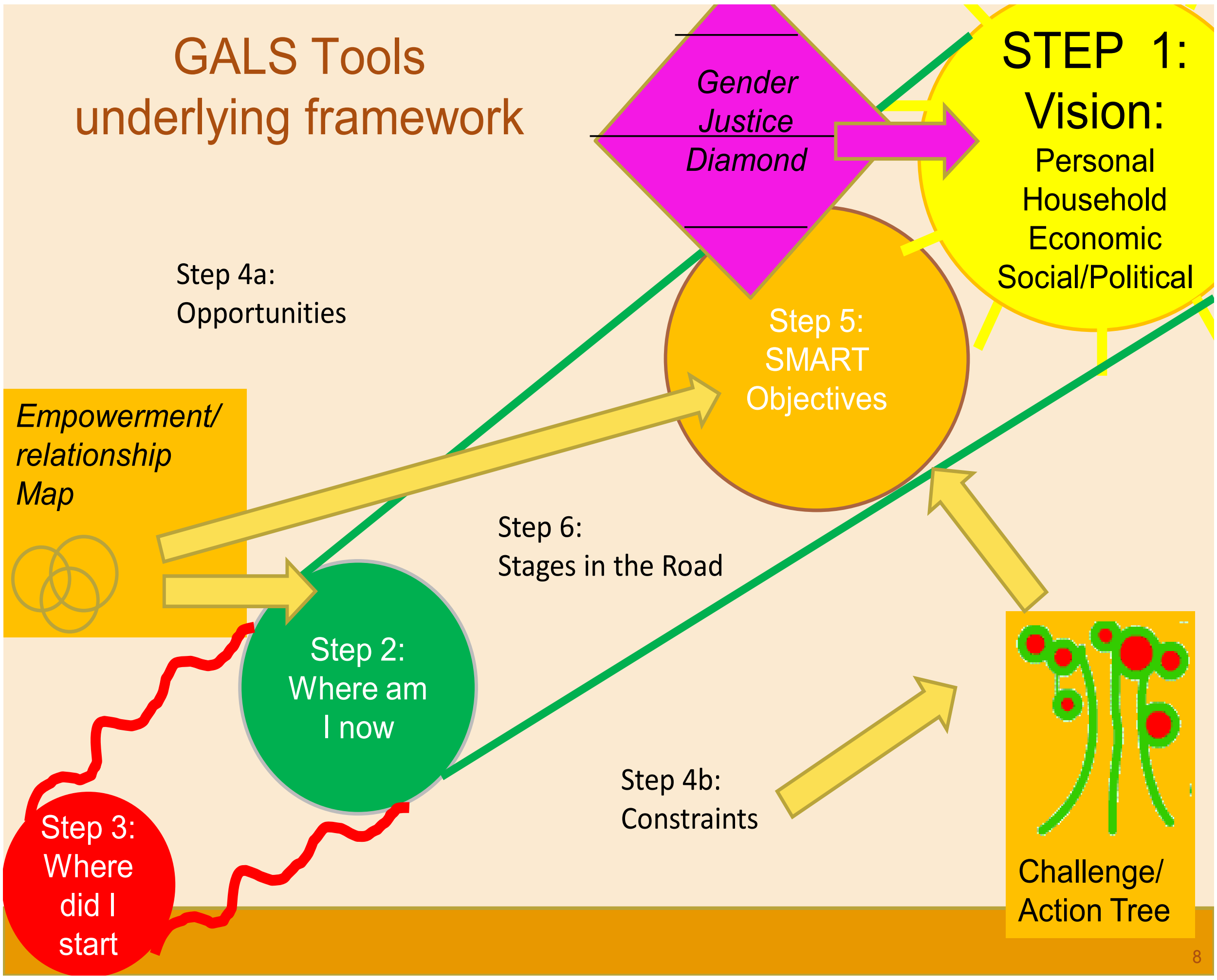


Figure 10: Rocky road to diamond dreams
(Source: New GALS Manual - 2014)

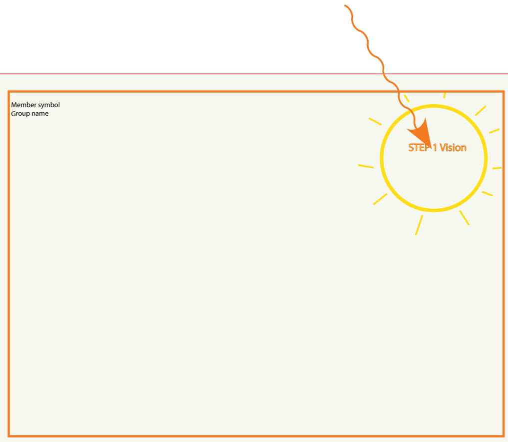
Steps in drawing the Vision Road Journey

The facilitator goes slowly through the steps with participants drawing on the blank flipchart while everyone else draws in their notebook diaries.

In all the exercises and steps, special reflection should be made to how the learner relates the changes to agricultural enterprises in terms of past and present situation which can be changed to a desired future and relevant actions for a better future. Each of the learners can select an agricultural enterprise to use for the exercises

Step 1: First circle – future

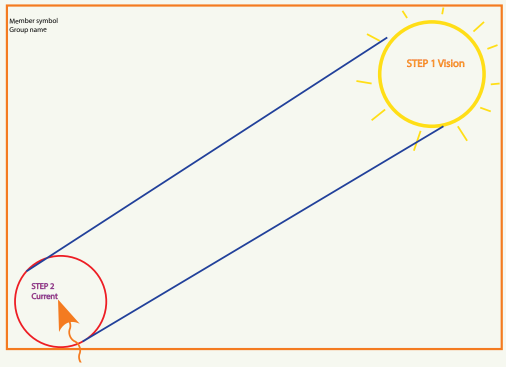
Draw a large circle at the top right hand corner of your page. This represents the desired future of a particular enterprise such as crop farming, livestock farming and household assets such as houses. It is a large circle at the top because it is like a sun and you are reaching for the sky. It is the vision which will inspire you to pick yourself up, and continue to move forward if you fall and stumble on the rocks along the road.



Step 2: Second circle – present and drafting the road

Draw a second large circle at the bottom left hand corner of the flipchart. This represents the present situation.

Draw two straight lines to link both circles. This represents your road from the present situation (bottom) to the future desired state (top). The road is straight and upwards, because this is how you hope you will reach up to your vision. In the bottom circle draw how your current starting situation is for things in your vision e.g. what type of house do you have now, who owns it?

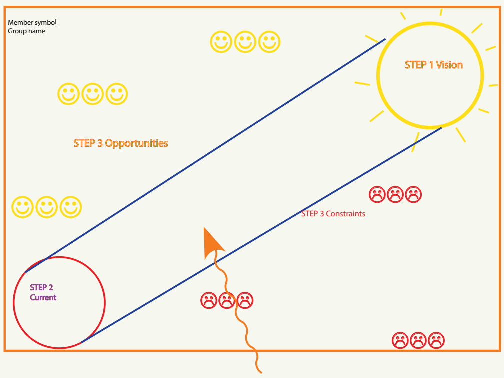


Step 3: Opportunities and constraints

On either side outside the road you will draw: insert at least 10 opportunities at the top of the road– the things which will lift you up if you fall down. The more opportunities you can think of, the easier it will be to advance. At least 10 constraints go under the road because these are the things that can drag you down. It is important to foresee and avoid them if possible. The things which are most under your control are placed nearest to the road. The things which you cannot control go furthest from the road.

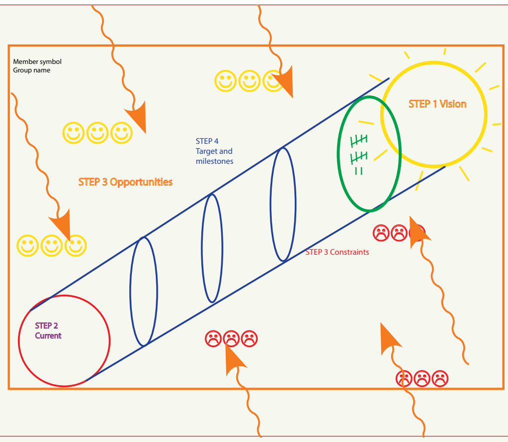
Emphasize the importance of identifying as many opportunities as possible – particularly ones over which the learners may have some control. It is that deep reflection and brainstorming which will really help people advance. It may be very useful to discuss with neighbors on this.

Also, emphasize to the participants that challenges or constraints are identified in order to foresee them and plan how to address them. Focus on those under one's control and see also if they can be turned into opportunities. Do not waste energy on all the possible disastrous acts of God, unless they can and need to be addressed.



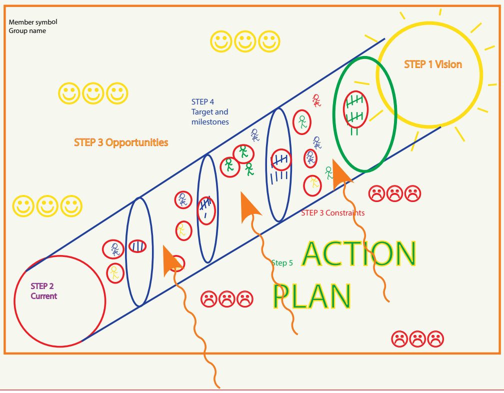
Step 4: SMART Objectives

Participants draw a circle immediately next to the vision and fill in how far they think they can get towards the vision in 6 months.



Step 5: Stages in the Road (25 minutes)

Ask participants to draw a minimum of five activities that they will conduct in order to achieve their SMART objectives. These are drawn in the space between the second circle and the SMART Objectives circle. These activities should reflect actual commitments not imaginations



Session III: Gender Balance Tree

Gender Balance Tree	
Estimated duration[5]	120 minutes
Session guiding questions	This session is intended to address issues of gender inequality in agricultural production in regard to roles & responsibilities. The key guiding questions are: a. What is the gender balance tree? b. What are the steps in the gender balance tree? c. What are lessons learnt in each step?
Session Objective	• To make participants appreciate the various roles & responsibilities that members of a household play to make a happy family/community
Preparation	• A clear understanding of roles and responsibilities in households/communities • Prior knowledge and information on the dynamics of household/community roles and responsibilities • Prior knowledge and information on the gender balance tree • Illustrations/charts of any available case scenarios on the gender balance tree • The trainer should prepare for likely scenarios of volatile situations
Materials/resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Audio-visual aids [song on the gender balance tree] • Pieces of paper for the trainer/trainees to draw a. The gender balance tree in the local context (language -(Luo/ Akaramojong), situation) [check the English equivalents] b. Case scenarios

5 Time not inclusive of practical sessions

Session type and delivery methodology	• Presentations • Plenary discussions • Pictionary/gender role play • Interactive drama • Group work
Take home and follow up	

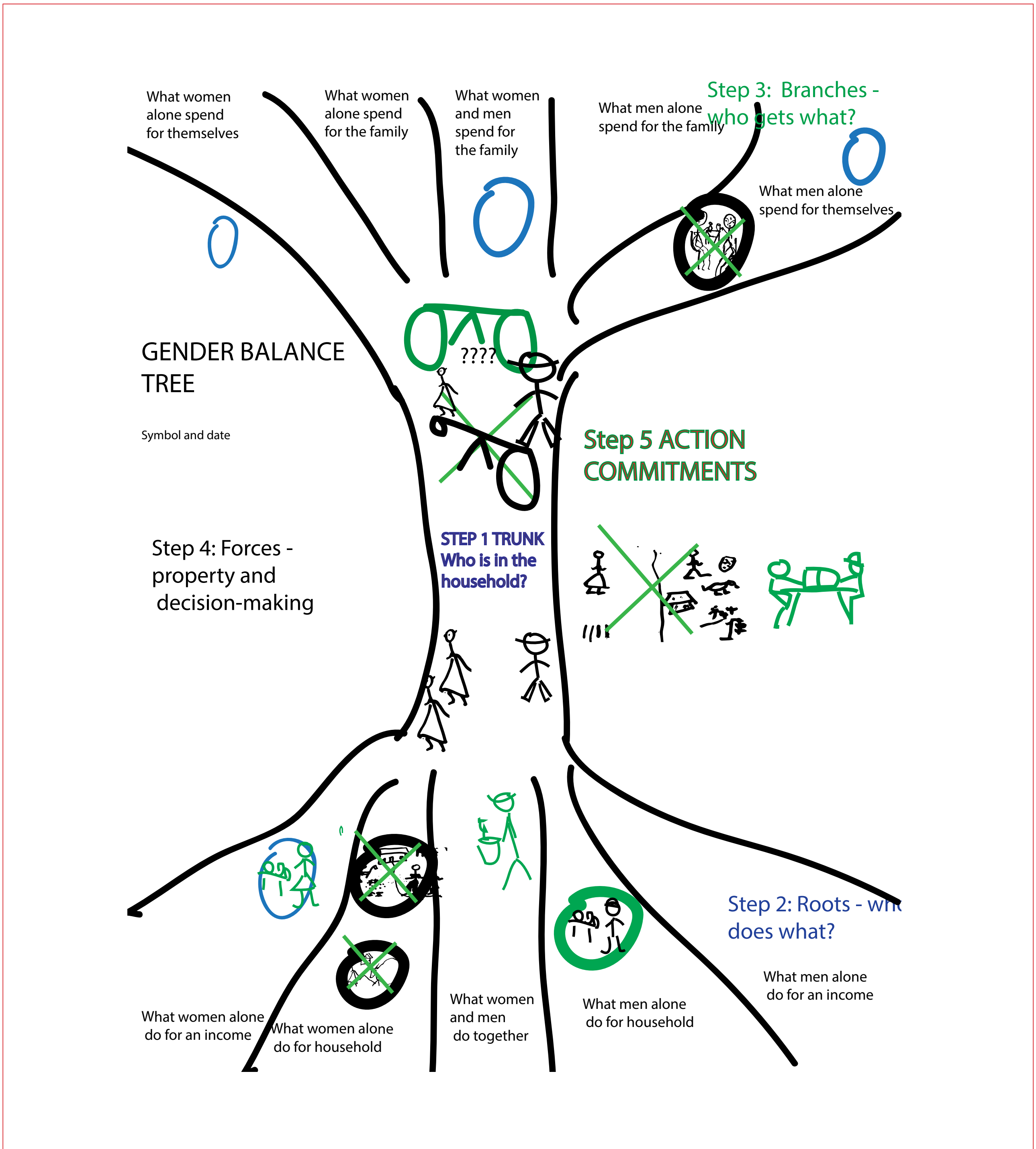


Figure 11: Gender Balance Tree
(Source: New GALS Manual - 2014)

Steps in drawing the Gender Balance Tree

Step 1: Trunk: who is in the household?

Ask participants to draw two lines in the middle of the paper for the trunk:
They should then put symbols for each household member on either side inside the trunk. Working women (including co-wives living in the same family) should go on the left side of the trunk in one colour (e.g. green), working men on the other in another colour (e.g. blue), with dependents in the middle to the side of their respective sex in the respective colour.

Step 2: Roots: who contributes what work?

a. Draw two roots for women and two roots for men on the respective side of the trunk in their respective colour. The central root is for joint activities but the line is in the colour for women/men.
b. On the outside root on each side put the activities which people of that sex perform alone for themselves.
c. On the inside roots put the activities which people of that sex perform alone for the family i.e. housework.

In the central root put those activities which both women and men do, putting the symbol on the side of the sex who does most.

Step 3: Branches who gets what fruit?

a. Draw four branches corresponding to each root, women, men and central trunk for joint household expenses.
b. On the outside branch on each side, draw symbols for personal expenditure that each sex makes for themselves alone.
c. On the inside roots put expenditures which people of that sex contribute to alone for the family

In the central root put those expenditures which both women and men contribute to.

Step 4: What is pushing the tree?

On their respective side of the trunk put symbols for:
- Types of decisions which women and men make – which decisions are made by women only, which by men only, which are made jointly? Or is one person the overall decision-maker or do they always sit down together?

Step 5: Action: what do we want to change?

- Does the tree balance? Are women doing most of the work and expenditure? Are men doing most of the work and expenditure? Put a symbol representing the degree of gender balance at the top of the trunk.
- Identify 5 action commitments – things you want more of or less of to make the tree balance.

Step 6: Facilitator wrap up

- The facilitator gives a brief wrap up and makes sure everyone has the steps in the Manual Section at the back of their Diaries.

Session IV: Empowerment Leadership Map

Empowerment Leadership Map	
Estimated duration[6]	120 minutes
Session guiding questions	This session is intended to show and address the power relations in the household/community The key guiding questions are: a. Who holds power in the household/community? b. What are the linkages between the different power centres? c. What are the roles and benefits of the different power centres? d. What are lessons learnt in the steps of empowerment map?
Session Objective	• To make participants appreciate the different power centres in a household/ community, the linkages, and roles and benefits
Preparation	• A clear understanding of the different power centres in a household/ community, the linkages, and roles and benefits • Prior knowledge and information on the empowerment map • Illustrations/charts of any available case scenarios drawing/using the empowerment maps • The trainer should prepare for likely scenarios of volatile situations
Materials/resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Audio-visual aids [song on the empowerment map] • Pieces of paper for the trainer/trainees to draw a. The empowerment map in the local context (language -(Luo/Akaramojong), situation) [check the English equivalents] b. Case scenarios
Session type and delivery methodology	• Presentations • Plenary discussions • Pictionary/gender role play • Interactive drama • Group work
Take home and follow up	• Each member of the household/community is a power centre in their own right • Power centres are not the preserve of one gender group • Coordinated power centres in a household/community yield better results • Power centres are not static but dynamic

6 Time not inclusive of practical sessions

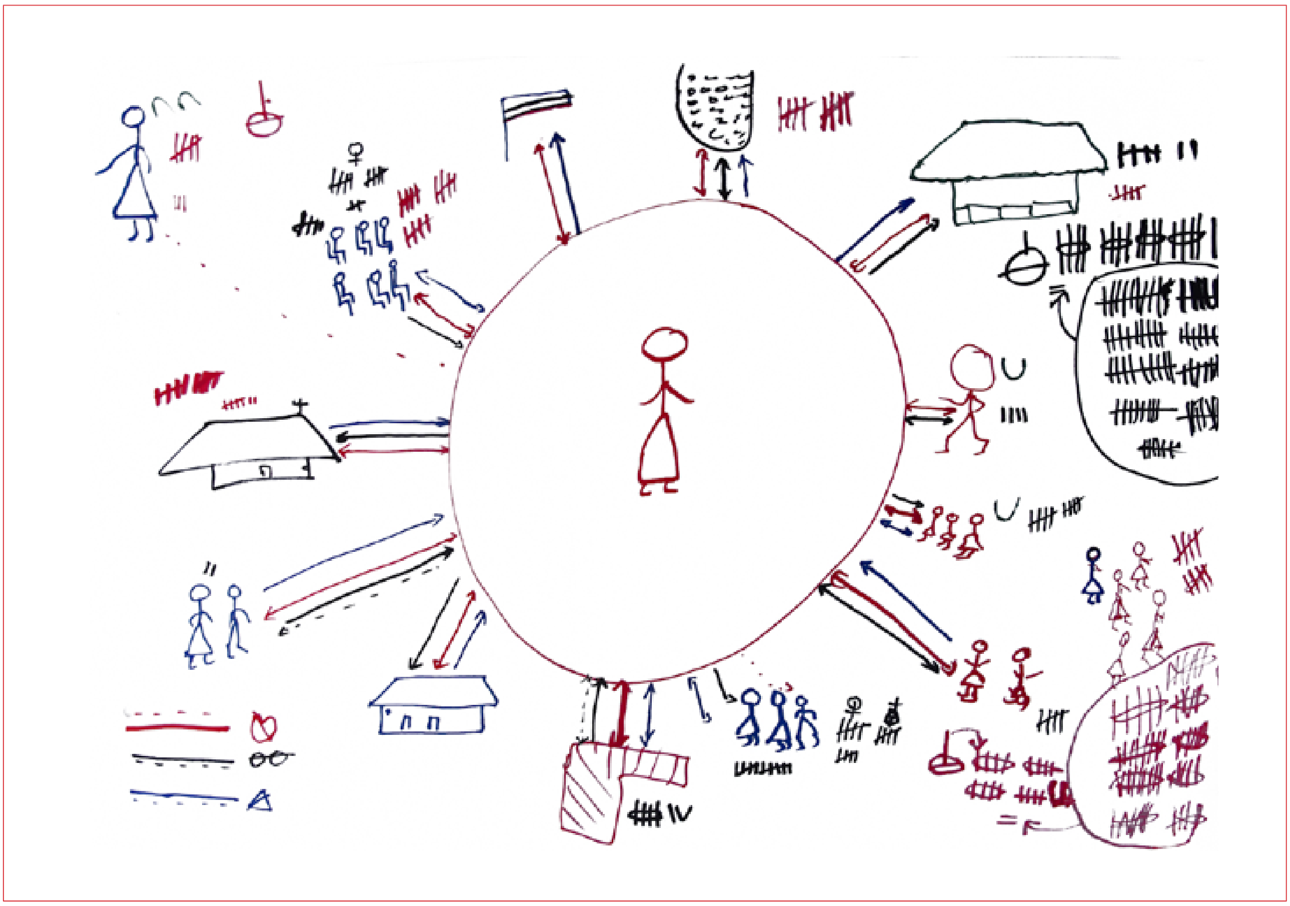
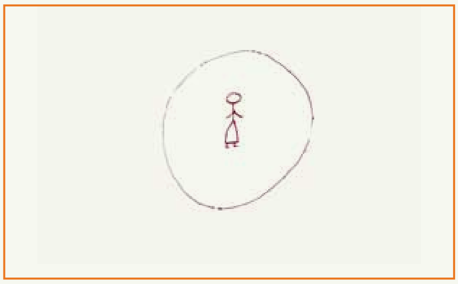


Figure 12: The Empowerment Leadership Map
(Source: New GALS Manual - 2014)

Steps in drawing the Empowerment Leadership Map

Step 1: Who am I?

First draw yourself in the centre of the sheet of paper.



Step 2: Who is important in my life?)

- Draw around you the different people who are 'important' in your life;
- Draw around you institutions which are 'important' in your life;
- In both drawings, work outwards from the centre, putting those who are most important closest to you.
- Important people' are not necessarily only your immediate household or even the wider family. It could include e.g. friends.
- Put men/boys in one colour and women/girls in another.

Step 3: Why are they important?

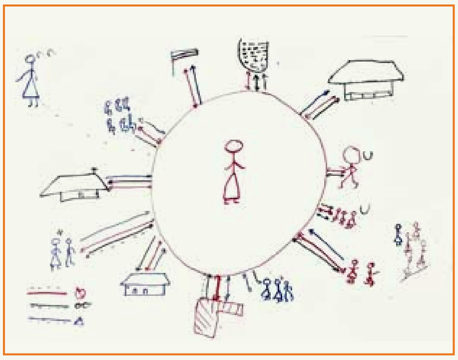
- Map the social/emotional relationships, economic and power relationships as arrows coming from or to yourself, or between other people on your map. Use different colour lines and symbols for:

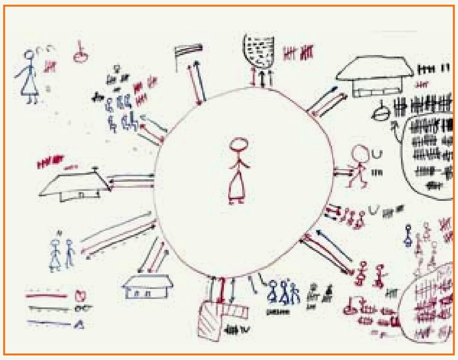
  a. Love (red): Who do I love most? Who loves me?
  b. Money (green): Who gives me money? Who do I give money to?
  c. Power (black): Who has most power on me? Do I have power on them?

- Think about the direction of the arrow and strength of the relationship - stronger relationships should be a thicker line. Weak relationships a thin or dotted line
- Include a key to show the meaning of each colour used. Let the community decide on which colour to use for love, money and power

Step 4: What can I change?

a. What/who can change?
b. What or who can I retain?
c. What or who should I leave?
d. What do I like and want more of?
e. Put a sign for teaching/or a particular tool next to 3-5 people you want to change, 3-5 people you want to retain and 3-5 people you want to leave in the next 6months,
f. Select at least 2 of these people to share with immediately on your return home from this workshop or at least within 1 week.





Step 5: Group work and presentation

- Consolidate the individual Empowerment Maps
- Group presentation

Step 6: Facilitator wrap up

The facilitator gives a brief wrap up makes sure everyone has the steps in the Manual Section at the back of their Diaries.

Session V: Challenge Action Tree

Challenge Action tree	
Estimated duration[7]	120 minutes
Session guiding questions	This session is intended to address the root causes of gender inequality in agricultural production in regard to division of labour. The key guiding questions are: a. What is the Challenge Action tree? b. What are the steps in the Challenge Action tree? c. What are lessons learnt in each step?
Session Objective	• To make participants appreciate the various causes of Gender inequalities and generate possible solutions to reduce them.
Preparation	• A clear understanding of causes and root causes of Gender inequality in households/communities • Prior knowledge and information on the Challenge Action tree • Illustrations/charts of any available case scenarios on the Challenge Action tree • The trainer should have the skills of exploring further the causes and root causes of gender inequality
Materials/resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Audio-visual aids [song on the Challenge Action tree] a. Case scenarios
Session type and delivery methodology	• Presentations • Plenary discussions • Pictionary/gender role play • Interactive drama • Group work

7 Time not inclusive of practical sessions

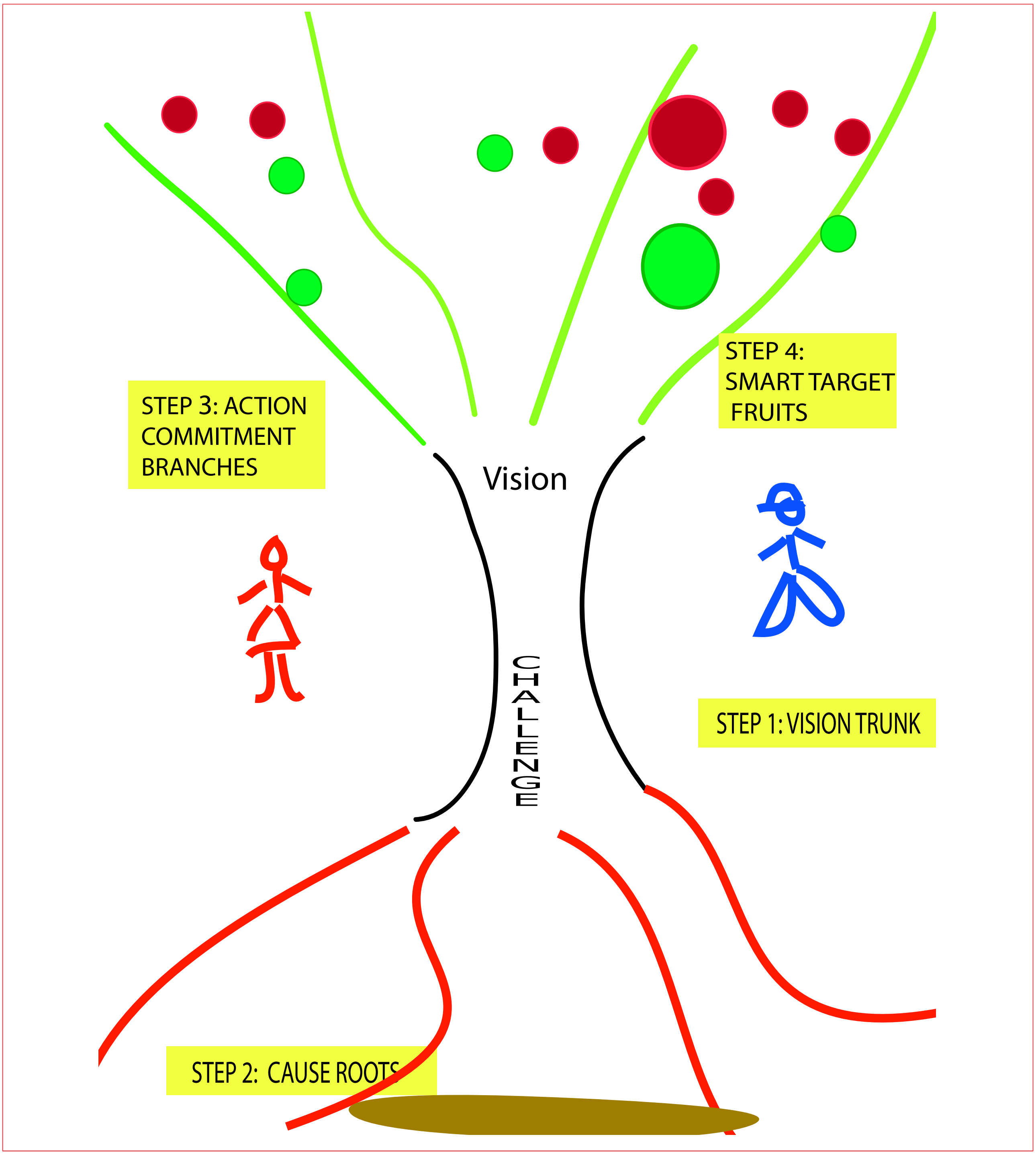
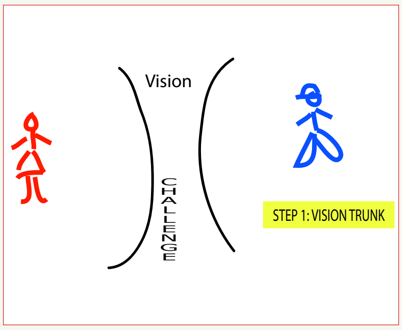


Figure 13: Challenge Action Tree
(Source: New GALS Manual - 2014)

Steps in drawing the Challenge Action Tree

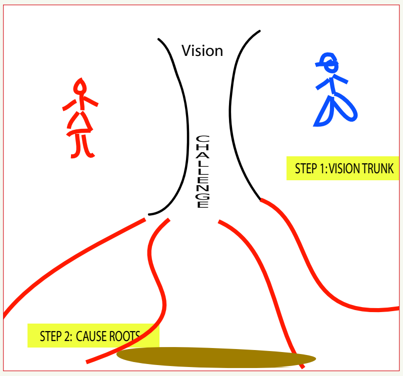
Step 1: Defining the trunk or challenge, and drawing the vision

- Draw two lines for the trunk in the middle of the sheet of paper. What is the main issue or challenge for the Tree?
- Place this towards the bottom of the trunk.
- What is the corresponding vision for the change, how do we put the challenge as a positive aim? Put this symbol towards the top of the trunk.
- Put one side of the trunk for women, one side for men.



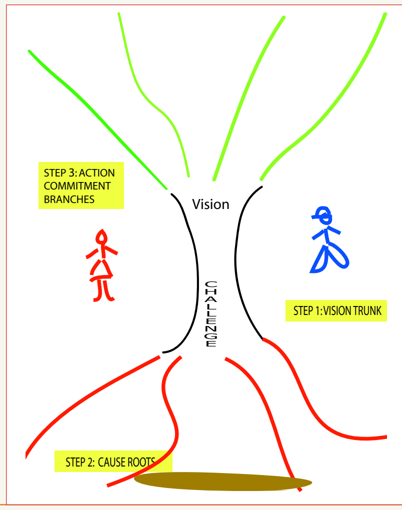
Step 2: Defining the roots or causes

- Each issue has a range of different causes or symptoms which people experience, many interrelated. Some causes are for women, some for men, and some for both.
- The roots then need to be categorised in a way relevant to the particular issue.



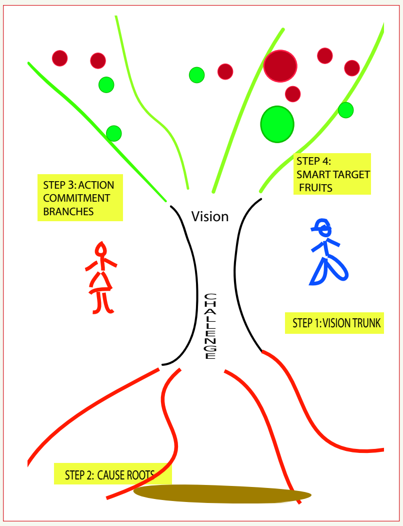
Step 3: Defining the branches or action commitments

- For each root draw one branch. Then for each element on the roots identify an appropriate action, or series of actions which can be taken.



Step 4: defining the SMART fruits or individual achievements

- For each action identify a SMART achievement fruit which can help you to identify whether you are progressing or not.



Module V: COMMUNITY-BASED NATURAL RESOURCES ACTION PLANNING

Introduction

Land is a finite resource. Viable agricultural land in rural areas is consistently becoming scarce due to various pressures including population growth, pollution, erosion, desertification, effects of climate change and urbanization. On the remaining land, local, national and international users with different socioeconomic status and power compete to achieve food security, economic growth, energy supply, nature conversation and other objectives. Action Planning is one of the tools that can help to find a balance among these competing and sometimes contradictory landuse demands.

To implement any activity, people always start with planning. Unfortunately, most of the communities never document their plans. This is an opportunity for the communities to assess the status of natural resources in their area, identify the associated problems occurring and develop an action plan, which in future can be used as a baseline for assessing progress on the implementation of the Climate Smart Agriculture and other interventions.

Action planning structure should fit within the national administrative structure. Knowing that the lowest planning unit is the subcounty, the planning should resonate with this i.e. plan as a village or parish and combine these lower level plans to a subcounty plan since the lowest administrative unit that can hold a budget vote is a subcounty.

It is envisioned that an Action Planning activity should take a minimum of two days. The first day should be for understanding the principles of Action Planning, identification and analysis of the natural resource management related problems, and mapping the current natural resource. The second day should be for developing a vision for the future the planning community wants, setting the goal to enable them achieve that future, developing the action plan to overcome the identified problems and drawing a map of the future they would want to have. The future time being planned for should be agreed upon at the start of the second day e.g. in five or ten-year's time.

Key steps in Action Planning

To develop any Action Plan, there is need;

1. Understand the main goal defining why action planning should be carried out. This is better understood by the project developers/funders, and the facilitators. The facilitators should first bring the community to the same page before starting the planning activity.
2. Identify the problems that are preventing a community in a particular area to achieve the goal.
3. Identify key actions that can be implemented to achieve the desired goal; including opportunities available to achieve the goal, resources required, supervision of action implementation and identification of indicators.

Day 1

Session I: Introduction to Community-based Natural Resources Action Planning

Session 1: Basics of community-Based Natural Resource Action Planning	
Duration	1 hour
Session guiding questions	This session is to enable participants to understand and appreciate the importance and process of community-based natural resource action planning. The key guiding questions are: a. What is community-based natural resource action planning? b. What is the objective of community-based natural resource action planning? c. What are the key steps used in effective community-based natural resource action planning? d. What are the key policy and legal frameworks, which support natural resource action planning? e. What are key natural resources in the planning area?
Session Objective	• To enable participants to understand and appreciate the importance and the process of carrying out community-based natural resource action planning. • To provide knowledge and skills in community-based natural resource action planning in a particular area. • To make participants appreciate the policies and legal frameworks that support community-based natural resource action planning.
Preparation	• Prior knowledge and information on the process of community-based natural resource action planning. • Prior knowledge and information on the policies and legal frameworks that support community-based natural resource action planning. • Prior knowledge and information on existing natural resources in the area and key resources use issues • Maps a. A satellite image/Google map of the targeted area b. Administrative and physical features of the area • Visual aids of examples of community plans drawn and action plans
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, • Masking tape; about eight (8) sheets of manila paper • Physical teaching aids, materials and tools • Visual aids
Session type and delivery methodology	• Presentations • Plenary discussions
Take home and follow up	• Community-based natural resource action planning is key to development • Community-based natural resource action planning is supported and guided by different policies and legal frameworks and should be encouraged • There is a difference between physical and landuse planning.

Policy instruments that support Action Planning

Action planning for CSA is supported by a number of policy and legal frameworks at international, regional, national and local levels. In Table 3 we highlight the Action Planning provisions in each legal instrument.

Table 3: A summary of the legal instruments that support Action planning

a. The Physical planning Act 2010: Declares the entire country as "a planning area"[8], for effective landuse management.

b. The National Land use policy 2007: The overall goal of the National Land use policy is to achieve sustainable and equitable socio-economic development through optimal land management and utilization in Uganda[9].

Specific goals of the Land Use Policy are:

i. To adopt improved agriculture and other landuse systems that will provide lasting benefits for Uganda.
ii. To reverse and alleviate adverse environmental affects at local, national, regional and global levels.
iii. To promote landuse activities, which ensure sustainable utilization and management of environmental, natural and cultural resources for national socio-economic development.
iv. To ensure planned, environmentally friendly, affordable and well-distributed human settlements for both rural and urban areas.
v. To update and harmonize all landuse related policies and laws, and strengthen institutional capacity at all levels of Government.
vi. The Land Act of 1998, amended in 2010: Is the major land policy reform and provides for security of tenure and ownership of land[10].
vii. The National Land Policy, GoU, 2013:

The policy goal is "to ensure efficient, equitable and sustainable utilization and management of Uganda's land and land-based resources for poverty reduction, wealth creation and overall socio-economic development". To achieve this government shall ensure that land is planned, used and managed sustainably for the benefits of the present and future generations[11].

c. Agriculture Sector Development Strategy and Investment Plan (DSIP)

The DSIP 2010/11 – 2014-15 emphasizes increasing rural incomes and livelihoods and improving household food and nutrition security. Under the programme of production and productivity, the strategy provides for agricultural water resources development on the basis of sustainable irrigation, water for livestock and aquaculture, ensure reduced losses through improved control of pests, vectors and diseases, Enhanced productivity of land through sustainable use and management of soil and water resources[12].

d. The Water Policy (1995): Addresses among others, formation of water committees, Local Governments to partner with user groups in operating, maintaining and managing water systems, Local Governments (Sub-counties to provide water and sanitation services, etc.)[13].

8 The physical planning Act 2010
9 The National Land use policy 2008
10 The Land Act of 1998, amended in 2010
11 The National Land Policy, GoU, 2013
12 DSIP 2010/11 – 2014-15
13 The Water Policy (1995)

e. The Wetlands policy (1995) and the Wetlands Sector Strategic Plan (WSSP): Recognize the central position of wetlands as providers of essential goods and services (food, incomes, water, and aesthetic beauty) to local populations. In accordance with the RAMSAR convention, the GoU has adopted the wise use approach. By the nature of the wide public goods and services, wetlands have stakeholder interests. In this respect, the National Environment Act and the Land Act 1998 entrusted all wetlands into the hands of the state to ensure their protection and wise use[14].

f. The District Development Plan (DDP): Each district has a District Development Plan (DDP), which contains information on what the district envisions as key activities to drive the district to where they would want to be. To ensure mainstreaming of any developed Action Plan, it should be aligned to the DDP of the district of interest. This will ensure continuity of activities started during the project lifetime even when the project has ended. Aligning the Action Plan with the DDP will also enable the district and the subcounty budget for the Action plan activities in their budgets. The vision and goals of the Action plan must, therefore, align with the DDP.

Session II: Identification of problems that affect the community's natural resources

Identification of problems that affect the community's natural resources	
Duration	3 hours
Session guiding questions	This session is to enable participants collectively agree on the main problems affecting the natural resources in the area using brain storming and transect walks. Through the transect walk, the participants will be able to evaluate the magnitude of the various problems that occur in their landscape and where they occur. The key guiding questions are: a. What are key natural resources and what are they used for? b. What natural resources use related problems and challenges were observed during the transect walk? c. How do the natural resources use related problems and challenges observed during the transect walk relate to those generated during the brain storming activity? d. Which ones of the listed problems are considered as major by the communities? e. How have you been coping with these problems? f. What opportunities exist that the communities can tap into to overcome these problems?
Session Objective	• To enable participants collectively agree on the key natural resources use problems and challenges affecting their community. • To assess the causes and effects of the key problems and challenges. • To make participants realize that it is possible to overcome the problems and challenges; given the available opportunities.

14 Wetlands policy (1995)

Identification of problems that affect the community's natural resources	
Preparation	• Prior knowledge and information on some of the natural resources problems and challenges affecting landuse of the targeted area. • Prior identification and invitation of the different categories of community members who are knowledgeable about the changes in the landscape. • Prior knowledge and information on existing natural resources in the area and key resources use issues • Maps a. A satellite image/Google map of the targeted area b. Administrative and physical features of the area • Visual aids of examples of other community's problem tree
Materials/ resources	Materials needed/checklist – could be placed in the appendix/annex • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Printed transect walk forms (at least 4 for each team going out for a transect walk) • GPS unit or mobile phone where coordinates can be read off.
Session type and delivery methodology	• Presentation (recap problems identified in the previous section) • Group work • Plenary discussions

Session overview

1. Problem identification. This team should list all the problems (with a focus on natural resources).
2. By the time they are through with problem identification, the transect walk team is back. There should then be a discussion of the representativeness of the problems identified.
3. Problem ranking: All problems should be ranked to identify the key problems affecting the community.

Facilitate the community members to divide themselves into two groups i.e. one for problem identification and another for a transect walk.

Problem identification team

The problem identification team should have a brain-storming session to identify all natural resources use related problems. These should be recorded on a flipchart. It is envisaged that by the time this team is through with the brain storming, the transect walk team will have returned from the walk. Allow them to validate the list, based on acquired field knowledge. If there are problems that the transect walk team identified during the transect walk but have been left out, let them be added to the list.

Before ranking the problems, the team should be facilitated to first of all separate natural resource use problems e.g. soil erosion, excessive intercropping, and poor farming and fishing methods from physical infrastructure problems e.g. roads, schools and health facility needs. Of the finally identified natural resource-related problems, effort should also be made to separate real problems from causes and effects of the problems using the problem tree analogy (Figure 14) as a guide. Place each identified problem either at the root, stem or branches and leaves of the tree. Only those problems that fall at the stem should be ranked. The rest should be fitted in the right column of the problem analysis table during the next session i.e. as cause or effect of a specific problem.

The team should them be facilitated to rank the final list of problems (from the biggest problem they are facing to the lowest). Pair-wise ranking could be used so as to eliminate bias.

Transect walk team

Plan with the transect walk team to select the route to take. The selected/decided route should cover as much of the variation that occurs in the area being planned for as possible. Provide the team with the transect walk forms (Table 4) and a GPS unit.

At each stop/observation point, the team should respond to all the variables in the column i.e. column #1 is for stop point 1 and column #2 is for stop point 2.

Table 4: Transect walk form†

	1	2	3
Vegetation			
Soils			
Slope (Low land, Middle slope, Steep, very steep			
Socio-economic indicators			
Food crops			
Cash crops			
Forest/Agro-forestry			
Resource management			
Problems			
Achievements (in the last five years)			
Future Opportunities			

†To be completed during the transect walk. Each number should represent a single stakeholder/stopover point

Session III: Problem analysis, and mapping community natural resources and problems

<table>
<tr><th colspan="2">Session 3: Problem analysis, and mapping community natural resources and problems</th></tr>
<tr><td>Duration</td><td>3 hours</td></tr>
<tr><td>Session guiding questions</td><td>This session is to enable participants get a deeper appreciation of the identified problems through assessing their causes and effects on the community's survival and mapping the areas where each identified problem is most prominent. Knowledge obtained and consensus reached during the transect walk about the varied drivers of natural resource degradation will now be documented using the problem analysis table and the current resources use map.

To complete the session in the planned period, the community should be divided into two groups, which should carry out the problem analysis and resource mapping concurrently. They should present the outputs in a plenary session to allow the rest of the community members to provide their input (critic and refine output).

The key guiding questions for problem analysis are:
a. What are key natural resources and what are they used for?
b. How have they changed over time?
c. Do the remaining natural resources efficiently provide all the ecosystem services as before?

The key guiding questions for resources mapping are:
a. What resources are abundant?
b. What resources are scarce?
c. Where are they located?
d. Where do people go to collect water?
e. Where do people go to collect firewood?
f. Where do people go graze livestock?
g. What kind of development activities do you carry out as a whole community? Where?
h. Which resource do you have the most problem with?
i. Where in the landscape are the effects of the problem most evident? Or which area of the community land is most affected by the problem?</td></tr>
<tr><td>Session Objective</td><td>• To enable participants to assess and internalize (appreciate the gravity of) the natural resource management problems they have in the area.
• To identify sites for implementing site-specific interventions.</td></tr>
<tr><td>Preparation</td><td>• Prior knowledge and information on the process of problem analysis.
• Mobilization of community leaders to participate in problem assessment and resource mapping.
• Maps
a. Administrative boundary map and,
b. Physical features of the area
• Visual aids of examples of a current natural resource map prepared by a community elsewhere</td></tr>
<tr><td>Materials/ resources</td><td>Materials needed/checklist – could be placed in the appendix/annex
• Flip charts/Newsprint paper
• Manila papers (about eight (12) sheets)
• Marker pens,
• Masking tape;
• Cards of various colors;
• Printed administrative boundary map (on A1 paper) for the planning area</td></tr>
</table>

Session 3: Problem analysis, and mapping community natural resources and problems	
Session type and delivery methodology	• Group work • Plenary discussions

Problem analysis

The problem analysis team should identify the causes and effects of each problem, the community coping strategies and available opportunities for solving the problem. The team should, for each key problem, complete a row of the problem analysis table (Table 5). To separate the problem causes from the effects, they can use the analogy of a problem tree (See Figure 14 below).

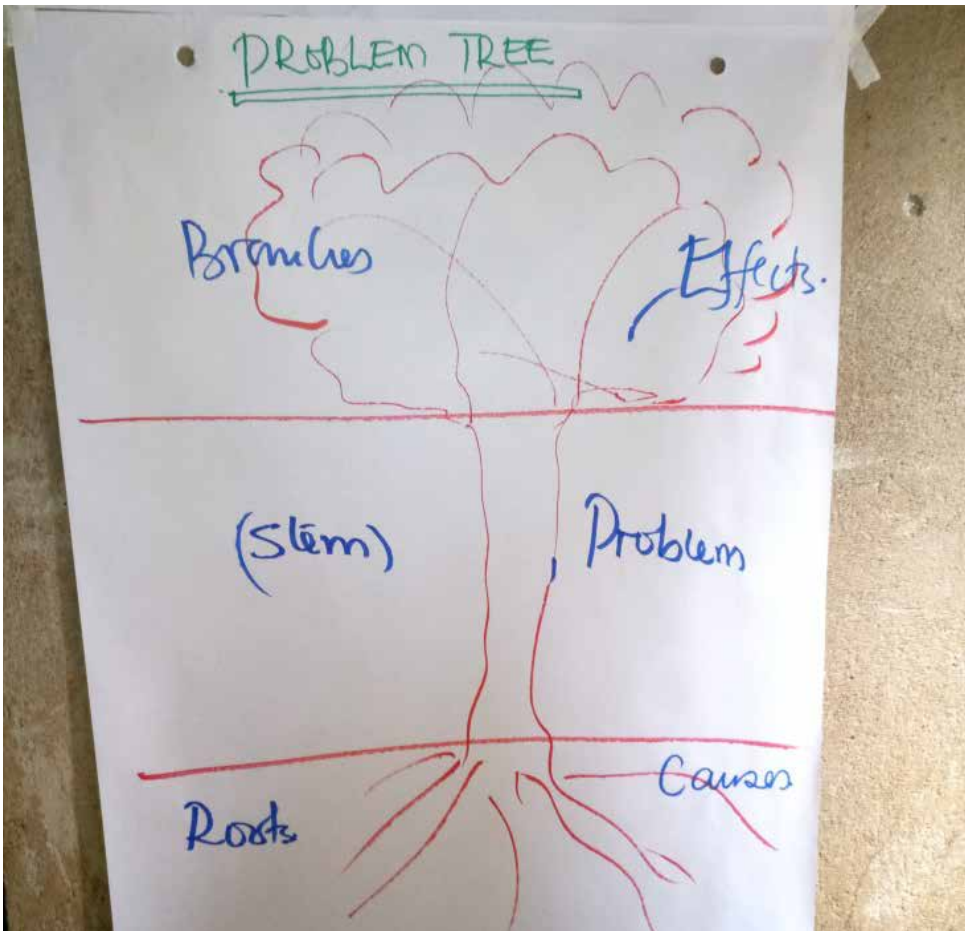


Figure 14: The relationship between the problem, its causes and effects (Source: Authors' elaboration)

Table 5: Problem analysis table

Problems	Causes	Effects	Coping Strategy	Opportunities
Example: Soil erosion	• Deforestation, • Charcoal burning • Cultivation on hills and steep slopes • Excessive intercropping	• Low crop yield • Poverty • Crop disease prevalence	• Making contours • Mulching • Stop bush burning	• Planting trees • Training in farming techniques by experts

Current resource map preparation

The current resource map should include all the natural resources that occur in the area e.g. protected areas, farmlands (subsistence and commercial farmland), wetlands, rivers, ponds and water sources. The following steps should be taken;

1. To enable the community members to generate a map that resonates with the national administrative boundaries, the facilitators should provide a map showing the outline of the whole subcounty divided into the parishes. Then provide a parish map that is divided into the villages that occur in the parish. These maps are expected to generate great discussion about the boundaries, especially with our constantly increasing districts, the lower administrative units are constantly being reshaped/divided. The facilitator should be sensitive to the communities' perception/knowledge of village, parish and subcounty boundaries and allow them to redraw the boundaries where necessary.
2. The team should then select a team member to either redraw the map on a blank manila paper (if the variations from the provided outline are major) or add extra lines to the provided outline map to indicate the additional villages.
3. To ease map orientation, add the main roads.
4. Thereafter, start populating the map with the natural resources.
5. Where possible, indicate/map the location of the problems/challenges that were identified.
6. After all natural resources and associated problems have been mapped, add physical infrastructure e.g. current location of schools, health centers, towns, settlements, water sources and markets.

Day 2

The second-day activities should include the development of the vision and goal(s), the action plan and the future map. Process to follow;

1. The community coming up with a Vision and goal: Discuss where the community wants to be in the foreseeable future with regard to the key issues identified. Use local descriptions that the community will understand when developing the vision. For example, what do the communities want their place to look like in five or ten years? Allow all community members to participate in vision development.
2. Divide into two groups
    - **Group 1:** Action Plan: The team should identify actions to address the problems identified. Parameters to consider are indicated in Table 6.
    - **Group 2:** Future resource map – guidance can include the location of the existing natural resources and landuse systems, the potential location of sites for the implementation of identified interventions (what they will look like in the future after the interventions are implemented).

A summary of Action Planning and Preparation of the Future map is presented in Session 4. Either the topics are carried out concurrently, as guided in the table below or carried out sequentially starting with the Action Planning. If carried out sequentially, however, it may not be possible to complete the two activities in one day.

Session IV: Action Planning and preparation of the future map

Session 4: Action Planning and preparation of the future map	
Duration	5 hours
Session guiding questions	This session is to enable participants to envision the future they want and develop a plan (Action Plan) of how to achieve that future. The group will craft a vision and goal for their parish or village, develop an Action Plan and draw the map showing what they would like their parish/village to look like in the future. To complete the session in the planned period, the community should be divided into two groups., which should carry out the Action Planning and develop the future map concurrently. They should present the outputs in a plenary session to allow the rest of the community members provide their input (critic and refine each output). The key guiding questions for Action Planning are: a. What actions should be carried out to address each of the identified problems? b. What resources will be required? c. What can the community provide and for what resources will they need external support? d. Who will be responsible for monitoring plan implementation? e. What will be the indicators to show that a specific planned action has been carried out successfully? The key guiding questions for resources mapping are: Where should the planned action intended to address the identified problems be implemented? Where should key infrastructural developments that will facilitate the implementation of the planned actions be placed?
Session Objective	• To enable participants to identify actions to address identified problems. • To enable participants to map the key interventions so as to have a visual impression of the future they want. • To cultivate a sense of community ownership of the Action Plan. This will be key in ensuring its implementation
Preparation	• Prior knowledge of planned actions in existing local government development plans that may address problems identified in this action planning process. • Prior knowledge of problems to address. • Prior mobilization of community and administrative leaders • An outline map of the administrative boundaries of the envisioned planning unit.
Materials/ resources	Materials needed/checklist – could be placed in the appendix/annex • Manila sheets (at least 10 sheets) • Marker pens, • masking tape;
Session type and delivery methodology	• Group work • Plenary discussions

1. Completing the Action Planning table

1. Once the community has developed its vision and goal(s), it should start developing the Action Plan. This will be based on the problems that were analyzed in the previous session.

2. For each problem;
    - Carry forward the opportunities identified during the problem analysis. Add more opportunities, which they could have missed out
    - Guide the community in a discussion to identify suitable actions to undertake to overcome the problem. It is necessary to be specific and break main activities down into sub-activities. The main question now is: What activities can the community /the stakeholders undertake to solve its key problem and hence achieve its vision of the future?
    - Identify the resources needed to accomplish the identified action
    - The community /local stakeholders identify components of the identified action (s) that they can address and resources they can provide
    - The community should also identify activities and resources where they will need external support. Once again be specific
    - Identify who will be responsible to guide and monitor the implementation of each activity. Write down the office that would be responsible not names since officers change over time.
    - A specific date (month and Year) needs to be agreed upon for the start of each activity
    - Identify key indicators that the community can use to measure progress on addressing a specific problem.

Response to the listed activities above should be inserted in the action Planning table (Table 6 below)

2. Preparation of the future map

- The future map should first be populated with current features that are expected to persist into the future
- The map should then be populated with natural resource features indicating the future the community would like to have. This should be informed by the actions outlined in the Action Plan e.g. if the community plans to increase tree cover or plant windbreakers, let them indicate on the map the areas where they plan to plant these trees.
- After all the proposed natural resource features have been included, the community can be allowed to propose some physical features they would like to have in their area, which are essential for the success of the planned natural resource restoration actions. The facilitator should be careful not to allow a natural resource plan to be turned into a physical plan. Physical features included should be those that complement the proposed natural resource development e.g. an agro-chemical shop or an agriculture training institute.

Table 6: Action Plan table

Vision								
Goals:								
Problem	**Opportunity**	**Action**	**Resources**	**Community contribution**	**External Contribution**	**Time to start**	**Who will follow up**	**Indicators**
Poor farming methods leading to soil erosion	OWC, Training opportunities in SLM (TOTs), Tree planting	Train communities in SLM practices	Technical skills, Land, Grass, Tree seeds and seedlings, Labor, Garden tools,	Land, Labor, Some tools, Locally available tree seeds and seedlings, Grass, ToTs	Some tools, Technical skills, Seeds for cover crops, Tree seeds and seedlings, Good seed of crops	February, 2021	ToTs, Agriculture officer, LC II chairpersons, LC I chairpersons, Area councilors, Subcounty technical staff, District Technical staff NGOs	Length of contour bands constructed, Trees planted, Cleanliness of water at the lakeshore, Area of wetland conserved
		Construct contour bands	Land, Grass, Tree seeds and seedlings, Labor, Garden tools,					
		Plant grass, Plant cover crops and trees Zero tillage	Land, Grass, Tree seeds and seedlings, Labor, Garden tools,					

Report

The outputs from the community Action Planning should be compiled into a report. The title of the report should reflect the objective of the Action Planning.

MODULE VI: CLIMATE SMART AGRICULTURE (CSA) SOLUTIONS AND PRACTICES

Session I: Background/introduction

Background/introduction	
Estimated duration[15]	
Session guiding questions	This session is intended to introduce to participants the agricultural production zones in Uganda, the characteristics of the targeted APZs, problems, potentials and opportunities in the targeted zones. It is also intended to introduce the functions which are achieved by implementing the different CSA technologies/practices The key guiding questions are: a. What are the agricultural production zones in the targeted areas? b. What are the characteristics of the targeted APZs? c. What are the key agricultural production problems in the targeted APZs? d. What are the key agricultural production potentials and opportunities in the targeted APZs? e. What are different functions of the different CSA technologies and practices?
Session Objectives	• To make participants appreciate agricultural zoning in Uganda • To make participants appreciate the challenges of agricultural production in Uganda and the potential functions of the CSA technologies and practices
Preparation	• A clear understanding of agricultural zoning in Uganda • Prior knowledge and information on the characteristics of the targeted APZ • Prior knowledge and information on the problems, potentials and opportunities of agricultural production in the targeted APZ • Maps showing agricultural zoning in Uganda, district administrative boundaries and physical features.
Materials/ resources	Materials needed/checklist a. Flip charts/Newsprint paper b. Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Field excursion to showcase some problems, potentials and opportunities
Take home and follow up	• Not all agricultural enterprises are suited to all parts of Uganda • Agricultural production/enterprises are guided by environmental suitability • Different APZs have different characteristics, that lead to varied agricultural production problems, potentials and opportunities • The agricultural production problems can successfully be addressed by use of CSA solutions • CSA technologies and practices are grouped according to their functions in addressing climate change and natural resource management challenges • For better results, the CSA technologies and practices should be applied as a package depending on the need.

15 Time not inclusive of practical sessions

Uganda is endowed with a diverse agricultural production system, which is within 10 agricultural production zones (APZs) as illustrated in Figure 15. The zones are determined by soil types, climate, topography, and socio-economic and cultural factors and contribute to the diversity of farming systems across the country (*Mubiru et al.,* 2017). Districts in northern Uganda fall within five of the APZs (Table 7). Due to the different zonal characteristics, the APZs experience varying levels of land degradation and vulnerability to climate-related hazards, which have included drought, floods, storms, pests, and diseases (GoU, 2007). Various Climate smart Agricultural Technologies have been developed and confirmed to be appropriate but have to be modified to suit the local situation based on the zonal characteristics.

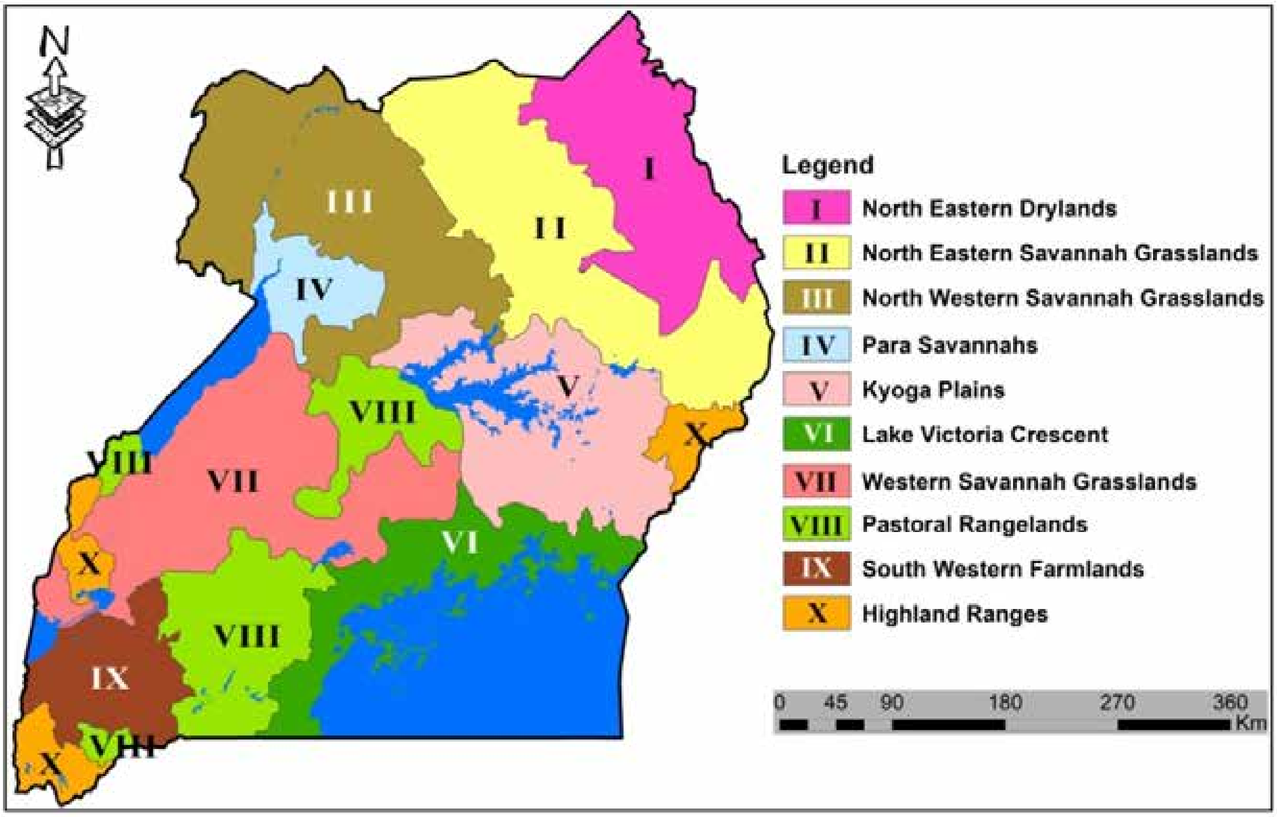


Figure 15: The Agricultural Production Zones in Uganda
(Source: Adapted from GOU, 2004)

Table 7: Agricultural Production Zones in northern Uganda and their characteristics

Characteristics	Agricultural Production Zone (APZ)				
	North Eastern Dry lands	North Eastern Savannah Grasslands	North Western Savannah Grasslands	Para Savannahs	Kyoga Plains
Scope (Districts):	Agago (formerly eastern Kitgum), Moroto, and Napak; and the northern part of Kotido District	Katakwi, Kitgum, Nakapiripirit, and Pader; and the eastern part of Lira district, the northern parts of Kapchorwa and Sironko districts, and the southern part of Kotido district.	Adjumani, Arua, Moyo, Oyam (formerly northern Apac), Yumbe; and the western parts of Lira and Nebbi districts and the northern part of Gulu district.	Eastern parts of Nebbi District, south-western parts of Gulu District and the western parts of Masindi District	Amolatar, Dokolo (formerly southern Lira), Iganga, Kaberamaido, Kamuli, Kayunga, Kumi, Pallisa, Soroti, and Tororo; and the northern parts of Bugiri and Busia districts and the southern parts of Apac and Mbale districts.
Mean annual rainfall	745 mm	1197 mm	1,340 mm – 1371mm	1259 mm	1215 – 1,328 mm
Rainfall range	600 – 1,000 mm	1,000 – 1,300 mm	1,200 – 1,500 mm	800 – 1,500 mm	
Rainfall duration	One rainy season of about 5½ months, from April to early September with the main peak in July/August and a secondary peak in May	One rainy season of about 7 months, from April to late October with the main peak in July/August and a secondary peak in May.	One rainy season of about 7½ months, from April to about mid-November with the main peak in August to mid-October and a secondary peak in April/May.	One rainy season of about 8 months, from late March to late November with the main peak from August to October and a secondary peak in April/May.	Two rainy seasons in the southern part with the main season from March to May with a peak in April and secondary season from August to November with a peak in October/November. The northern part of the zone has one rainy season which starts from March to November, with the main peak in April/May and a secondary peak in August/September.

Characteristics	Agricultural Production Zone (APZ)				
	North Eastern Dry lands	North Eastern Savannah Grasslands	North Western Savannah Grasslands	Para Savannahs	Kyoga Plains
Dry period	One long dry season of about 6 months from October to March. The driest months are from December to February.	One long dry season of about 4 months from mid-November to late March. The driest months are from December to February.	One long dry season of about 4 months, which starts from mid-November to late March. The driest months are December to February.	One long dry season of about 3½ months, from December to about mid-March. The driest months are December to February.	The main dry season in the southern part is from December to February, while the secondary dry season is from June to July. The northern part has one dry season which starts in December to about mid-March.
Average minimum and maximum temperature	12.5 – 32.5 °C	15 – 32.5 °C	15 – 25 °C.	17.5 – 32.5 °C	15 – 32.5 °C.
Altitude range	351 – 1,524 m ASL[16]	975 – 1,524 m ASL.	351 – 1,341 m ASL	351 – 1,341 m ASL	914 – 1,800 m ASL.
Agricultural enterprises	Gum Arabica, Simsim, Sunflower, Apiculture, Goats/Skins, Beef cattle/ Hides and Ostriches	Apiculture, Beef cattle/Hides, Goats/ Skins, Simsim, Cassava, Pulses, Sunflower	Spices (ginger, cardamom, white/black pepper, birds eye chillies, red chillies); Tobacco; Apiculture; Cotton; Pulses; Simsim	Spices (ginger, cardamom, white/ black pepper, birds, eye chillies, red chillies); Fisheries; Cassava; Apiculture; Beef cattle/Hides; Goats/Skins; Mangoes	Fisheries, Apiculture, Maize, Pulses, Beef cattle, Cassava, Goats

From the zonal characteristics (Table 7), several problems/challenges, potentials and opportunities manifest as a result (Box 3).

16 ASL = above sea level

Box 3: Agricultural production problems, potentials and opportunities in northern Uganda

Problems

- Most of the APZs in northern Uganda have one long rainy season and often when this one rainy season fails the area suffers from food shortages and in extreme cases, famine.
- Most of the soils are light with predominantly silt and sandy textures, therefore the soils suffer from moisture deficits during prolonged and severe dry periods; this affects mainly the perennial cropping systems.
- Land degradation due to poor land/soil management
- Agriculture is mainly rain-fed
- Low yields partly due to poor agricultural technology development
- Pests and diseases
- Post-harvest losses
- Low market opportunities partly due to substandard products

Potentials and opportunities

- Generally, the land is flat and easier to manage including mechanization and setting up irrigation infrastructure.
- Land is still abundant hence high potential for increased production and farmers can afford to rest the land to rejuvenate soil fertility

5.1 Climate Smart Agriculture Solutions

CSA technologies and practices present opportunities for addressing climate change challenges. For technologies and practices to be considered climate-smart they have to enhance crop productivity to ensure food security at household level and support at least one of the other objectives of CSA, that is, adaptation (resilience) and/or mitigation.

Several CSA practices and technologies have been developed and being adapted and promoted across the country. The practices and technologies are categorized into 6 groups according to their functions in agricultural production (Box 4).

Box 4: Categories of CSA practices and technologies according to their functions in agricultural production

CSA practices and technologies for:	
• Soil and water conservation • Soil fertility enhancement • Water management	• Livestock management • Risk management/spreading risk • Post-harvest handling

For ease of communication and training, the practices and technologies are grouped into six categories according to their functions in agricultural production. However, they are not independent of one another; therefore for best results, it is advised that they are combined to address the issues at hand.

† Haylage is forage chopped and dried up to the wilt stage or to a moisture content of 60-70%

‡ PICS bags = Perdue Improved Crop Storage bags

Session II: CSA practices/technologies for soil and water conservation

CSA practices/technologies for soil and water conservation	
Estimated duration	3 hours
Session guiding questions	This session is intended to make participants appreciate soil and water conservation as one of the functions used in CSA. It is also intended to provide knowledge and impart skills in soil and water conservation using appropriate technologies/practices such as CA, contour bunds, mulching, stone-line, etc. The key guiding questions are: a. Do you face problems of soil & moisture loss and how does this affect agricultural production? b. What are the challenges related to soil and water management in agricultural production c. What are the appropriate technologies and practices used to prevent loss of soil and its moisture from agricultural landscapes d. What helps to decide on the technology/practice to be used in preventing soil and moisture loss? e. What approaches do farmers use to promote/scale the use of different soil and moisture conserving technologies and practices? f. How to establish/use the different soil and moisture conservation technologies and practices
Session Objective	• To give a general overview on soil and moisture loss, the causes and consequences, using local examples and experiences • To introduce and explain the various technologies and practices, which prevent soil and moisture loss. • To demonstrate the establishment/use of soil and water conservation technologies and practices.
Preparation	• Prior knowledge and information on the causes and consequences of soil and moisture loss in agricultural production. • A clear understanding of the appropriate soil and water conservation technologies and practices • Practical knowledge and skills to demonstrate soil and water conservation technologies and practices • Physical teaching aids, materials and tools e.g. A-frame, spirit level • Visual aids exhibiting different case scenarios of soil and moisture loss as well as successful conservation and restoration.
Materials/ resources	Materials needed/checklist a. Flip charts/Newsprint paper b. Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper c. Physical teaching aids, materials and tools e.g. A-frame, spirit level d. Visual aids
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Field excursion to showcase some case scenarios of soil and moisture loss as well as successful conservation and restoration • Practical sessions to demonstrate establishment and maintenance

Take home and follow up	• Problems and challenges of soil and moisture loss can be successfully addressed with appropriate soil and water conservation technologies and practices • Each individual farmer has a personal responsibility to conserve soil and water • Most soil and water conservation technologies and practices need collective action/group work • Farmers working together realize more benefits from the application of the soil and water conservation technologies and practices

Overview

Soil erosion and inadequate soil moisture are major problems in many Ugandan landscapes. The problem of soil erosion is extreme in the Highland Ranges (north-eastern, eastern, south western and western), because of the steep slopes, which render the soil to be easily eroded. However, even where the slopes are gentle, like most APZs in northern Uganda, gullies can turn the gentle slopes into unproductive wastelands.

Soil erosion and soil moisture loss are closely related. It has been observed that farming practices that lead/encourage soil erosion also reduce the capture, storage and availability of moisture in the soil. A great extent of soil erosion in Uganda is caused by water running off the soil surface. If the surface runoff can be captured and conserved in the soil, erosion can be slowed or halted altogether and moisture availability for plant growth can be enhanced. Since rainfall has become increasingly erratic, it is imperative that moisture is conserved in the soil and made available to the crops.

This section outlines various CSA practices and technologies that can be used to conserve soil and water. These include Conservation Agriculture/Conservation Farming, Contour bunds, Grass strips, Trash-lines, Stone-lines and Mulching.	This section also describes various techniques needed to plan these soil and water conservation measures: how to use simple tools to mark contour lines and how to measure vertical intervals and slope gradients

Conservation farming/agriculture

Conservation farming is any system or practice which aims to conserve soil and water. Conservation agriculture (CA) is one of the elements of conservation farming. Zero or minimum tillage, direct seeding and a varied crop rotation are important elements of CA.

"Conservation agriculture (CA) aims to make better use of agricultural resources through the integrated management of available soil, water and biological resources, combined with limited external inputs. It contributes to environmental conservation and to sustainable agricultural production by maintaining a permanent or semi-permanent organic soil cover" – FAO, 2002.	Conservation agriculture has three basic principles: • Disturb the soil as little as possible • Keep the soil covered as much as possible • Mix and rotate crops

Disturb the soil as little as possible (minimum tillage): In conventional farming, farmers plough and dig to prepare a fine seedbed and control weeds. But in the process destroy the soil structure and contribute to soil erosion and declining soil fertility. In CA, tillage is reduced to ripping planting lines or making holes with a stick, hoe, or jab planter for planting.

Keep the soil covered as much as possible (soil cover): In conventional farming, farmers remove or burn the crop residues or mix them into the soil with a plough or hoe. In the process the soil is left bare, so it is easily washed away by rain, or is blown away by wind. In CA, crop residues are spread uniformly on the field; crop residues spread to create a mulch cover and leguminous cover crops protect the soil from erosion, conserve soil moisture and limit weed growth throughout the year. This also helps to build the organic matter content which is essential in maintenance of soil fertility, especially in tropical soils. Soil moisture retention by residues provides an optimum environment for biological activities, which are essential in enhancing soil health. When leguminous cover crops are used they fix atmospheric nitrogen to boost soil fertility.

Several cover crops have been evaluated in Uganda and they included Mucuna pruriens (velvet bean), *Dolichos lablab, Canavalia, Crotalaria ochroleuca* (sun hemp), *Canavalia ensiformis* (jack bean), and *Tephrosia candida*. Some of the different cover crops evaluated are presented in Table 8.

Table 8: Some of the different cover crops evaluated in different APZs in Uganda

Type	Quantity of seed (kg ha^{-1})	Recommended spacing[1]	Growth habit	Comments
Mucuna pruriens (velvet bean)	25	75cm x 60cm	Annual herb	Mucuna is a very vigorous climber which improves soil fertility and farm productivity
Canavalia ensiformis (jack bean)	25	75cm x 30cm	Annual herb	Canavalia improves very poor soils and is tolerant of drought and shade. It is easy to manage and can be intercropped with almost all crops. It grows on during the dry season.
Tephrosia vogelii	25	100cm x 100cm	Perennial shrub[2]	Can grow in highlands
Tephrosia candida	2	100cm x 100cm	Perennial shrub[2]	Tephrosia candida is a soft, woody herb with dense foliage. It stands 0.5–4 m tall, and contains stems and branches with short and long white or rusty brown hairs. It is commonly used to deter pests and diseases, specifically fleas and ticks on animals. It is not suitable for livestock or human consumption because it is not highly nutritious and can be poisonous for fish and some other animals. Since it is a nitrogen-fixing plant, it can be intercropped with other plants and used as a source of green manure.
Dolichos Lablab	2	75cm x 60cm	Annual herb	Lablab is a vigorous, drought resistant climber

Type	Quantity of seed (kg ha^{-1})	Recommended spacing[1]	Growth habit	Comments
Crotalaria ochroleuca (sun hemp)	5	Drill seed, 75cm between row	Annual herb	Crotalaria is fast growing, matures within 3 to 4 months, and is drought tolerant and adapted to poor soils. Nitrogen fixation of crotalaria is very effective.
Crotalaria grahamiana	5	100cm x 100cm	Perennial shrub[2]	Can grow in highlands
Crotalaria juncea		100cm x 100cm	Perennial shrub	Can grow in highlands
Cajanus cajan (pigeon pea)			Perennial shrub	Multipurpose (provides soil cover and is food grain). It is ideal for intercropping. It does not compete with other crops since it has a deep taproot and a slow initial development. It is especially well suited for dry climates and for restoration of poor soils. Residues can be used as mulch for the next crop.

[1]The recommended spacing will allow good ground cover within 2-3 months (for the annual herbs). The perennial shrubs take much longer to cover the ground. The spacing can be increased if the cover crops are grown for seed multiplication. Where the cover crops are to be intercropped with a crop (e.g. maize), plant the cover crop between the rows of the crop after the first weeding, and then leave the cover crop to continue growing until land preparation for the next crop when the cover crop can be incorporated into the soil or cut and left on the surface as mulch.

[2]The perennial shrubs are best for areas that a badly degraded and they should be left to grow for two or more seasons. They also grow well in highland areas.

Mix and rotate crops (crop rotation)

In conventional farming, the same crop is sometimes planted every season on the same piece of land. This allows certain pests, diseases, and weeds to survive and multiply. It also lowers soil fertility leading to lower crop productivity. In CA, this is minimised by planting the right mix of crops in the same field, and judiciously rotating crops from season to season. Rotation with legumes helps to improve and maintain soil fertility. Mixing crops, for example, cereals (e.g. maize) with legumes (e.g. beans, groundnuts, etc.) reduces the risk of total crop failure, maximizes land utilization, and increases food security and farm profits.

To gain the full benefits of CA, all three principles have to be applied at the same time. However, this is sometimes not possible and from experience application of any of the principles or a combination of any two is far better than not applying any at all.

Practicing Conservation Agriculture/Farming

The CA package prescribes dry season land preparation, precision input management, crop residue retention and crop rotations involving cereals and leguminous crops. These practices aim to improve the soil structure, water retention and reduce the need for external inputs (e.g. chemical fertilizers) while at the same time improving crop yields.

It has been advised that before you start with CA, it is necessary to address various soil problems such as compacted soils and hardpans (IIRR and ACT, 2005). Soil compaction is often as a result of land degradation, which mainly occurs through deforestation, burning of grasslands/organic residues, and continuous cultivation, with minimum soil fertility enhancement leading to soil erosion and organic matter and nutrient depletion. Planting basins and rip-lines are major components of the recently introduced conservation farming package for renovation of degraded landscapes that is being extensively promoted for smallholder farming. By breaking through pre-existing hard/plough pans, PPBs and riplines improve water infiltration and root development.

Permanent Planting Basins (PPB): Permanent Planting Basins (Figure 16), as used in conservation farming, is a crop management method which enhances the capture and storage of rainwater and allows precision application of limited nutrient resources. The method is widely used to reduce risk of crop failure due to erratic rainfall. It is reported that use of PPB in combination with improved seed and crop residues to create a mulch cover that reduces evaporation losses, has consistently increased average yields by 50 to 200% depending on the amount of rainfall, soil type and fertility (Twomlow, 2012). This strategy is a good option on small plots for annual crops and where animal draught power is not an option.

Figure 16: An illustration of how to make permanent planting basins (Source: Uganda Landcare Network)

Rip lines using animal draught power: Farmers who own (or can hire) oxen to pull implements can use a sub-soiler to break up hardpans. Hardpans are soil layers that act as barriers to root and water movement. The compactness of the soils in these features affects agricultural land in a number of ways, including among others, inhibiting root and water movement; facilitating runoff hence limiting water infiltration and retention; and making plowing difficult. As a consequence, they affect agricultural productivity. Subsoiling is usually necessary only in the first year. If there is no hardpan, the farmer can use an animal drawn ripper to open up a narrow furrow 15-20cm deep for planting seed. The soil between the furrows is left undisturbed.

Examples of CA techniques in reference to the three basic principles

Direct sowing with a hand hoe (Minimum tillage): Many Ugandan farmers cultivate using the hand hoe. Such farmers can practice CA by digging small planting holes in lines, at recommended spacing, leaving the rest of the soil undisturbed. The farmer can put fertilizer and compost or manure in the holes to raise the soil fertility and the water-holding capacity and thereafter sow the seeds.

Soil cover

Crop residues: - can be placed between plant rows to create a mulch cover, which protects the soil from erosion, conserves soil moisture, and suppresses weeds. This way the few weeds that emerge can be pulled out by hand or by scraping lightly with a hand hoe.

Cover crops: - some cover crops are multipurpose, that is, they are planted to provide a soil cover, improve soil fertility and produce food and animal feed. It is advisable to plant cover crops which fit in the local cropping system. Cover crops can be grown up to six month or beyond, after which they are slashed or killed by herbicide just before planting the next crop, leaving the dead material on the ground to serve as mulch.

Crop mixes and rotations

Crop mixes should be adapted to the local conditions and household resource constraints. It is a common practice by many Ugandan farmers to mix maize with either beans or ground nuts. However, most farmers do this haphazardly without any consideration for optimum patterns. Many farmers also do crop rotations which is part of the local cropping systems. Cereal-legume rotations are desirable.

Agro-forestry systems: Branches pruned from widely spaced rows of leguminous trees are spread as mulch on the soil surface in the alleys between the tree rows, thus enriching the alleys with nutrients from the leaves as well as conserving soil moisture. The crops grown in this alley-cropping system may yield better than crops grown alone, but only if competition between trees and crops for light and water can be kept to a minimum.

Benefits of conservation agriculture relative to conventional farming

Both conventional farming and conservation agriculture have similar operations including field preparation, planting, fertilization, weeding, and harvesting. However, the point of departure is how these operations are conducted, the time spent, the cost of operations as applied in each farming method, and the accruing benefits (Table 9). Generally, conservation agriculture means less work because one does not need to plow the land and it may not be necessary to weed as many times as is the case with conventional farming. Conservation agriculture also suppresses weeds and reduces soil erosion; it improves the soil structure, water holding capacity, organic matter content and soil fertility, all leading to more stable yields and higher productivity and profitability.

Table 9: Benefits of conservation agriculture relative to conventional farming

Element	Conventional farming	Conservation agriculture
Soil moisture	Crop residues are often burnt or buried in the ground leaving the soil bare leading to soil moisture loss.	Crop residues and cover crops provide a mulch cover so there is less evaporation from soils.
Erosion	Since the soil is left bare, wind and water erosion is a common phenomenon.	Cover crops and mulch protect the soil surface from wind and rain, thus minimizing soil loss through wind and water erosion.
Soil fertility	Poor management of organic matter through burying and burning depletes soil fertility. Planting the same type of crop season after season removes valuable nutrient from the soil.	Crop residues and cover crops stay on the soil surface, adding to the organic matter. Legumes in crop mixes or rotations and leguminous cover crops improve soil fertility by fixing atmospheric nitrogen.
Weeds/ pests and diseases	Leaving the soil bare allows weeds to grow unhindered. Planting the same type of crop season after season encourages certain weeds, pests and diseases to flourish.	The cover crops or mulch suppress weeds and prevent them from growing quickly. Crop rotations help to reduce the proliferation of pests and diseases by breaking their life cycles
Costs and labour	Ploughing and weeding are expensive operations, take a lot of time, and are tedious and laborious work.	Less time is spent ploughing and weeding. Costs are reduced to a bare minimum since there are fewer operations.
Crop diversity	Mono cropping produces one crop, with the risk of failure if there are extreme weather events (floods, or drought) or pests and disease attacks. Farmers' incomes and diets depend on a single crop.	Crop rotations and crop mixes produce a range of crops. They reduce the risk of total crop failure in case one crop succumbs to extreme weather events or pests and disease attacks.
Environment	Conventional farming leads to environmental degradation because it encourages soil erosion leading to pollution of water sources. It releases CO_2 in the atmosphere which contributes to global warming.	Conservation agriculture reduces soil erosion leading to cleaner water sources throughout the year. It increases the amount of carbon in the soil, acting as a carbon sink and reduces global warming.
Yield	Yields fall over time due to declining soil fertility. This has led to encroachment on forest areas, swamps, etc.	Soil moisture and fertility is conserved, so land productivity is higher and yields are stable.

Factors affecting the adoption of conservation agriculture

Although CA has been fronted as the solution to many of challenges encountered in smallholder farming, its adoption has not been swift. Practitioners of CA point to several challenges that limit its adoption. These challenges are categorized as socio-cultural, economic, and policy and institutional.

Socio-cultural impediments

- Switching to CA involves a fundamental change in mindset. The attitude of farmers or their mindset has often been cited as a major impediment to the adoption of CA practices. Many farmers believe that one can only plant in a well tilled seedbed as opposed to fields covered with crop residues as prescribed in CA. More than often, crop residues which is an essential element of CA are burnt leaving the soil bare and exposed to the elements of weather [heat, wind, rain, etc.].
- The transformation from conventional agriculture to CA requires considerable farm management skills. However, farmers do not challenge themselves to learn new skill and are inclined to doing business as usual.
- Crops such as millet and sesame which have very small seeds can be difficult to sow without disturbing the soil.
- Some farmers have refused to include cover crops into their cropping systems for the sole reason that some cover crops are not multipurpose. In addition, well known multipurpose cover crops such as pigeon peas are mythically associated with harsh weather conditions in some parts of the country, while pigeon pea is not a common food crop in these areas.
- Since the known cover crops need moisture to grow well and therefore have to be grown during the cropping season, many farmers are not willing to sacrifice a cropping season to grow cover crops instead of their food.

Economic impediments

- The transformation from conventional agriculture to CA involves investment in equipment and inputs such as herbicides, pesticides and fertilizers. The benefits of CA can only be realized if farmers can access and afford the cost of the necessary equipment and inputs. Many farmers using CA point to high costs of equipment and inputs as one of the main impediments to its adoption.
- Other challenges include crop residue management: keeping the soil covered is an important element in CA, but it has proved to be difficult. This is mainly because farmers have many uses for the crop residues, e.g. they are used as fodder and for fencing, roofing, and fuel. It has also been noted that access to cover crop seed can be a challenge.
- It is believed by some that conservation agriculture allows more weeds to grow, making weed management a serious challenge in CA plots.

Policy and Institutional impediments

- Traditional research and extension services are weak and slow in responding to the changing needs of farmers, especially in the context of a changing climate.
- There has been inadequate support in knowledge, skills and incentives, making CA non attractive to would-be adopters.
- There is limited access to credit and financing and at present there is limited access to crop insurance

Local sources of CA equipment

Conservation agriculture equipment is not easy to come by, however there are a couple of institutions engaged in fabricating, testing and adapting CA equipment to the Ugandan environment (Table 10).

Table 10: Institutions that fabricate conservation agriculture equipment in Uganda

Institution	Location
Agricultural Engineering and Appropriate Technology Research Centre (AEATREC) – Namalere, NARO	Kawanda/Namalere (13km Kampala-Gulu HWY)
Tillers International	Lira, northern Uganda
SAIMMCO (Soroti Agricultural Implements and Machinery Manufacturing Company)	Soroti, eastern Uganda
TONNET Agro Engineering Co. Ltd	Kampala
Engineering Solutions	Bugolobi, Kampala

Contour bunds

A contour bund is an embankment or ridge built across a slope along the contour (Figure 17). It prevents water from flowing down the slope; this also prevents soil erosion. The embankment is about 50-75 cm high on the up slope side. Water is trapped behind this wall and percolates into the soil providing the moisture for a relatively longer period than if the flow was on a flat area. Soil accumulates behind the bunds, and over time creates a level bench-like terrace. This retains fertility and moisture, leading to higher yields of crops grown on the land between the bunds.

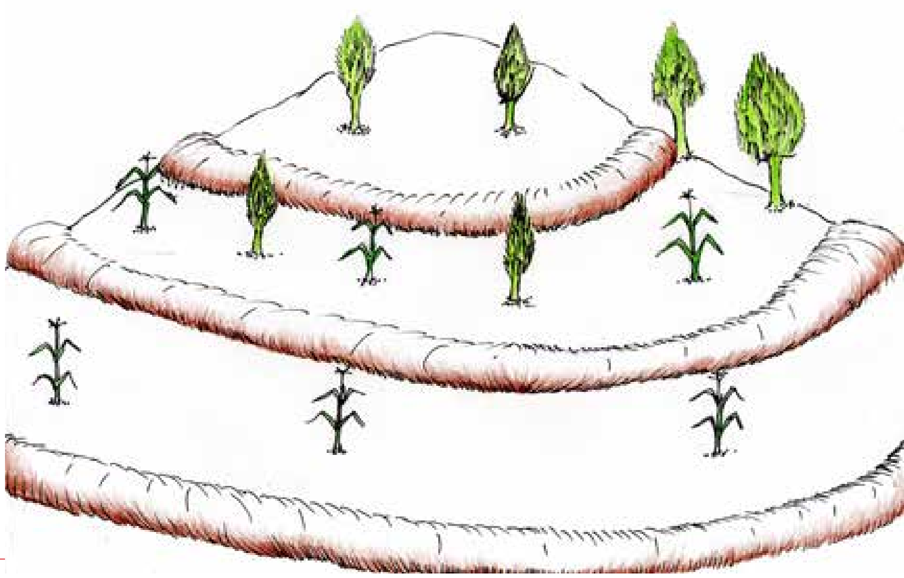


Figure 17: An illustration of contour bunds (Source: Uganda Landcare Network)

The bund may be a simple ridge of soil, a line of large stones with the gaps filled in with soil, a ridge of soil faced with stones on the down slope side, or a wall built entirely of stones. The bunds can be planted with grasses, fodder legumes and trees.

The bund may have a shallow ditch running along its upper side with tied ridges spaced at intervals of about 10 m. The tied ridges stop water from flowing along and out of the ditch. That means large pools of water do not accumulate in one place and flow over the top of the bund and its lowest point. The ends of the bund are usually closed with a short ridge to prevent water from flowing around them and creating a gully.

Contour bunds can be used in all APZs, except that in areas with steep slopes contour bunds are constructed at shorter intervals to reduce the momentum of the water runoff.

Advantages of contour bunds

- Bunds hold water and allow it to soak into the ground. They prevent water from draining away causing gullies.
- Soil gradually builds up behind the bunds, forming a bench terrace.
- Soil fertility also builds up on the terrace producing higher yields.
- Bunds can be built by an individual farmer or by a group.
- The bunds can be used to produce feed for animals.

Disadvantages and constraints

- Building bunds needs a lot of labour (organize a group of farmers to build them quickly)
- The bunds take land out of crop production (planting grasses, fodder crops or fruit trees make them productive)
- Breaks in a bund can cause gullies (make sure the bunds are close enough together to prevent large amounts of water from building up in heavy rains; repair breaks promptly)
- Rodents may live in the bunds, especially those made of stones (they can be controlled using conventional methods or by using thorny branches)

How far apart to space bunds

The spacing between bunds depends on several factors. Considerations include:

- Steeper slopes need more bunds so they can develop into bench terraces (Table 11).
- The terraces between the bunds should be wide enough for farming. Farmers who plough with oxen often do not like bunds less than 7m wide. Farmers who cultivate using hoes may prefer smaller distances between the bunds.
- Bunds take land out of crop production. For example, a bund 1 m wide every 10 m reduces the area available for crops by 10%. This means that yields must be at least 10% higher on the remaining land for the farmers to be motivated to build the bunds

Table 11: Spacing of bunds

Slope (%)	Spacing (m)
‹ 5	› 15
6 – 10	10 – 14
11 – 15	8 – 9
16 – 20	7
› 20	‹ 7 Use bench terraces if possible

How to make a contour bund from soil

You will need an A-frame or line-level, digging tools, and stones for stone bunds. To stabilize the bunds, you will need suitable grasses, legumes and tree seedlings. Here is how to make a bund from soil.

1. Work out the gradient of the slope
2. Decide on the spacing of the bunds (see Table 11 for guidance). Use sticks to mark out where to begin building each bund down the slope.
3. At the top of the slope, mark out a contour line (a line running at same height across the slope) where you want to build the first bund.
4. Scrape the soil from either side of the contour line, remove the grass so the soil can be compacted and pile soil and stones up to form an embankment running along the line.
5. Compact the embankment and shape it so that the top is level.
6. Move down the slope to where you want to build the next bund and repeat steps 3-5.
7. Plant the bunds with grass, fodder legumes and trees to stabilize them and make them productive.

Marking contour lines

Contour lines are horizontal lines across the slope, linking up points at the same elevation. It is important to mark contour lines as precisely as possible when building barriers such as level bunds and bench terraces that protect the soil from erosion. Two simple ways of making contours are with the line-level and the A-frame.

Contour lines are: Horizontal lines across a slope & link up points at the same elevation	Contour lines help in construction of: • bunds • Grass strips • Stone lines • Trash lines • Bench terraces

The line-level

A line-level consists of two wooden poles of the same height (usually 2 m) with a string 10 m long joining them. The poles have marks every 10 cm. A spirit level is tied exactly in the middle of the string.

You will also need sticks or pegs to mark the contour on the ground (about 20 pegs per 100 m), and a stone or hammer to drive the pegs into the ground. Three or four people are needed to mark contours using a line-level.

Using a line-level to mark contour lines (Figures 18 and 19)

a. Always start laying out contours at the top of the slope (not the middle or bottom), or immediately below the cut off drain (if you have dug one). Drive a peg into the ground where you want the first contour to begin.

b. One person holds the first pole upright at the first peg. The other person walks roughly level with the other pole until the string is tight. The third person checks the spirit level in the middle of the string, and directs the second person to move the pole up or down the slope until the bubble is exactly in the middle of its run (meaning the line is level). Drive a peg into the ground next to the second pole.

c. The two people holding the poles then both move forward until the first pole is at the second peg. Keeping the string tight, the second person again moves his or her pole up or down the slope until the line is again level. Drive a third peg into the ground here. Repeat the process until the whole contour line is marked out.

d. To start a second contour line further down the slope, find a starting point by measuring the vertical interval you want (see section on measuring vertical intervals). Then repeat the process for the new contour line.

e. In difficult topography, it might be inconvenient to measure 10 m at a time. Try using half the length of the string (5m).

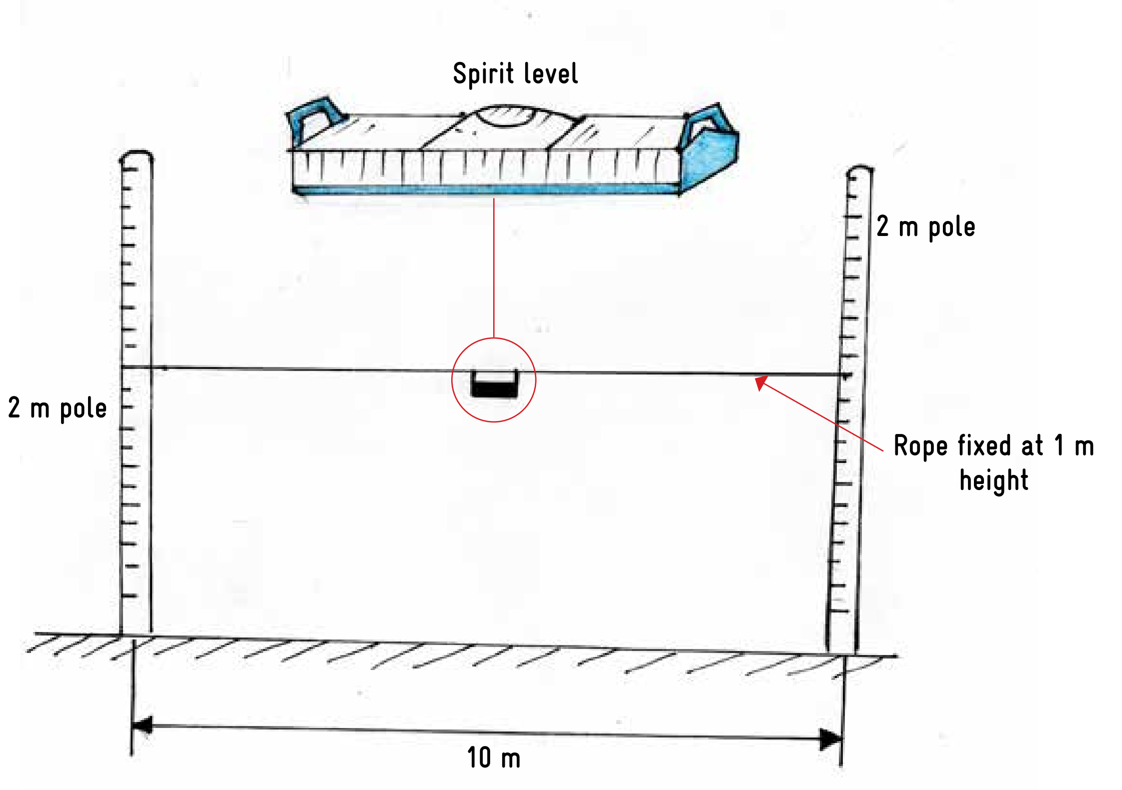


Figure 18: An illustration of a line-level (Source: Uganda Landcare Network)

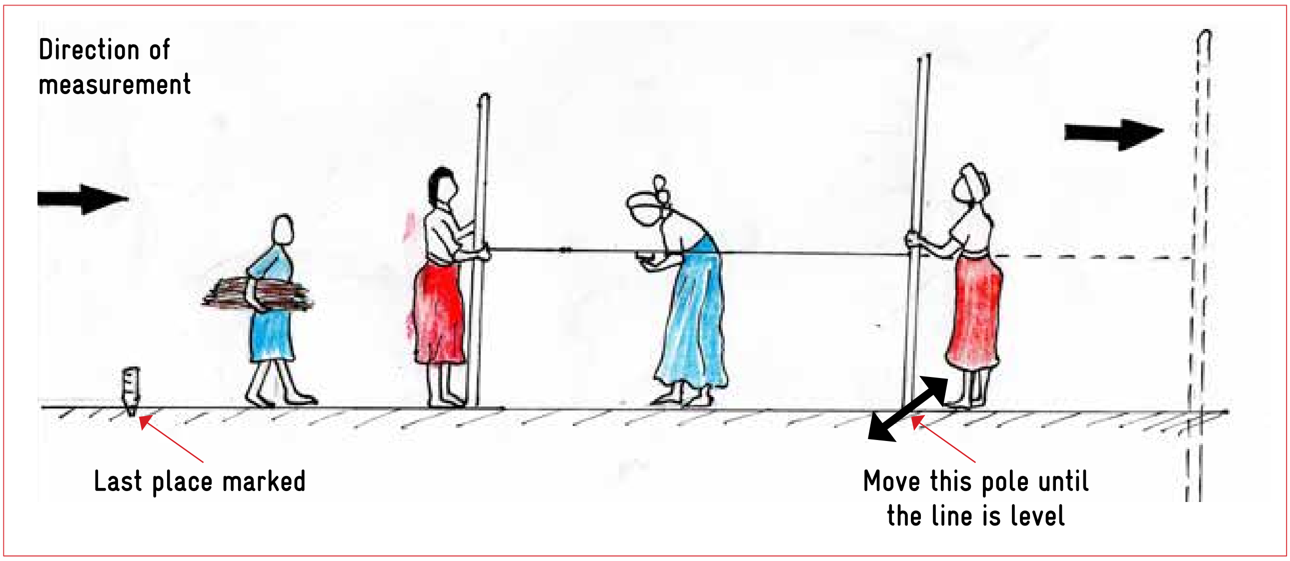


Figure 19: An illustration of how a line-level is used (Source: Uganda Landcare Network)

Measuring vertical intervals and slope gradients

A 'vertical interval' is the distance in height between two objects, such as two terraces or contour bunds. Conservation structures should be built at a small enough vertical interval to prevent erosion.

Measuring vertical intervals with a line-level (Figures 20 and 21)

1. To measure a vertical interval of 1 m, fix the string on one pole of the line-level at 100 cm (1 m). You can untie the string from the other pole; you will not need it.
2. Have the person with the free end of the string hold it on the ground at the top of the slope.
3. A second person with the pole and the string attached moves straight down the slope. The first person pulls the string to keep it tight. The third person watches the bubble in the spirit level
4. When the bubble is in the centre of its run, the string is level. The pole is exactly 1 m below the free end of the string. Mark these two places with pegs or stones.
5. On gentle slopes, the string may be too short. Try measuring the vertical interval in two steps of 50 cm each.

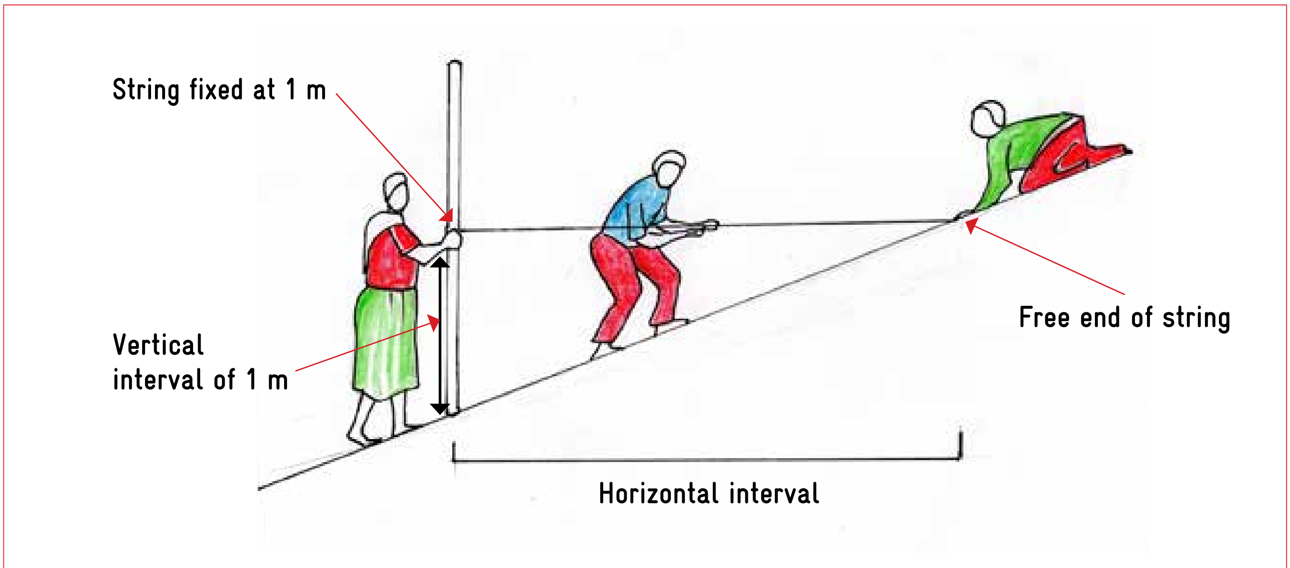


Figure 20: An illustration of measuring a vertical interval of 1 m using a line-level (Source: Uganda Landcare Network)

To mark a larger vertical interval of, say, 1.5 m, you can first measure a 1 m vertical, then one of 0.5 m.

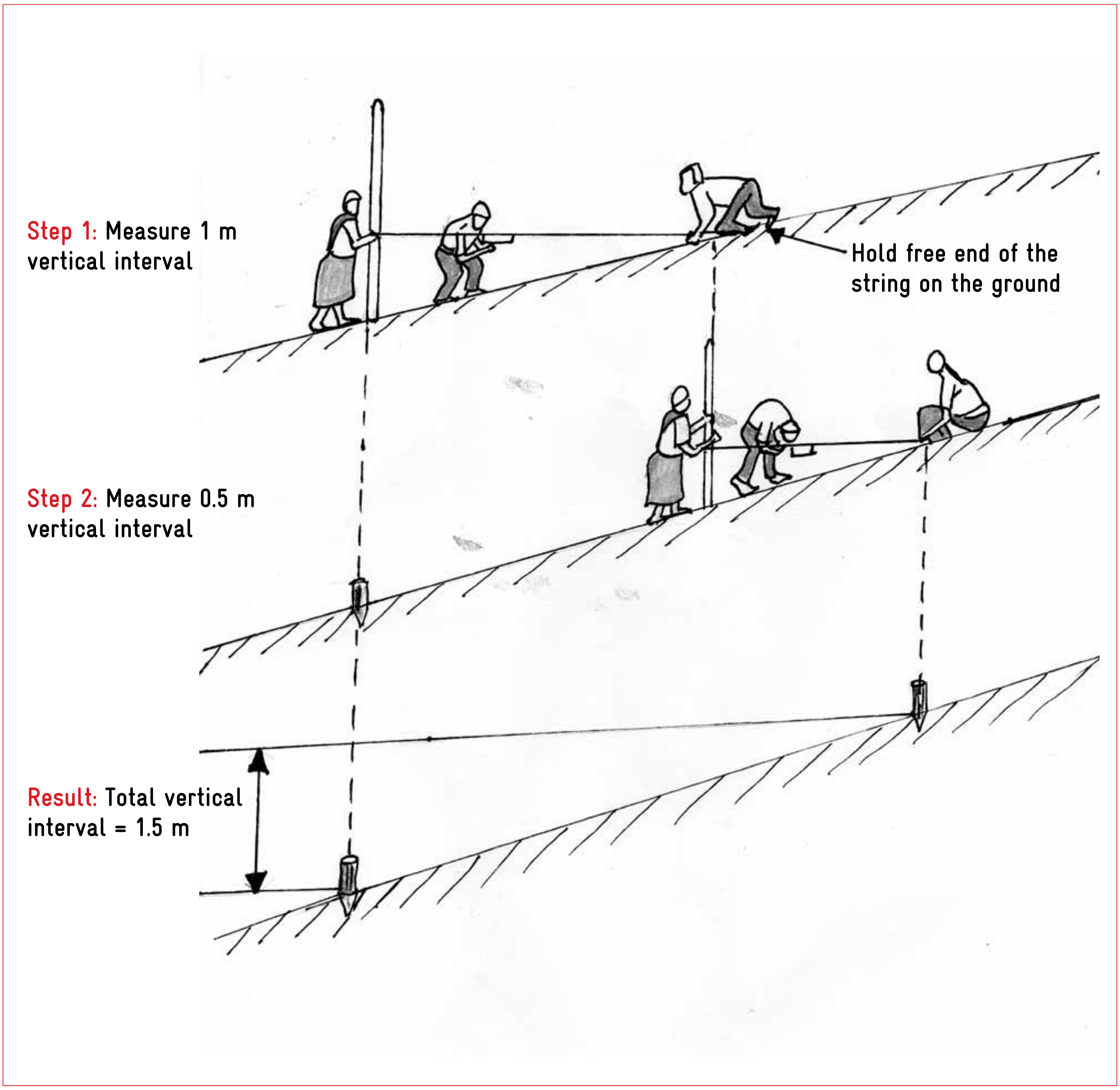


Figure 21: An illustration of measuring a vertical interval of 1.5 m using a line-level (Source: Uganda Landcare Network)

A rule of thumb for spacing structures such as check dams and bench terraces:

- On slopes less than 15%, use a vertical interval of 1 m.
- On the slopes steeper than 15%, use a vertical interval of 2.5 times the depth of the soil. For example, if the soil is 50 cm deep, space check dams at vertical intervals of 125 cm

Constructing an A-Frame for locating and constructing contour lines

The A-frame: An A-frame is made of three poles fixed together like a letter A (Figure 22). It can be made from local materials. You will need about 2m of strong string, a stone to act as a weight, 2 wooden poles with flat ends 3 m long, 1 pole about 2 m long to use as a crosspiece, a hammer and nails, and a knife.

Assembling an "A"- Frame

a. Take the two 3-m poles and fix them together at the top.
b. Fix the 2-m pole horizontally about 1 m from the bottom to form an A shape. [Use nails instead of strings to fix the poles together; this makes the A-frame more rigid and less prone to errors].
c. Tie one end of the string to the stone, and hang it from the top of the A. [The stone should hang freely about 15 cm below the cross bar].
d. Stand the A-frame on a level piece of ground.
e. Make a small, temporary mark on the cross bar where the string hangs past it.
f. Turn the A-frame around so that each foot stands exactly where the other had been. [Mark a second temporary mark on the crossbar where the string hangs past it].
g. Mark a large, final mark midway between the two temporary marks. If the string hangs against this mark, the two feet of the A- frame are exactly level.

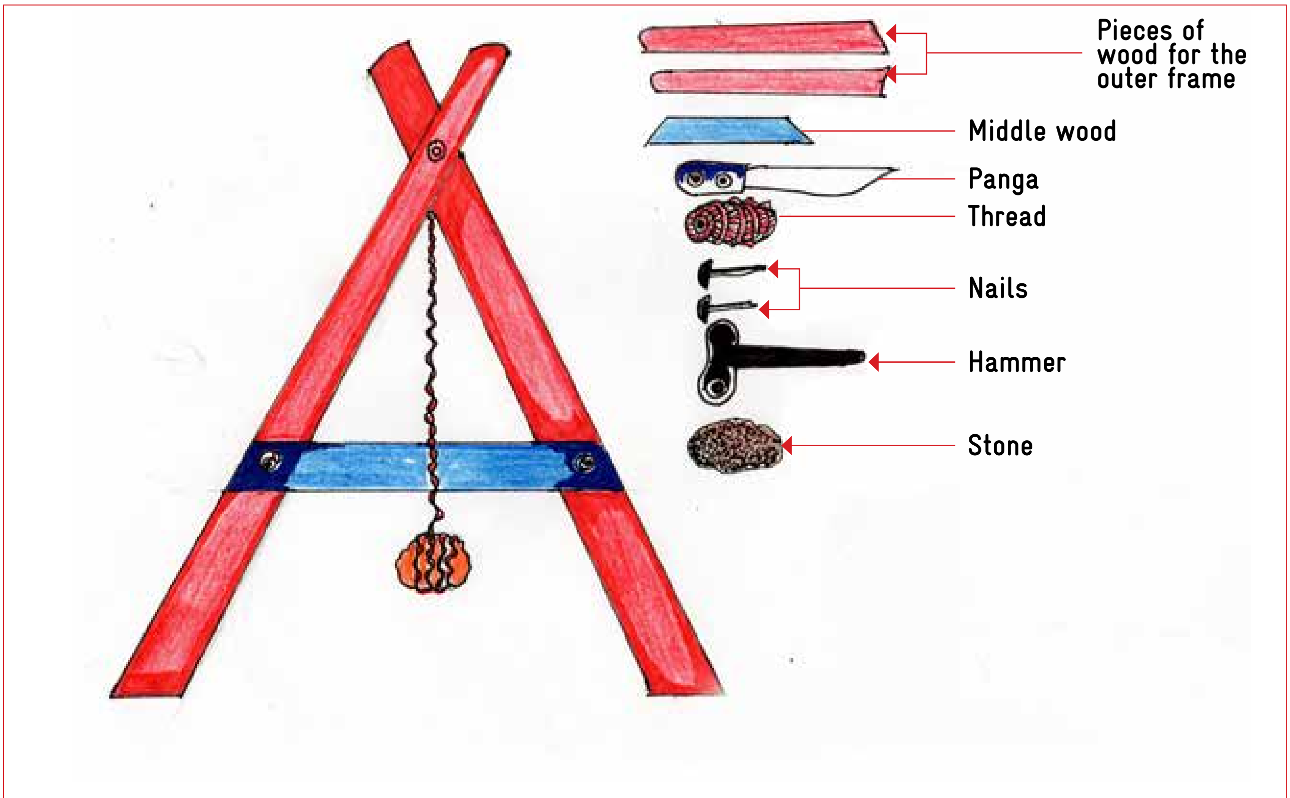


Figure 22: An illustration of how to assemble an A-frame (Source: Uganda Landcare Network)

Using A-Frame to mark contour lines (Figure 23)

Guide/Procedure for using an "A"- Frame

Use the A-frame only on calm days, since the wind disturbs the string and can give wrong measurements.

a. Use a peg to mark the starting point. Put one of the feet of the A-frame next to it. Avoid putting the feet in holes, depressions, or stones, ridges, humps or anthills.
b. Holding one leg in place, move the other one around until the string hangs precisely over the mark on the cross bar. Hit a peg into the ground to mark it.
c. Hold the second leg in place, and pivot the first leg around until the string hangs exactly over the mark on the cross bar again. Drive another peg into the soil at this point.
d. Continue pivoting along the contour, making the locations as you go, until you reach the end of the field.
e. Then move down the slope to where you want to begin the next contour line, and repeat steps a to d.
f. The spacing of contour lines will be guided by the slope gradient, as given in Table 11.
g. The guiding principle is the slope. Once the slope angle is determined, then the spacing will be guided by Table 11.

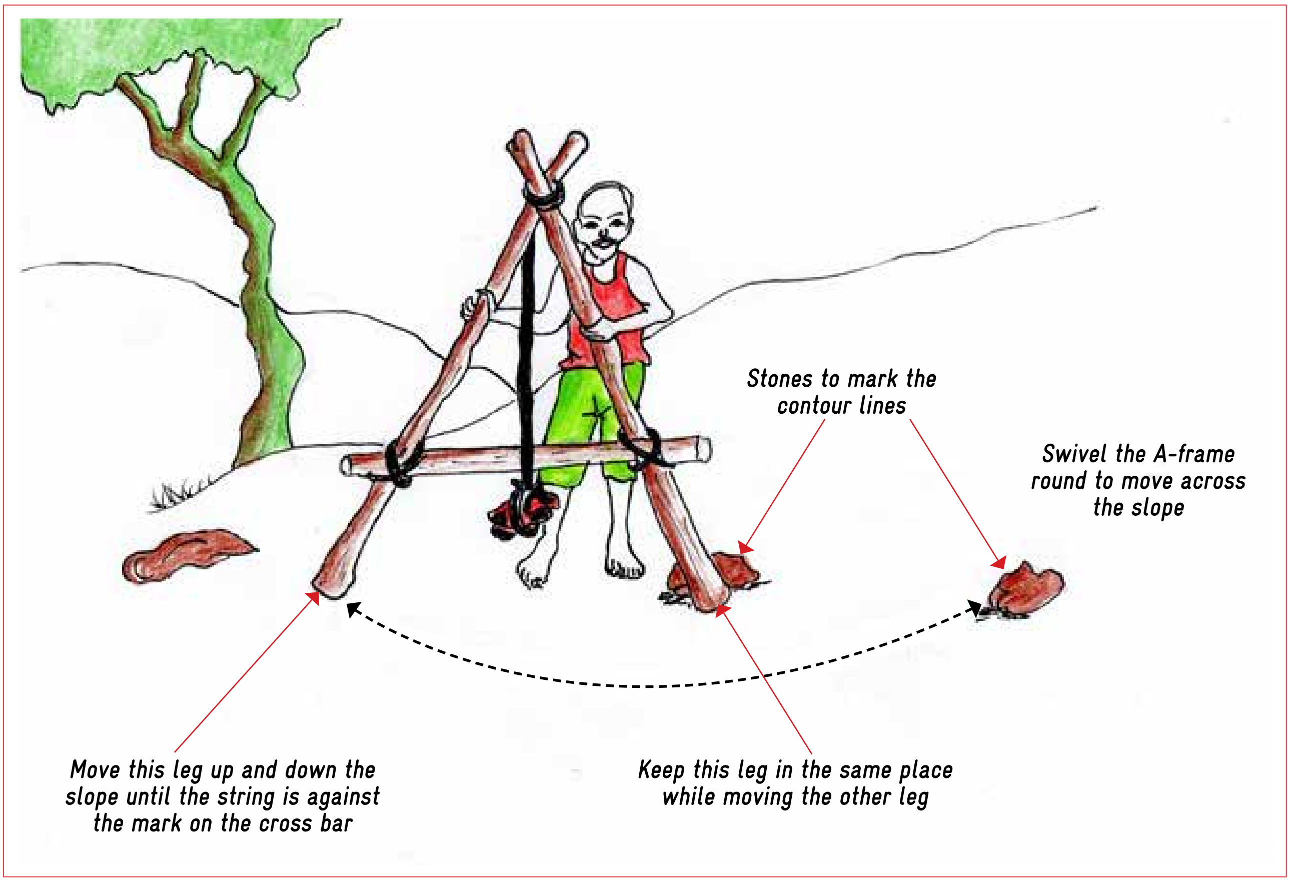


Figure 23: An illustration of how to use the A-frame (Source: Uganda Landcare Network)

Contour bunds that were introduced earlier are one among several physical structures used to conserve soil and water. There are several other physical structures constructed along contour lines for the purpose of controlling soil erosion and water runoff e.g. stone lines, grass strips, among others.

How to make a stone bund/line (Figure 24)

NB: A stone bund is best suited for areas where stones are already available in the area; otherwise it may not be cost-effective.

Guide

Stone bunds need a foundation to make them stable.

i. Measure the slope and mark out the contour (as described in making contour bunds) and space them using the spacing at different gradients (Table 11).
ii. Dig a shallow trench 0.3m deep and 0.2-0.3m wide along the contour. Place large stones in the trench, then pile other stones on the top of them to build a wall.
iii. Use smaller stones and soil to fill any gaps and to reinforce the back of the wall.
iv. Continue to build the wall with the stones until you reach the desired height. Fill in behind it with soil.
v. Plant the bund with grasses, fodder legumes and trees.

Bunds can be built entirely of stones. Just pile large stones along the contour, and fill in any gaps between them with smaller stones, soil and thorny shrubs.

Figure 24: An illustration of stone bunds/lines (Source: Uganda Landcare Network)

Grass strips

Guides

- A grass strip is planted along the contour on cultivated land to reduce the amount of water flowing down the slope and to retain soil (Figure 25). Usually grass strips are about 1 m wide. They are used mainly to replace physical structures (such as contour bunds) on gentle slopes.
- Grass strips are suitable where the climate is not too dry for grass to grow densely. If no grazing is allowed the grass strips build up into terraces and provide fodder for livestock.
- Napier grass is the excellent species for grass strips and bund stabilization. Napier grass produces high quality (protein rich) forage and is best suited to high rainfall areas. Napier grass is also drought tolerant and can grow well in drier areas.
- Vetiver, which is more drought tolerant than Napier grass, can be used, though it is not suitable for fodder.
- Selection of a grass that is suitable for a specific environment is essential

Advantages of grass strips

- Grass strips help reduce runoff and trap eroded soil.
- If they are not grazed, the grass strips will build up into terraces.
- The strips provide cut-and-carry fodder for cattle.

Disadvantages and constraints

- Grass strips may not establish well in arid areas, rendering them to be less effective.
- The strips can easily be over grazed and damaged by animals.

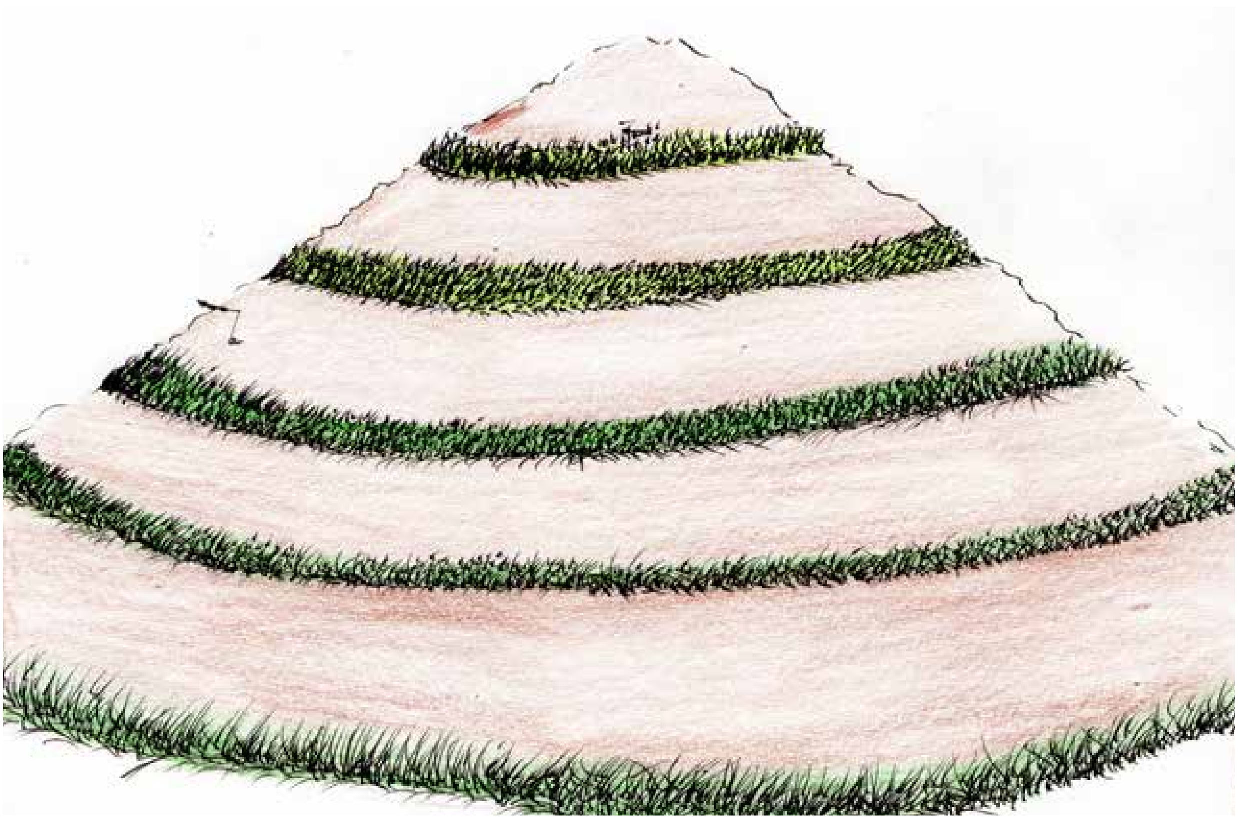


Figure 25: An illustration of grass strips (Source: Uganda Landcare Network)

How to make and manage grass strips

1. Mark out contour lines (as described in making contour bunds) and space them using the spacing at different gradients (Table 12).
2. You can sow grass seed, or plant sods from a well -developed grass land nearby. Select a palatable grass species; with guidance from farmers on which type of grass they prefer. Please note that grass that forms runners is not suitable because it will disturb the crops.
3. When the grass has grown, encourage farmers to cut-and-carry grass rather than allowing animals to graze the strips.
4. The grass should be re-sown or replanted if necessary. Make sure the strips do not get narrowed by plowing: they have to be at least 1m wide to be effective.

Table 12: Spacing for grass strips down the slope

Slope (%)	Spacing (m)
< 3	> 33
3 – 5	20 – 33
6 – 8	13 – 18
9 – 11	10 – 12
12 – 15	7 – 9

Trash lines

Trash lines are made from crop residues, grass and other organic materials collected from the field (Figure 26). These are arranged along contours at appropriate intervals. They slow down surface runoff and reduce soil erosion. Trash lines are used to replace physical structures like stone or soil bunds on gentle slopes. They are usually about 1m wide.

Guides

Where to use trash lines

Trash lines are useful in areas where crop residue and other trash found in the field is not used for livestock feed or fuel.

How to make trash lines

- Mark out the position of the trash line using a line-level or an A-frame. The spacing between the lines depends on the slope. On the gentle slopes, the spacing can be more than 5 m.
- Collect the trash from the field and arrange it along the contour lines you have marked out.

Figure 26: An illustration of trash-lines
(Source: Uganda Landcare Network)

Advantages of trash lines

- Trash lines slow down surface runoff that could cause soil erosion.
- They retain soil, gradually building up terraces along the contour.
- They also allow rain water to seep into the soil, raising the soil moisture content and retaining it for a longer duration.
- The trash eventually decomposes, adding organic matter to the soil, helping retain moisture and improving the soil fertility.
- You can knock pegs into the ground to keep the trash line in place.

Disadvantages and constraints

- Trash lines are not practical in dry land areas and other APZs where trash is in short supply.
- They tend to harbor diseases and pest e.g. insects, rodents and reptiles.

Mulching

Mulch is a layer of straw, leaves or other plant materials used to protect the soil surface (Figure 27). The main purpose of mulch is to conserve soil moisture by protecting the soil surface from the hot sun. It also reduces the impact of the falling rain on the soil; this minimizes soil erosion and crusting, and water runoff.

Figure 27: An illustration of a mulched maize garden (Source: Uganda Landcare Network)

Guides

Where to use mulch

All APZs in Uganda can benefit from mulching, especially the light soils with predominantly silt and sandy textures as those in northern Uganda. However, since mulching is intended to conserve soil moisture, it may not be suitable on heavy soils with a tendency of water logging. It is suitable for almost all crops especially row crops such as maize, beans; perennial crops such as bananas, coffee; and horticultural crops such as cabbage and tomatoes.

Advantages of mulching

- Mulch conserves soil moisture (it allows rainwater to soak into soil and reduces the rate of evaporation from the soil surface, therefore raising the moisture content of the soil).
- Reducing of temperature fluctuations in the soil, since stable and conducive soil temperature regimes encourage good plant growth.
- Mulching creates a favorable environment for soil microorganisms, which enhances soil health.
- As the mulch breaks down, it improves the organic matter and nutrient content of the soil.
- Mulch suppresses weeds, which compete with crops for essential resources such as sunlight, moisture, and nutrients, if not suppressed.

Disadvantages and constraints

- Mulching may be difficult in dry areas where crop residues and other organic materials are used as either animal feed or fuel.
- It can be used as habitant for some pests and fungal diseases.
- Mulch is not suitable for small grain crops which have very close spacing.
- If used in very wet conditions and on heavy soils, mulch may aggravate water logging.

What to use as mulch

Large amounts of organic materials are needed to get the full benefits of mulching. Any organic debris-straws, weeds removed from fields, pruning from hedgerows can be used. Avoid crop residues that harbor pests such as maize stalk-borer. Where weeds are not used as animal feed, they can be used as mulch.

When to use mulch

- Under conventional tillage, before planting the main crop, plough under the mulch to incorporate it into the soil.
- Under conservation tillage, keep the mulch on the field while the crop is growing so the mulch controls weeds.

Session III: CSA practices/technologies for improving and maintaining soil fertility

CSA practices/technologies for improving and maintaining soil fertility	
Estimated duration	3 hours
Session guiding questions	This session is intended to make participants appreciate soil fertility enhancement as a critical function for CSA. It is also intended to provide knowledge and impart skills in soil fertility enhancement using appropriate technologies/practices such as organic fertilizers, agro-forestry, and fallows. The key guiding questions are: a. Do you face problems of soil fertility and how does this affect agricultural production? b. What are the challenges related to soil fertility management in agricultural production c. What are the appropriate technologies and practices used to enhance soil fertility? d. What helps to decide on the technology/practice to be used in enhancing soil fertility? e. What approaches are used to promote/scale the use of different soil fertility enhancement technologies and practices? f. How to establish/use the different soil fertility enhancement technologies and practices
Session Objective	• To give a general overview on soil fertility and the challenges of declining soil fertility in agricultural production, using local examples and experiences • To introduce and explain the various technologies and practices, which are used in soil fertility enhancement. • To demonstrate the use of appropriate technologies and practices for soil fertility enhancement.
Preparation	• Prior knowledge and information on the status of soil fertility, causes and consequences of soil fertility loss in agricultural production. • A clear understanding of the appropriate soil fertility enhancement technologies and practices • Practical knowledge and skills to demonstrate soil fertility enhancement technologies and practices • Physical teaching aids, materials and tools. • Visual aids exhibiting different case scenarios of nutrient deficiencies/hunger signs in crops. • Visual aids exhibiting simple processes of making and proper/improper utilization of soil fertility enhancement technologies and practices
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Physical teaching aids, materials and tools • Visual aids

CSA practices/technologies for improving and maintaining soil fertility	
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Field excursion to showcase some case scenarios of declining soil fertility as well as successful soil fertility management • Practical sessions to demonstrate technologies and practices for soil fertility improvement
Take home and follow up	• Healthy and fertile soil is the foundation for land productivity • Plants obtain nutrients from two natural sources, that is, organic matter and minerals. • Soil organic matter, nutrients and soil structure are the main factors influencing soil fertility • Decreasing soil fertility is one of the major forms of land degradation in Uganda • Reduced soil fertility hinders the production of food, fodder, fuel and fibre. • The key drivers of decreasing soil fertility and low productivity on small-scale farms in Uganda are continuous cultivation with minimum soil fertility enhancement; soil nutrient mining; poor land management and inappropriate farming practices/systems. • There are several technologies and practices that can be used to address issues of soil fertility and land productivity in Uganda

Overview

Healthy and fertile soil is the foundation for land productivity (Liniger *et al.*, 2011). Plants obtain nutrients from two natural sources, that is, organic matter and minerals. Reduced soil fertility hinders the production of food, fodder, fuel and fibre. Soil organic matter, nutrients and soil structure are the main factors influencing soil fertility (Liniger *et al.*, 2011).

Decreasing soil fertility is one of the major forms of land degradation in Uganda (NSOER, 2017). It has long been documented that soil fertility is an impediment in almost all the APZs in Uganda especially where there has been agricultural intensification (NARO/MAAIF, 1996). It has also been documented that the rate of soil fertility decline in Uganda is among the highest in sub-Saharan Africa (Nkonya *et al.*, 2008), with an estimated average annual nutrient depletion of 70kg of nitrogen (N), phosphorus (P) and potassium (K) (Nkonya *et al.*, 2004).

The key drivers of decreasing soil fertility and low productivity on small-scale farms in Uganda are continuous cultivation with minimum soil fertility enhancement; soil nutrient mining; poor land management and inappropriate farming practices/systems e.g. overgrazing; burning of grasslands/organic residues; which lead to soil compaction, erosion, acidification, and low soil moisture and organic matter content.

Besides land degradation, most Ugandan soils are naturally poor. They are old and highly weathered and therefore have little mineral nutrient reserves; consequently they depend on organic matter for soil nutrients. If the soil is inherently poor, extra effort is needed to improve its fertility.

This section describes various methods to maintain and improve soil fertility. It covers composting; use of animal manures; bio-fertilizers and chemical fertilizers; fallows/ improved fallows and agro-forestry.

Composting

Background

Compost is made out of organic waste materials such as leaves, weeds, manure, household waste, etc (Figure 28). Compost supplies a wide variety of plant nutrients but most especially nitrogen. Besides plant nutrients, compost creates a favorable environment for soil macro- and micro-organisms, a manifestation of good soil health. It also improves the water holding capacity (WHC) of the soil and helps the soil to withstand compaction.

Compost works well in all APZs and on all soils. That notwithstanding, composting works best under warm, moist and well aerated conditions that allow the materials to quickly decompose. In that regard, the process of making compost may take longer in cold environments e.g. the Highland Ranges. In the drylands, there may be too little moisture to make quality compost.

- Composting works best under warm, moist and well aerated conditions that allow the materials to quickly decompose
- In drylands there may be too little moisture to make quality compost.

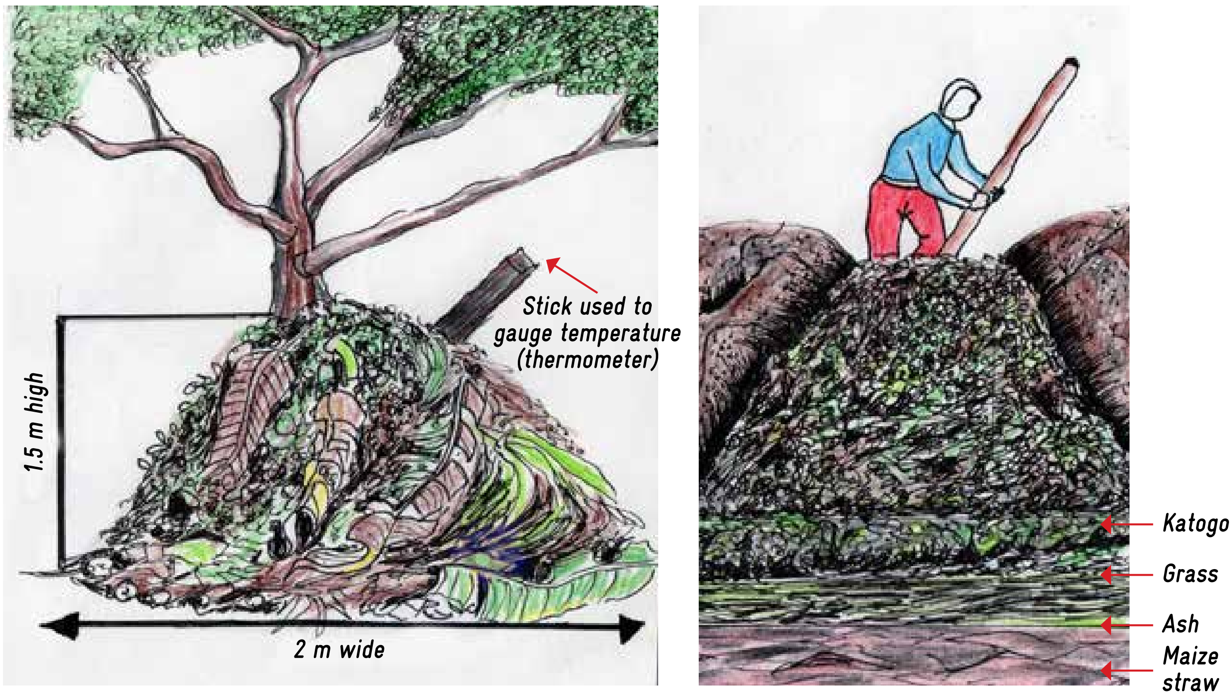


Figure 28: Compost making (Source: Uganda Landcare Network)

Advantages of composting

- Compost is a valuable natural fertilizer that contains readily available plant nutrients.
- It improves the water holding capacity of the soil
- It improves fertilizer use efficiency
- Its effects last for several cropping seasons
- When making compost, organic materials from around the farm and house are recycled, thus keeping the environment clean
- All farmers, rich and poor, can make compost using materials and tools they already have.

Disadvantages and constraints

- Composting is difficult in areas where organic materials, farmyard manure, and water are scarce.
- Different types of organic materials are required, such as crop residues and other biodegradable materials
- The process of making compost is labour intensive
- Making compost requires some basic knowledge

How to make compost

There are two basic methods for making compost: - heap and pit. The only real difference between the two is that the heap is built above the ground, while in the pit method one is required to dig a large pit.

Heap method:	Pit method:
Done in an open area, where organic materials can be gathered and stored until one is ready to add them to the pile. This method is more suitable for high rainfall areas. The heap allows excess water to drain away and prevents water logging.	Better for dry areas where moisture is limited and windy conditions occur.

Materials required for making compost

- Various organic materials: crop residues, farmyard manure, kitchen waste, urine, etc.
- Tools to dig a pit (for the pit method), a cart or wheel barrow, a machete
- Water, a watering can or other container
- Top soil or manure compost from another pile (to act as culture)
- A 2-m long pointed stick (to be used as thermometer to the temperature during the composting process)

How and when to apply compost

Since it is not easy to make large quantities of quality compost, farmers may prefer to apply it on high value crops e.g. fruit trees or spread it on the less fertile areas of their fields. When spread across a field, cover the soil with a few centimetres of compost before ploughing, thereafter plough it under. Never leave freshly spread compost on the soil surface; because if it is exposed to the sun or rain, valuable nutrients are lost through volatilization or leaching. When planting grain seed e.g. maize, beans, soy bean, etc. one can apply small quantities of compost directly into the planting hole or furrow.

Materials for making compost

The best materials for making compost are those that break down or decompose quickly. Woody materials or vegetation that has dried out completely may take a lot more time to break down or decompose.

In integrated nutrient management, compost used in combination with inorganic fertilizers increases the nutrient use efficiency, especially that of nitrogen. Since compost contains large amounts of nitrogen fertilizer, it helps reduce the nitrogenous requirements, helping farmers to reduce on expenses towards purchase of nitrogenous fertilizers.

Steps to follow in making a compost heap/pit

- Select a suitable site, not too closes to houses or sources of drinking water. This is because compost produces a liquid that can contaminate nearby water sources such as shallow wells or open ponds. The selected site should be under a shade either under a tree or roofed structure. Also ensure that the site does not flood during heavy rains.
- Collect all available organic materials that decompose easily e.g. animal manure and urine, crop residues, grasses, weeds (but not seedy or noxious ones), kitchen waste including ash, etc. Chop up any coarse vegetation or crop residues with a machete,
- Decide how big to make the pit or heap. This depends on how much organic materials are available. In general, the pit can be as wide as needed but the ideal depth is about 50 cm. A heap may be roughly 2m wide and 1 to 1.5m high. A heap or pit less that $1m^2$ is too small.
- Spread small braches or other coarse materials such as maize stovers at the bottom of the heap or pit, to a depth of about 10 to 15 cm. This helps the air to circulate and allows water to drain away
- Spread different organic materials in layers. Make a layer of organic materials about 5 to 15 cm thick; then spread a thin layer (1 to 3 cm) of soil or ash on top. The thickness of each layers is not as important as using a variety of different materials to give a variety of nutrients in the final compost.

Manure

Background

Manure commonly consists of animal dung and urine. Like most organic materials, manure when added to the soil it improves or sustains soil fertility, improves soil structure, and increases water holding capacity of the soil. Compared to inorganic fertilizers, manure contains small amounts of nitrogen, phosphorous and potassium. Urine contains more nitrogen than solid dung. Chicken droppings and poultry litter make the best-quality manure because they are rich in nitrogen. Biogas slurry makes excellent manure.

Usually the quality of manure depends on the diet of the animal. The way the manure is handled/managed also affects its quality. To produce good quality manure the following should be observed:

- Animals are fed with high-quality feeds such as legumes and concentrates
- The manure is kept covered and protected from the elements of weather (rain, sunshine, wind)

Advantages

- Using manure as fertilizer encourages the growth of beneficial microorganisms, worms, and other soil organisms
- Manure increases the organic matter in the soil, improves the soil structure, and increases its water holding capacity
- It recycles nutrients and preserves soil fertility
- It improves water- and nutrient-use efficiency
- It benefits the environment by using waste in a productive way.

Disadvantages and constraints

- Large amounts are needed compared to inorganic fertilizers
- Collection and application of manure is labour intensive
- Fresh manure is injurious to seedlings as well as mature crops
- Manure contains seeds of weeds; therefore its application may lead to spreading of weeds, some of which may be invasive.

How to collect manure

Manure can be collected in different ways:

- If you are using a free range grazing system, confine the animals at night and collect the manure at regular intervals from the kraal.
- Make a channel in the animal shed so urine can flow into a lined pit. If the pit is large enough, shovel the manure into it as well.

Making a manure pit

- Dig a pit in the ground and either line it with a strong polyethylene material or with bricks fixed with cement; this will hold the manure. The pit should be large enough to hold the manure produced in 2 to 3 days.
- Make the floor of the animal shed to slope towards the pit.
- Construct a channel leading from the animal shed to the pit
- If you cannot afford cement, make a plaster by mixing red soil, cow dung and ash. Smear the mixture on the bottom and sides of the pit and channel. Repeat this five times to make the pit and channel leak-proof
- Cover the pit with a plastic sheet, straw, dry banana leaves, or tree branches to shed it and keep out the rain. When the manure is exposed to sunlight, the amount of nitrogen in the manure gets reduced and this reduces the value of the manure as a fertilizer.
- If you cannot make a manure pit, pile the manure in a shaded place; this will protect the manure from direct sunlight. Also protect the manure from rain if possible.

How to apply manure

Fresh manure (and especially fresh urine) can be injurious to plants, i.e. if applied close to the seed or growing plant it will 'burn' the germinating seedling or the plant. To avoid this, manure has to be left to decompose for some months. This requires protecting the manure from the sun and rain during the decomposition process. However, one can use fresh urine directly if it is diluted by mixing 1 part of fresh urine with 2 to 5 parts of water.

The best time to apply manure is at the beginning of the wet season, before the crops have been planted.

Some of the ways to apply manure:

- Apply manure directly to the soil. Dig the manure into the soil so that the nutrients in the manure are not lost to the air. Manure is usually applied before sowing annual food crops. In case of perennial crops, manure can be applied while the crops are growing.
- Make liquid manure and apply it to high-value crops e.g. vegetables or fruit trees
- Collect urine in a pit, treat it by adding wood ash, and then apply the liquid to the soil around crops.
- Night Kraaling: Keep animals in a kraal especially at night for several months. After which the kraal is transferred to another place. Plough the old kraal and plant crops

How to make liquid manure

One can make liquid manure by putting a sack full of fresh animal manure in a drum of water and leaving it for about 3 weeks to ferment. After the fermentation process, one can use the liquid manure to water high-value plants such as vegetables and fruit trees. One can also make liquid maure using fresh leaves of nitrogen-fixing trees such as leucaena and gliricidia. Other materials for making liquid manure include green grass clippings or fresh weeds.

Steps to make liquid manure

- Fill a sack with wet manure, fresh leaves or compost
- Tie the open end with a rope and place the bag into an empty drum
- Put a big stone on the bag to hold it down
- Fill the drum with water and cover it
- After 3 weeks, remove the bag from the drum
- Dilute the concentrated liquid manure in the drum at a ratio of 1 part of the liquid manure to 4 – 6 parts of fresh water.
- Two to three weeks after vegetable seeds have germinated; use a watering can to pour the diluted liquid manure around the base of the plants. Avoid slashing the diluted liquid manure on the vegetable leaves directly. Repeat this after every 3 to 4 weeks

Due to its pungent smell, urine can be used to control pests
Urine is collected in jerrycans and allowed to ferment for 5 to 15 days. After the fermentation process, the urine is prayed (undiluted) to control certain pests. The urine also improves soil fertility.

Inorganic fertilizers

Background

Inorganic fertilizers when used judiciously help to enhance soil fertility and increase land and crop productivity. However, farmers need to understand that inorganic fertilizers are not a substitute for organic fertilizers such as compost and manure. In order to get the best out of both the inorganic and organic fertilizers, it is always important to apply them in combination.

Advantages

- Inorganic fertilizers have concentrated nutrients and are easy to carry and apply. For example, a 50-kg bag of urea contains as much nitrogen as a tonne of compost.
- Applying inorganic fertilizers is easier and quicker, especially for women, youths and those that may be physically challenged.
- If applied correctly and combined with other soil and moisture conservation measures, inorganic fertilizers can greatly improve crop yields.

Disadvantages and constraints

- Farmers may not have the money to buy inorganic fertilizers
- Fertilizers may not be available at the right time and in the required amounts
- They require more skill to use than organic fertilizers. Farmers need to know how much to apply and when, how and where to apply them
- Inorganic fertilizers can be a waste of money if the land is not managed well, for example if soil erosion is not controlled or when applied under dry conditions.
- They can cause environmental pollution if they are not managed appropriately
- Farmers have to apply fertilizers year after year to maintain good yields

Types of inorganic fertilizers

Inorganic fertilizers are manufactured materials, which contain at least 5% of one or more of the three primary nutrients (nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O). All these nutrients are present in the soil, but in variable amounts. If the supply of one type is insufficient, crops will not grow well. Farmers can make up the deficient nutrient by applying fertilizer.

Different types of fertilizers contain different amounts of nitrogen, phosphorous, and potassium. Table 13 shows the commonly used inorganic fertilizers in Uganda and the variable amounts of nitrogen, phosphorous, and potassium.

Table 13: Some important fertilizers in Uganda

Common names (formulae)	Grade of analysis in per cent				
	N	P_2O_5	K_2O	Mg	S
Nitrogen fertilizers					
Ammonium sulphate $[(NH_4)_2SO_4]$	21	0	0	-	23
Ammonium nitrate $[NH_4NO_3]$	33-34.5	0	0	-	-
Urea $[CO(NH_2)_2$	45-46	0	0	-	-
Phosphate fertilizers					
Single superphosphate $[Ca(H_2PO_4) + CaSO_4]$	0	16-20	0	-	12
Triple or concentrated superphosphate $[Ca(H_2PO_4)_2$	0	46	0	-	-
Ground rock phosphate (mineral phosphate)	0	20-40	0	-	-
Potash fertilizers					
Muriate or chloride of potash (KCl)	0	0	60	-	-
Sulphate of potash (K_2SO_4)	0	0	50	-	18
Sulphur fertilizers					
Gypsum $(CaSO_4.2H_2O$	-	-	-	-	16-18
Multinutrient fertilizers					
Diammonium phosphate (DAP) $[(NH4)_2HPO_4]$	18	46	0	-	-
Calcium ammonium nitrate (CAN) $5Ca(NO_3)_2$-$NH_4NO_3.10H_2O$	27	0	0	-	-
NPK e.g. 22-22-11; 19-19-19; 17-17-17					

Different crops need different types and amounts of inorganic fertilizers. The best type of fertilizer for maize is not necessarily the best for rice, beans, sunflower, etc.

Hunger signs in plants

If plants do not get enough of a particular nutrient they need, the symptoms show in the general appearance as well as in the colour of the plants. Very typical symptoms are: the nutrient deficient plants are stunted (small), the leaves have a pale green colour or a very dark bluish green colour, are yellowish or have reddish spotting or striping. At harvest, the yields are reduced, sometimes severely.

Identification of nutrient deficiency (hunger signs) (Box 5) is easy in some cases, but difficult in others. The reason for this is that deficiency symptoms of two different nutrients can be nearly identical or that the deficiency of one nutrient is masking (hiding) the symptom of another deficiency. The hunger signs may also appear or disappear as the weather changes (change between wet and dry conditions). It may also be the case that plants are suffering from not yet visible latent deficiency (hidden hunger). Furthermore, care should be taken not to confuse hunger signs with virus or fungus disease symptoms or damage caused by insect/animal pests.

Box 5: General hunger signs for some crops

- Stunted plants (common to all deficiencies), poor plant health and small plants
- Loss of colour (common to all deficiencies), yellow disclouration of leaves from tip backwards, older leaves brown
- Lower leaves may die prematurely while the top of the plant remains green (sometimes mistaken for lack of moisture)

→ Not enough nitrogen

Stunted plants with a light green to pale yellow color on the older leaves starting from the tip towards the base of the leaf blade while spreading outwards. This is followed by drying and dropping of the older leaves.

(Source: NARO)

- Stunted plants
- Leaves dark bluish green, purpling and browning from tip backwards (often also at stems)
- Plants slow to ripen, remaining green
- Roots are few and short
- Fruits may be misshapen, grain is poorly filled

→ Not enough phosphorus

Dwarf and abnormally dark green plants. Purpling of leaves and stems. Delayed maturity, poor root and seed/fruit development.

(Source: NARO)

- Stunted plants
- Leaves show discolouration along outer margins from tip to base
- Outer edges of leaves yellow or reddish, becoming brownish or scorched and dead (edge necrosis); leaves wilted
- Lodging
- Tree leaves are yellowish, reddish, pinched, cupped or curved
- Fruit is small, many have lesions or injured spots, poor storage and keeping quality

→ **Not enough potassium**

Interveinal chlorosis starting from leaf edges and moving inwards, mid-rib remains green, followed by scorching and browning of tips of older leaves. Weak plants that easily lodge.

(Source: NARO)

Symptoms of nitrogen deficiency can be cured by applying urea immediately. However, overcoming phosphorus and potassium deficiencies must wait for the following cropping season

Sources of nitrogen, phosphorus and potassium:

Nitrogen (N)

- Nitrogen does not stay long in the soil – it disappears quickly. Farmers can add nitrogen to the soil by:
- Adding compost, animal manure, or green manure (especially made from leguminous plants)
- Planting legumes/pulses such as beans, soy bean, etc. in crop rotation or intercropping. The legumes fix nitrogen from the air and store it in the soil for plants to use.
- Adding inorganic nitrogen fertilizer e.g. urea

Phosphorus (P)

Unlike nitrogen, phosphorus stays in the soil for a long time. All crops need enough phosphorus to grow well because it promotes root development. Farmers can add phosphorus to the soil by:

- Incorporating tethonia (false sunflower) into the soil as green manure. One can also make liquid manure using tethonia as was described earlier.
- Applying phosphorus fertilizer e.g. DAP or TSP

Potassium (K)

Grasses e.g. elephant grass are rich in potassium. Farmers can add potassium to the soil by:

- Mulching using elephant grass
- Applying potassium fertilizer e.g. KCL, NPK (13-13-21; 12-12-17; 11-22-22; 10-26-26)

Using inorganic fertilizer does not guarantee a high yield unless they are properly managed and combined with organic fertilizers. They are best suited to areas which are not too dry (i.e. areas with enough rainfall or with irrigation) or too wet. Without enough soil moisture and on very wet soils, the investment in fertilizer will be wasted.

Inorganic fertilizers often give good yields when applied to improved crop varieties. In most cases improved crop varieties need inorganic fertilizers to realize their potential.

How to apply inorganic fertilizer

- Try to place fertilizer as close to the crop roots as possible, but not too close, as it may burn the plants or their delicate roots, especially if the soil is dry. If burning does occur, irrigation helps to reduce the damage. Nitrogen fertilizer is especially prone to burning.
- Try to apply fertilizers when soil has enough moisture i.e. when rain showers are expected or when the rainfall season is already underway. It is also advisable to apply fertilizer in the evening to avoid losing the fertilizer through volatilization. This way, the rainwater or dew will carry the fertilizer down into the soil to the crop roots.

Time of application

- Basal dressing – applying fertilizer before or during planting
- Top dressing – applying fertilizer (normally nitrogen) while the crop is growing

Placement

- Broadcasting – applying fertilizer by throwing handfuls over the field
- Side dressing – applying fertilizer by putting it in a furrow to one side of a row of crops; used mainly on row crops such as maize and legumes and horticultural crops.

Fallows/improved fallows

Background

A fallow is a cropland which is left uncultivated for one or more years in order to rejuvenate/recover the fertility of the soil. To accelerate the rejuvenation/recovery process, the land can be sown with grasses or legumes, which help improve soil fertility by accumulation of organic matter (OM). Some grasses e.g. elephant grass besides accumulation of OM, help improve soil fertility by adding potassium (K) to the soil. On the other hand, legumes (Table 14) besides accumulation of OM help to improve soil fertility by fixing nitrogen.

Fallows can be used in all APZs where farmers can afford to leave land uncultivated for one or more years e.g. in northern Uganda. Improved fallows which reduce the period required to rejuvenate/recover soil fertility from 1-2 years to about 6 months are good in densely populated areas with a lot of pressure on land e.g. the Highland ranges and the Lake Victoria Crescent.

Table 14: Legumes used to establish improved fallows

Type	Growth	Suggested spacing [monoculture]	Comments	Suitable AEZ
Canavalia	Annual	75 × 30 cm	High aboveground biomass yield, drought tolerant	Can grow in all AEZ, including highlands
Mucuna	Annual	75 × 60 cm		
Tephrosia vogelii	Perennial shrub	100 × 100 cm	Can grow in highlands	
Tephrosia candida	Perennial	100 × 100 cm		
Crotalaria ochroleuca	Annual	Drill seeds, 75 cm between rows		
Crotalaria grahamiana	Perennial shrub	100 × 100 cm	Can grow in highlands	
Crotalaria juncea	Perennial shrub	100 × 100 cm	Can grow in highlands	
Dolichos Lablab	Annual	75 × 75 cm		

For the annual herbs, the recommended spacings (Table 14) lead to good ground cover within 2-3 months. The perennial shrubs take much longer to cover the ground. The spacing can be increased if the cover crops are grown for seed multiplication. Where the cover crops are to be intercropped with a crop (e.g. maize), plant the cover crop between rows of the crop after the first weeding, and then leave the cover crops to continue growing until land preparation for the next crop when the cover crop can be incorporated into the soil or cut and left on the surface as mulch.

The perennial shrubs are best for areas that are badly degraded and they should be left to grow for two or more seasons.

Advantages

- Fallows restore soil fertility and protect the soil from erosion
- Fallows reduce the incidence and severity of crop pests and diseases by breaking their life cycles
- The fallow land can be a source of pasture or fodder for livestock

Disadvantages and constraints

- During the fallow period the land is taken out of crop production
- Fallows can allow weeds and bush to spread
- Fallows may cause or fuel bushfires

How to manage improved fallows

- Fence off the land and sow it with grass or legume seeds.
- Keep livestock off the land until it is ready for cut-and-carry or for grazing
- Control aggressive weeds that may compete with the sown legumes

Agro-forestry

Background

Agro-forestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, bamboo, palms, etc.) are deliberately grown on the same land as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence/on the same plot of land.

Alley Cropping

In this practice agricultural crops are grown along with long-term tree crops (Figure 29). It involves growing crops in-between trees planted in rows. The spacing between the rows is appropriately designed to accommodate a matured tree size while leaving plenty of space for agricultural crop to grow and receive sunlight. This requires skillful management and careful planning. The agricultural crop provides the annual income while the tree crop matures. Local tree species like grivellia, markamia *(musambya)*, acacia, etc are generally preferred in alley cropping system.

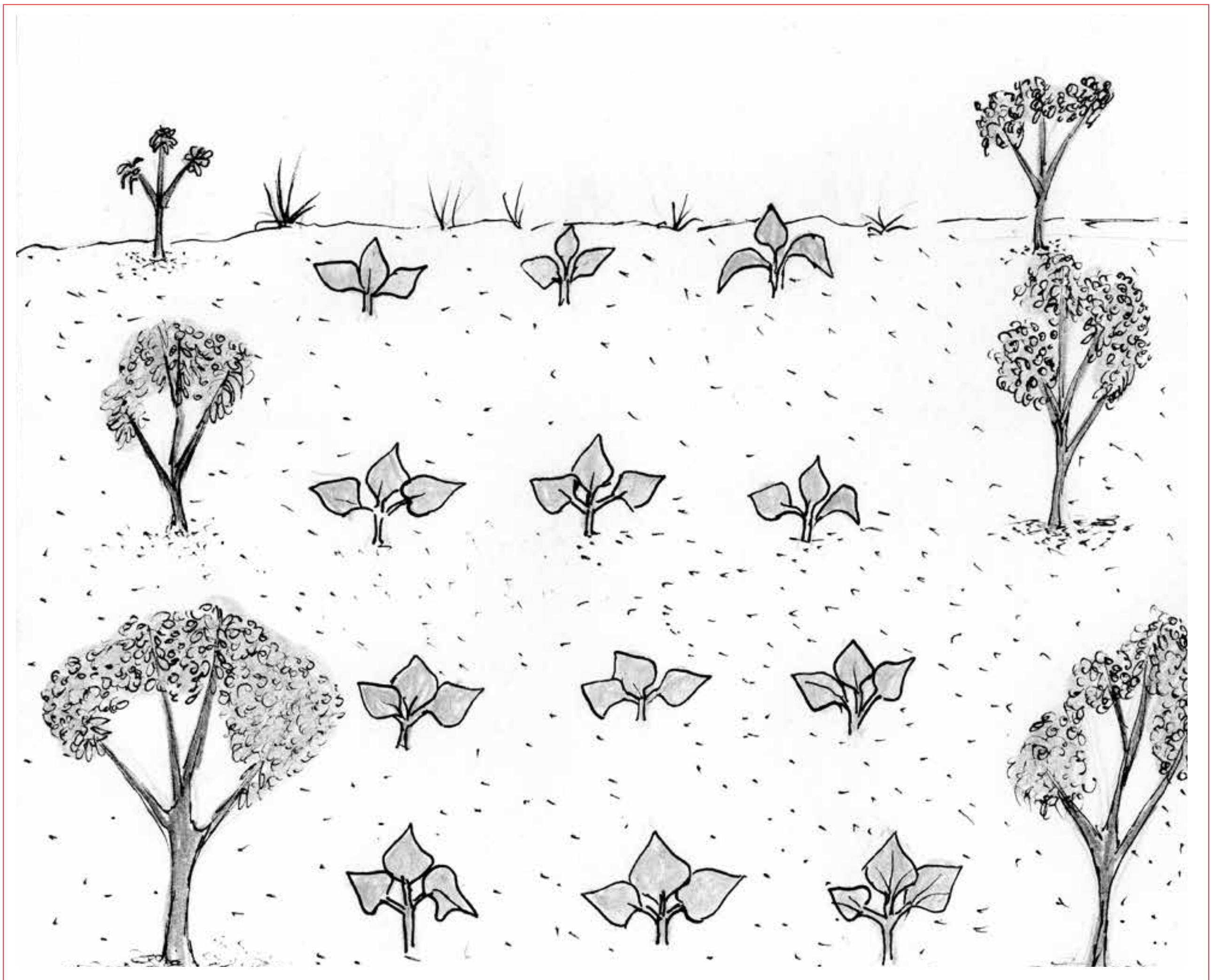


Figure 29: An illustration of alley cropping (Source: Uganda Landcare Network)

Riparian Buffer Strips

This practice is popularly also known as "filter strips". The purpose of riparian buffer strip is to catch soil, nutrients and pesticides from flowing into water bodies. The trees and shrubs are planted along the river or lake, which in turn also prevents stream bank erosion. Buffer strips can be planned to provide habitation for wildlife and also production of exotic forest products as in the case of forest farming

Windbreaks or Shelterbelts

In this type of agro-forestry practice multiple or a single layer of trees and shrubs are planted along edges of the fields. This shields the crops or the livestock from the effects of the wind, or extreme temperatures. They protect the fields from soil and water erosions as well, therefore creating a more favorable environment for the crops to grow. This system can also be designed to specifically build natural shelter for livestock; this reduces feed costs, odour/smell, animal stress and mortality while pleasing the eyes aesthetically.

Advantages

- Reduction of pressure on natural forest and upland ecosystems
- Sustained, year-round production
- Soil improvement (both chemical and structural)
- Watershed improvement (stability, erosion control, water production)
- Crop diversity and reduced risk
- More efficient use of space (more levels used, instead of single crops at one level)
- Microclimate improvement
- Shelter/habitat for wildlife
- Economic advantages (greater income, less risk).

Disadvantages and constraints

- Trees viewed as permanent
- Fewer short-term returns
- Long-term returns from trees difficult to predict
- New systems often less readily adopted by farmers
- Crop yield may decrease if system is not well planned and maintained
- Requires education of farmers and help from extension agents
- Initial capital expenditure may be required

Session IV: CSA practices/technologies for water management

CSA practices/technologies for water management	
Estimated duration	3 hours
Session guiding questions	This session is intended to make participants appreciate the importance of water management including, harvesting and utilization, and excesses. It is also intended to provide knowledge and impart skills in water harvesting using appropriate technologies/practices such dams, catchments, and tanks and the management of excesses. The key guiding questions are: a. Do you face water scarcity for domestic and agricultural production? b. Do you experience water excesses (floods) in your area? c. What are the challenges related to water scarcity in agricultural production? d. What are the challenges related to water excesses (floods) in agricultural production? e. What are the appropriate technologies and practices used in water harvesting and utilization? f. What are the appropriate technologies and practices used in the management of excess water? g. What helps to decide on the technology/practice to be used in water management? h. What approaches are used to promote/scale the use of different water management technologies and practices? i. How to establish/use the different water management technologies and practices?
Session Objective	• To give a general overview on water management in agricultural production, using local examples and experiences • To introduce and explain the various technologies and practices, which are used in water management. • To demonstrate the use of appropriate technologies and practices in water management.
Preparation	• Prior knowledge and information on water management including water harvesting, retention and diversion • Prior knowledge and information on available water resources and benefits of water management. • A clear understanding of the appropriate water management technologies and practices • Practical knowledge and skills to demonstrate water management technologies and practices • Physical teaching aids, materials and tools. • Visual aids exhibiting different case scenarios of water management. • Visual aids exhibiting simple processes of water management
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Physical teaching aids, materials and tools • Visual aids

CSA practices/technologies for water management	
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Practical sessions to demonstrate technologies and practices for water management
Take home and follow up	• You only have control over water while it is still on your plot • It is important to a tap and store water from different sources for use during period of scarcity • Challenges associated with water can be successfully addressed with appropriate water management technologies and practices • There are many available small and large scale water management technologies and practices for domestic use and agricultural production • Water management provides micro and macro ecosystem services, which contribute to address climate change challenges.

Overview

Management of rainwater

When rain falls on the ground it can do three things:

1. It may evaporate quickly	• If the water evaporates, it is lost into the atmosphere (though it may fall again somewhere else as rain
2. It may seep into the soil	• If the water seeps into the soil, it can stay in the soil as soil moisture where plants can use it to grow. Or it may filter deeper down into the soil where it can only be reached by plants with deeper roots. Or it can accumulate as ground water on surface of impervious soil layers.
3. It may run off the surface	• Water that runs off the surface may end up in open water sources such as ponds, lakes, rivers, etc. As this water moves over the soil surface, it dislodges small soil particles and carry them away, causing erosion.

Farmers need to understand that they only have control over rainwater when it is still on their land/property. Therefore every farmer needs to devise means to harvest/tap that rainwater before it leaves his/her land/property. There are several ways of rainwater harvesting, where runoff from roofs, rock outcrops, ground, etc. is harvested and channeled to water reservoirs where it is stored for later use.

Management of excessive water

There is a cliché in Ugandan speak that goes: “water is life expect in Bwaise”. Bwaise is a Kampala suburb where residents have to contend with seasonal floods every year and the cliché is that to the residents of Bwaise water is not synonymous with life because of its devastating effects. It is true, if excess water is not properly managed it can be a source of misery instead of life, leading to morbidity and mortality in human beings and livestock, and reduced yields or total failure in crops.

This section describes different methods used in management of rainwater including harvesting. It also covers several useful methods used to store water in different reservoirs and how to use it for domestic purposes or for agricultural production. It further covers methods used in the management of excessive water.

Dams

Background

Large volumes of runoff on the ground can be channeled and harvested in valley dams, valley tanks, earth dams, etc (Figure 30). Dams can store water for dry season needs (either for domestic use or production). They can be dug into the ground, or made by constructing an embankment. The soil that is excavated is used to build the sides of the dam. Some dams may fail if they lose water too quickly through seepage, or because they silt up. Therefore the location where to site a dam has to be chosen carefully, with suitable soil and free from excessive silting.

Safety precautions

If not secured well, dams can be dangerous to people, especially children, and animals. In order to protect animals and children from falling into the water where they can drown, the area around the dam must be fenced off. The fence also serves to prevent animals from drinking directly from the dam, which otherwise leads to contamination.

How to select a site for a dam

Locate the dam where the soil is not too sandy. Soils with too much sand or gravel are prone to seepage and therefore will not hold water. In addition, sandy soils do not bind together strongly; therefore the banks will not be strong and may often give away leading to water loss. Clay soils bind very well, therefore the soil should have enough clay; this will help to prevent seepage and also have strong banks, which all help to hold water in the dam.

Figure 30: An illustration of a woman drawing water from a water dam (Source: Uganda Landcare Network)

Methods used to test the soil to determine whether it is good for building a dam

Test 1

Take a handful of wet soil and squeeze it into a ball. Throw it in the air and catch it.

- Bad soil with too much sand or gravel in it will not stick together, causing the ball to fall apart.
- If the ball sticks together well, the soil may be good, but you need to do another test to confirm this.

Test 2

- Dig a hole 1m across and the same depth as you want to make the dam
- Early in the morning fill the hole to the top with water. By evening some of the water will have sunk into the soil.
- Then fill the hole completely with water again. Cover the hole with leafy branches or other materials to protect it from the sun
- The next morning if most of the water is still in the hole, the soil is good for holding enough water to build a pond in that location.

Evaporation is a major problem, especially if the dam is exposed to wind. Small, deep dams are better than large shallow ones, because the deep dams lose less water to evaporation. Seepage can be reduced by lining the bottom of the dam with compacted clay.

Rock catchments

Large outcrops of solid rock can be used to harvest a lot of water for domestic use and agricultural production. The outcrop must be with a relatively large enough surface to be used as the catchment area. All the cracks in its surface must be sealed to prevent water from escaping underground. An embankment made of stones/bricks and cement is built around the outcrop to channel water into a reservoir, this can be an underground storage tank or small dam.

Things to consider in selecting a rock outcrop for water harvesting:

When a rock outcrop has been selected for purposes of water harvesting it should be protected from animals/people to ensure the quality of the runoff to be harvested.

Water tanks

Background

All water harvesting systems need somewhere to store the water. This may be a dam, reservoir, soil itself, or in specially built tanks. Tanks can be used to store water collected from the ground surface, rooftops, springs, or streams. The stored water can be used for domestic purposes and agricultural production, including crop irrigation or watering animals. Water tanks may serve individual households, groups of households, the entire community or institutions.

Water tanks can be built above or below the ground:

Above ground	Below ground
Ferro-cement tanks	Hemispherical tanks
Plastic water tanks	Bottle-shaped tanks
Metallic water tanks	Dome-cap tanks
	Brick-cap tanks

Above or below the ground

Advantage	
Above-ground tanks	• Easy to inspect for cracks and leaks, and easy to clean and maintain • Water can be taken out using a tap or pipe (gravity flow) • The water is better quality (little contamination)
Below-ground tanks	• Can support a little more water at relatively lower cost, because the ground supports the weight. (walls can be thinner than those used in above-ground tanks) • The water may come from the ground surface or rooftops. The tank fills quickly • Underground tanks are cheaper to construct than above-ground tanks
Disadvantages	
Above-ground tanks	• Above-ground tanks take up space that could have been used for something else • They are expensive to build because the walls must be strong • Very wet weather or extreme heat may cause cracking • The water temperature varies according to the prevailing weather conditions i.e. warmer in hot weather and colder in cold weather.
Below-ground tanks	• Water must be removed with a hand pump or bucket and pulley • It is difficult to empty the tank and to get inside to clean it. • Leaks are hard to detect • The water may be contaminated by groundwater or flooding • If the tank is left open, animals or small children may fall in and drown • The tank may be damaged by large tree roots or by groundwater

How to select a site for a tank

- Locate the tank where the largest amount of water can be stored with the least amount of digging or earth fill.
- If the tank is to be used for watering animals, build it near where the animals are kept
- To protect the water from getting contaminated, choose a location where drainage from farmsteads, feedlots, sewage lines cannot reach the tank.
- Avoid sites near unstable ground, such as gullies or near deep-rooted trees.
- Do not plant trees with deep roots near the tank
- Keep in mind that the tank can suddenly collapse and release all the water, therefore select a safe location for the tank e.g. away from power installations and put a solid foundation under it.

How to build and maintain a tank

There are several tank designs; therefore tanks are built differently depending on the design. The following are some general guidelines:

- Line the inside of the tank to reduce water losses through seepage. Appropriate low-cost lining materials include red clay, soil from termite mounds, cement, stone, bricks or plastic
- Cover the tank with a roof to reduce evaporation and to prevent mosquitoes from breeding in the water. The cost of the roofing can be minimized by selecting a design with a narrow opening at the top.
- Check the tank regularly for cracks, and conduct routine maintenance.
- Do not allow the tank to stand for a long time without water; this will cause the tank walls to crack
- Clean the pipes and screens regularly to prevent them from getting blocked
- Cover all inlets, outlets, and overflow pipes with screens to prevent mosquitoes, other insects and rodents from getting in.

Ferro-cements tanks

Ferro-cement tanks (Figure 31) are built above ground to store rainwater collected from rooftops. The walls and floors are reinforced with wire mesh. The walls do not need to be very thick, so little cement is needed.

Advantages of ferro cement tanks

- No excavation is required
- It is easy to take water out of the tank through a tap
- Leakages or damages can be detected easily

Disadvantages and constraints

- Ferro-cement tanks are fairly small: the biggest are 10 m^3 (10,000 litres)
- They are relatively expensive to construct
- Skilled labour is needed for construction

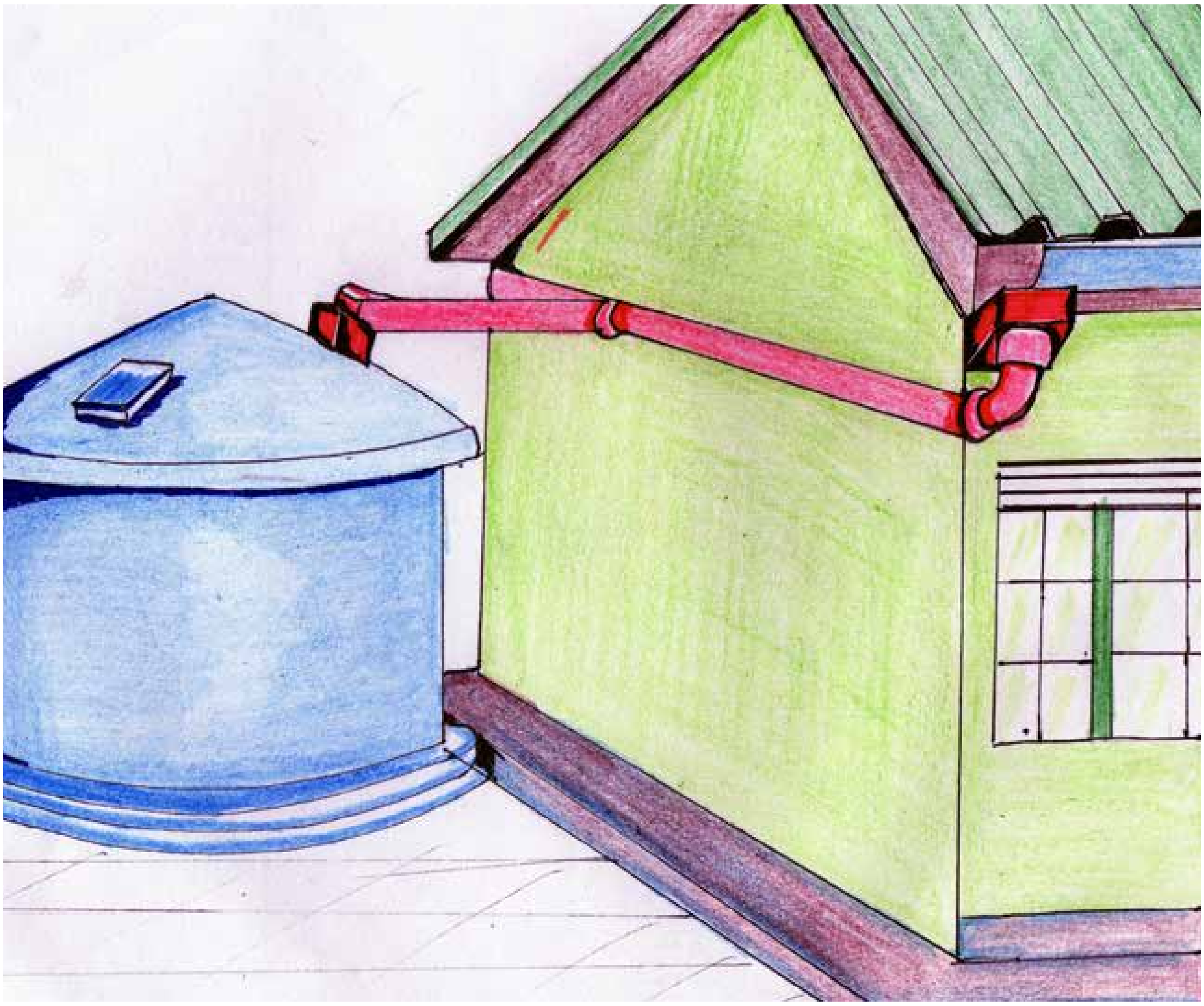


Figure 31: A Ferro-cement tank (Source: Uganda Landcare Network)

Hemispherical tanks

Hemispherical tanks are shaped like half a round ball (Figure 32). They are built below the ground level. They store water collected from the ground surface e.g. rock embankments or from rooftops.

Figure 32: Hemispherical tank (Source: Uganda Landcare Network)

Advantages of hemispherical tanks

- Hemispherical tanks are fairly easy to construct; this means that even semi-skilled or local people can construct them.
- They are relatively cheaper to build
- Drawing water and cleaning inside is fairly easy, since the tanks are not as deep as other types

Disadvantages and constraints

- They take up a lot of space
- A lot of water is lost through evaporation if the tank is not roofed properly

Dome-cap tanks

A dome-cap tank (Figure 33) is an underground or aboveground tank built in two parts: a domed roof made of reinforced cement, above a cylindrical pit lined with mortar. The dome may be above the ground, or it may be buried.

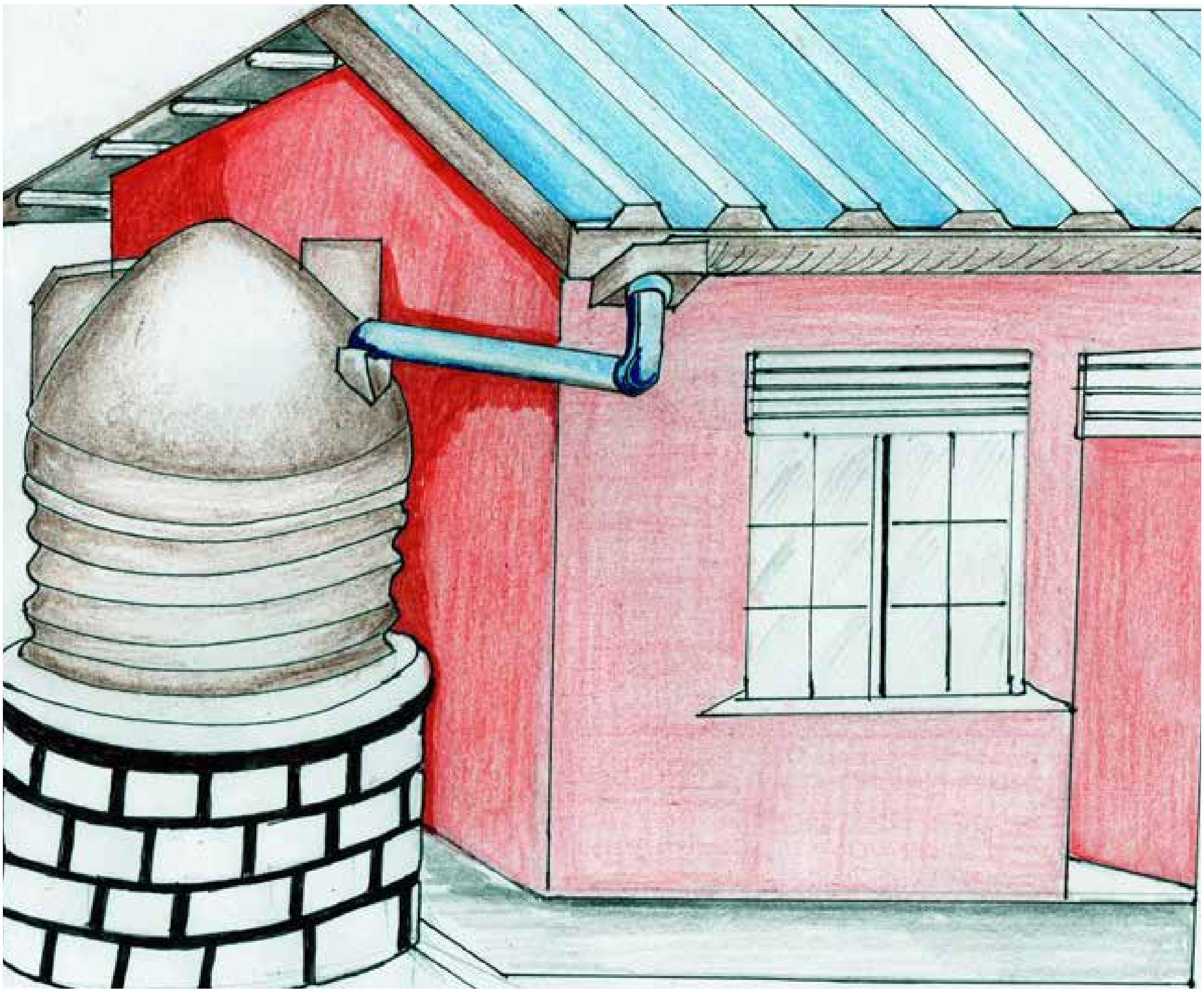


Figure 33: A dome-cap tank (Source: Uganda Landcare Network)

Advantages of dome-cap tanks

- Dome-cap tanks can be built in most soil types. However, they should not be built in clays or sandy soils that are more than 2 m deep.
- They are long lasting
- They do not take up much space.

Disadvantages and constraints

- Dome-cap tanks are more expensive than hemispherical tanks
- They can be difficult to build; making the dome shape needs special skills.
- Cleaning and maintenance can be challenging because of the small opening at the top.

Brick-cap tanks

Brick-cap tanks are similar in shape to the dome-cap tanks (Figure 34). The difference is that the top is made of burnt bricks.

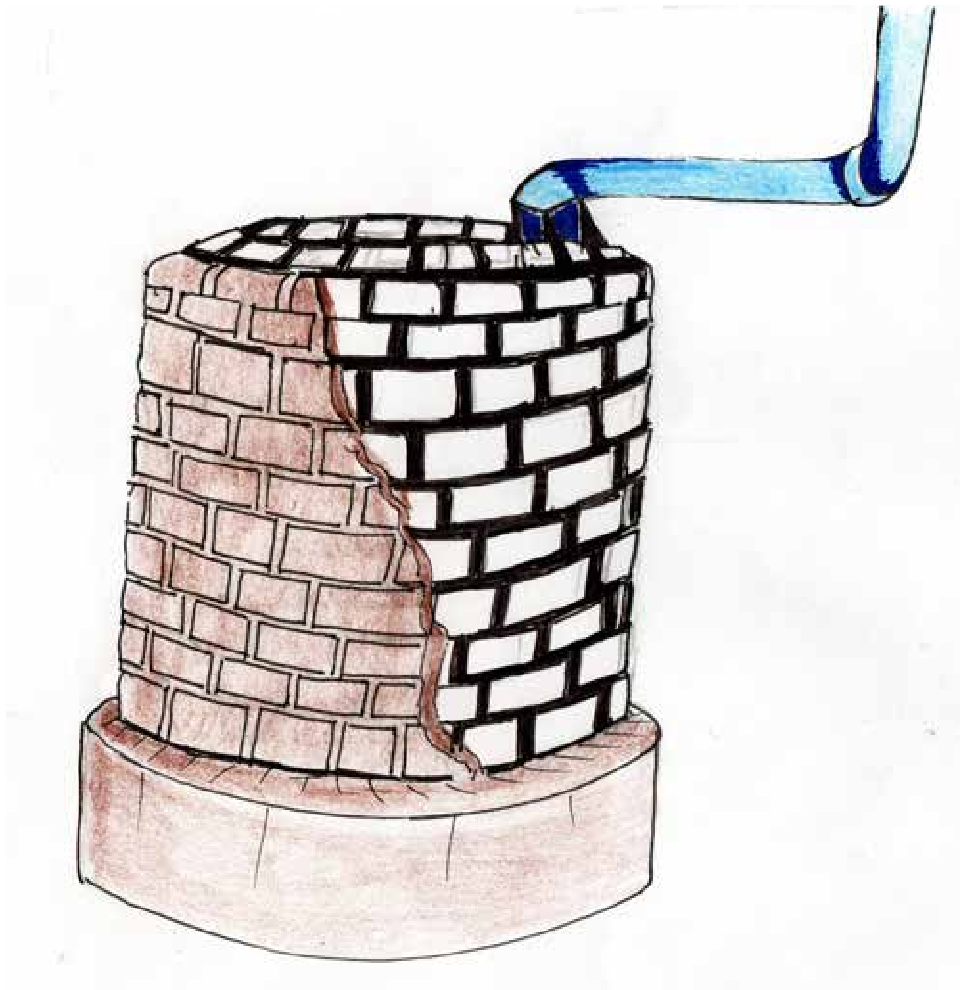


Figure 34: Brick-cap tank (Source: Uganda Landcare Network)

Advantages of brick-cap tanks

- Brick-cap tanks are strong enough for relatively unstable sandy soils.
- They are long lasting

Disadvantages and constraints

- Good bricks may be expensive and hard to find (good bricks are made out of clay soil)
- Laying the bricks requires someone skilled enough
- Cleaning and maintenance can be challenging because of the small opening at the top

Management of excessive water

There are several methods of managing excessive water. These include construction of water trenches to ward off the excessive water; construction of dams/valley tanks/ponds to harvest the excessive water for future use; using the flooded fields to grow excessive water tolerant crops e.g. paddy rice, yams, eucalyptus trees, etc.

Construction of water trenches

An ideal soil is comprised of 25% air (Figure 35). However, when a field gets flooded with excessive water, all the air pockets in the soil which contain oxygen get filled up with water; this creates anaerobic conditions which cannot support crop growth. Many crops/plants need oxygen in the soil for the roots to function properly; otherwise the roots die leading to the death of the entire crop/plant.

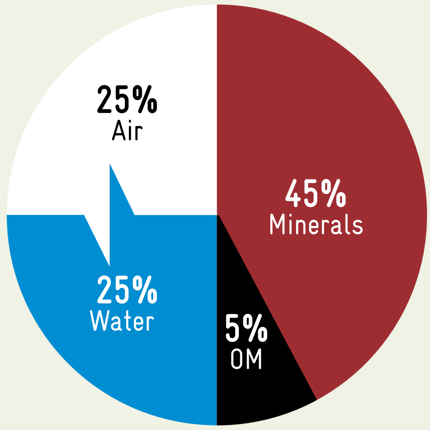


Figure 35: Ideal composition of soil (Source: Authors' elaboration)

In addition, when excessive water (floods) stay on a field for a long time, the soil gets compacted, this renders it less productive. It is therefore imperative that excessive water is warded off the field by constructing drainage channels. After successfully warding off the excessive water it may be necessary to either plough or rip the field to break the compacted soil layers to make the land more productive.

How to construct drainage channels

In constructing the drainage channels the purpose is to let the excessive water into the channel to be drained off the field. To achieve this, when the channels are being constructed the soil is thrown downhill in what has come to be known as *Fanya chini* (*fanya chini* means "throw soil downhill" in Swahili). See Figure 36.

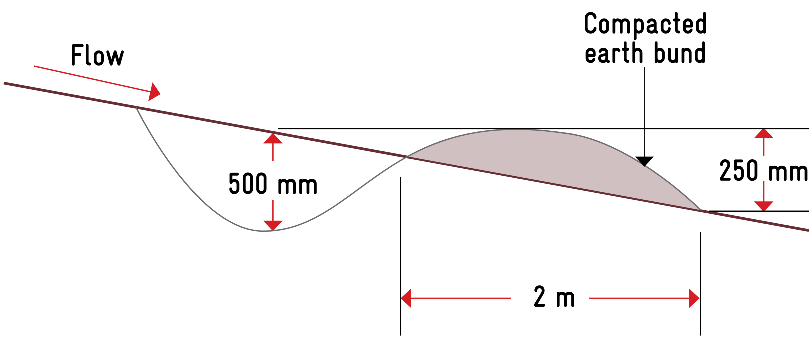


Figure 36: An illustration of Fanya Chini (Source: NARO)

Construction of dams/valley tanks/ponds

It is not uncommon for communities to grapple with excessive water in one season and then grapple with drought in the following season. This kind of scenario can be avoided by constructing dams/valley tanks/ponds and try harvesting some of the excessive water for later use either for domestic or agricultural production. The choice between dam/valley tank/pond depends on the size of the catchment. Valley dams have the biggest capacity and can be used to harvest excessive water from large catchments. This is done by digging drainage channels from the field leading to the valley dams where the excessive water can be harvested and stored for future use.

Using the flooded fields to grow excessive water tolerant crops

Sometimes it may not be possible or cost-effective to ward off excessive water from a field and it is just pragmatic/prudent to seize the opportunity and use the excessive water on the field by growing excessive water tolerant crops such as paddy rice, yams and eucalyptus trees.

Session V: CSA practices/technologies for livestock management

CSA practices/technologies for livestock management	
Estimated duration	3 hours
Session guiding questions	This session is intended to introduce to participants CSA technologies and practices for livestock management. The key guiding questions are: a. What is the main diet of livestock? b. What are the main ways used in feeding livestock? c. How has livestock diet been compromised by climate change and what are the consequences? d. What are the appropriate technologies and practices used in livestock management? e. What helps to decide on the technology/practice to be used in livestock management?
Session Objective	• To give a general overview on livestock management, using local examples and experiences • To introduce and explain the various technologies and practices, which are used in livestock management. • To demonstrate the use of appropriate technologies and practices in livestock management.
Preparation	• Prior knowledge and information on livestock management including the main diet of livestock and the main ways practiced in livestock feeding • A clear understanding of the appropriate livestock management technologies and practices • Practical knowledge and skills to demonstrate livestock management technologies and practices • Physical teaching aids, materials and tools. • Visual aids exhibiting different case scenarios of livestock management.
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Physical teaching aids, materials and tools • Visual aids
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Practical sessions to demonstrate technologies and practices for livestock management

CSA practices/technologies for livestock management	
Take home and follow up	• The main diet of livestock is plants/plants parts, water and mineral salts. • There are three main ways to feed livestock: Grazing and browsing; Cut-and-carry; and Tethering • Extreme weather events such as drought and floods have extremely compromised livestock diet, leading to low productivity in terms of beef and milk; poor health and in extreme cases death. • There are several CSA technologies/practices which can be used to manage livestock successfully and profitably amidst a changing climate.

Overview

The main diet of livestock is plants/plants parts, water and mineral salts. However, because of the extreme weather events such as drought and floods, livestock diet has been extremely compromised leading to low productivity in terms of beef and milk; poor health and in extreme cases death. There are three main ways to feed livestock:

a. Grazing and browsing

The animals are let out to graze on pastures and browse on shrubs. The quality of the grazing can be conserved or improved in various ways. This section describes various ways of managing pasture, by improving the mix of forage species, and conserving and improving soil fertility

b. Cut-and-carry

Under cut-and-carry also known as zero grazing, the animals are kept in a shed or paddock, and feeds are harvested and brought to the animals. The feeds can be freshly cut or fed as hay or silage. In addition, the animals can be given feed supplements. This method of feeding animals is best practiced on animals with high production levels. This section also describes the components of cut-and-carry, including how to conserve feed as hay and silage.

c. Tethering

Gathering enough feed for livestock is a labour intensive activity. To reduce on the burden of carrying fodder long distances, animals can be tethered near the fodder source and fed there.

Animals can be fed with a combination of grazing and cut-and-carry. For example they may be allowed to graze, but also given supplementary feed in form of hay, silage, or concentrates. Or they may be fed by cut-and-carry during the wet season when forage is in abundance (and crops are growing in the fields), and allowed to graze on permanent pastures and crop residues in the dry season.

Over-sowing

Background

Over-sowing means broadcasting seeds of good quality pastures such as *desmodium* on existing natural grazing land. It is not necessary to plough the land. However, the land can be ripped and manure or fertilizer added to help improve the improved pasture establishment. Over-sowing improves the quantity and quality of the feed. This is one of the cheapest ways to improve pastures.

Over-sowing can be done in all APZs where grazing land has been degraded. It does well on lighter and looser soils, in overgrazed areas.

Advantages of over-sowing
• Over-sowing improves the quantity and quality of forage • Sowing legumes improves the soil fertility • Sowing on degraded soils reduces soil erosion • Little labour is needed
Disadvantages and constraints
• Forage seed may not be readily available • Some areas used for grazing are communal; this requires consensus from all community members.

Forage species for over-sowing

Legumes	Grasses	Fodder trees
Alfalfa	Buffel grass	Calliandra
Green leaf and silver leaf desmodium	Cocksfoot	Leucaena
Lablab	Elephant grass	Sesbania
Seca and verano stylo	Panicum	Tree lucerne
Siratro	Phalaris	
White clover	Rhodes grass	
	Setaria	

How to broadcast seed

- Over-sow pasture before or at the beginning of a rainy season
- Choose a site with loose soil
- Treat seeds with hard coats, which can slow their germination or prevent them from germinating altogether
- Apply 0.5 to 1.0 kg of seed per hectare; this is determined by the type of pasture being over-sown. Only a little seed is needed, therefore mix the seed with dry soil, sand or ash to make sowing easier.

Management

Keep animals off the area while the pasture is growing

If the grazing land is owned by a community, the community must form a management group to decide:

- When and how to use the forage (cut-and-carry or grazing)
- The type and number of animals to feed or graze

How to keep animals off the pasture

Treating seeds with hard coats
Some legume seeds take long to germinate because they have hard coats. Here are some of the ways to treat them to make them germinate faster: • Rub small quantities of seed on a rough surface, such as concrete or sandpaper. This is the most common method used by small-scale farmers • Put the seed together with some gravel/sand in a closed container or cement mixer and shake/rotate the mixture for at least 30 minutes

Hot water treatment

- Boil water and after removing the hot water from the heat Source: put the seed in the hot water
- Leave the seed in the hot water for 5 to 10 minutes
- Spread the seeds out in a thin layer (less than 1 cm thick) in order to cool off quickly
- Plant the seeds

Fodder banks

Background

Fodder banks are reserve pastures that are used to feed livestock during the dry season. A mixture of improved grasses and forage legumes provides the best quantity and quality of feed. Animals should be kept off the fodder bank during the growing period.

Fodder banks are useful in pastoral areas where feed shortages, especially during the dry season are a serious problem.

Advantages of fodder banks

- Fodder banks ensure that there are animal feeds all year round
- No additional labour is required since the feed is conserved in the field
- Milking cows do not need to travel long distances in search of feed during the dry season. This improves animal productivity
- Improved forage types can yield large amounts of feed

Disadvantages and constraints

- It may be difficult to protect the fodder bank from stray animals.

How to make a fodder bank

- Set aside an area of grazing/range land to use as a fodder bank
- Choose what type of forage to plant/sow in the fodder bank
- Plant/sow the seeds at the beginning of the rains
- Keep animals off the pasture until it is well established

Permanent grass-legume pasture

Background

Permanent grass-legume pastures are sown on prepared seedbeds (unlike over-sowing where there is no prepared seedbed). These pastures are used mainly in controlled grazing in dairy farms and other intensive, large scale farms.

Advantages of permanent grass-legume pasture

- The pasture produces large quantities of high quality forage
- The pasture protects the soil from erosion
- The pastures maintain or improve soil fertility
- If managed properly, the pasture can last for a long period of time
- The pasture can be used as a seed bank of pasture species

Disadvantages and constraints

- Forage seeds are sometimes not readily available and they are expensive
- Managing the pasture requires skilled labour
- If not well managed, weeds can overwhelm the pasture.

How to grow the pasture

- Just before the rains, prepare a clean and fine seedbed
- At the beginning of the rainy season, sow the seeds at a rate of 6 to 10 kg/ha. Cover the seeds lightly by raking them into the soil
- Allow the pasture to establish well before letting in animals to graze
- After the pasture is established make sure it is not over grazed
- Keep the animals off the pasture to allow the plants to produce seed and reproduce. This is especially important for legumes.
- Control weeds
- Maintain a balance between legumes and grasses by reseeding if necessary

Controlled grazing

Background

Controlling the number and types of livestock that graze a pasture prevents overgrazing and also helps to avoid feed wastage (Figure 37). Generally, this helps the animals to grow better and produce more meat and milk. Cattle are grazers and goats are browsers, so they eat different types of plants. Together, they utilise the pasture fully more than a herd of cattle or goats would alone.

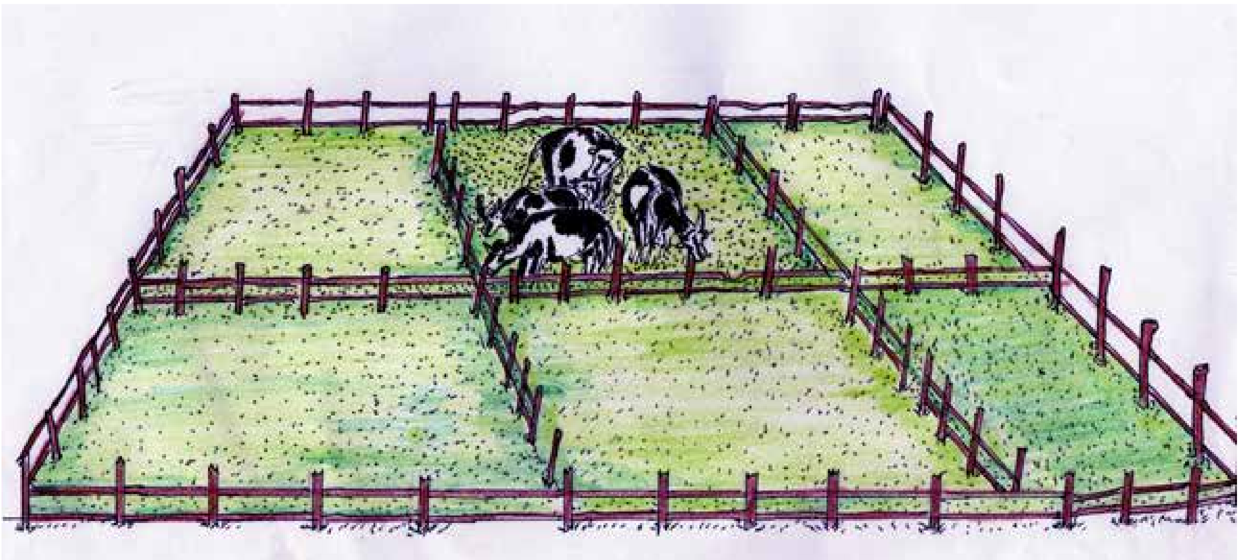


Figure 37: Controlled/rotational grazing (Source: Uganda Landcare Network)

Advantages of controlled grazing

- Controlled grazing allows the forage to grow continuously and produces enough fodder throughout the year
- It maintains a good mix of plant types in the pasture
- It maximizes animal production from a pasture at minimal cost and over a long period of time

How to manage controlled grazing

- Allow young and milking animals to graze a pasture first, so that they get the best forage
- Allow different types of animals (cattle, goats, and sheep) to graze. This makes the best use of mixed pastures
- Keep the grazing animals on the pasture for a maximum number of hours each day
- Stop the grazing when the plants are forming seed. This allows them to re-grow the following year, even if they are grazed heavily after seeding
- Maintain a long-term balance between the grasses and legumes in the pasture
- Stop the grazing, clear the bush and weeds and reseed the pasture if necessary.

Rotational grazing

Background

Rotational grazing is form of controlled grazing. It involves dividing pastureland into several paddocks, and allowing livestock to graze each paddock in turn. The animals are allowed to graze for a certain period of time (e.g. one week) before letting them to move to the next paddock. The grass in the grazed paddock has a chance to re-grow until there is enough forage to be grazed again. The number of cattle has to be adjusted to the amount of grass available, especially during the dry season.

Rotational grazing is possible where there are private grazing areas

Advantages of rotational grazing
• Rotational grazing allows pastureland to be used efficiently. Animals are regularly allowed into fresh pasture, which they can graze fully before being allowed into the next area • It minimises the incidences of livestock pests and diseases by breaking the life cycles of parasites • It ensures they is a supply of quality feed all year round
Disadvantages and constraints
• Extra work is needed to construct and maintain the paddocks and to make sure the animals stay in the right one.

How to manage rotational grazing

- Fence off the required number of paddocks
- Decide the order in which the animals will graze
- Let the animals graze each paddock properly before being allowed into the next one

Improved silvopastoral systems

Background

Silvopastoral systems (SPS) are agroforestry arrangements that purposely combine fodder plants, such as grasses and leguminous herbs, with shrubs and trees for animal nutrition and complementary uses (Figure 38). However, many natural silvopastoral systems are degraded and have rendered the systems less productive. Improved silvopastoral systems entail converting degraded extensive, treeless pastures into a richer and more productive environment, where trees and shrubs are purposely planted interspersed among fodder crops such as grasses and leguminous herbs

Figure 38: A silvopasture system where cattle is made to graze on pasture grown under trees (Source: https://nation.com.pk/)

Cut-and-carry

Background

Cut-and-carry involves keeping animals in a shed or paddock and bringing fodder to them – rather than allowing them to graze outside (Figure 39). This method is also known as zero-grazing. It is particularly useful for high value livestock such as dairy cattle and goats, fattening animals, and young animals raised for slaughter. It is an intensive method of animal production and used particularly where land is scarce. It requires a dependable source of quality feed, sufficient labour to collect the feed and carry water.

Figure 39: An illustration of cut and carry (Source: Uganda Landcare Network)

Wet and dry season options

During the wet season, fresh forage is cut and fed to the livestock. Feed is often scarce during the dry season. The options during the dry season include;

- Grow extra forage so that you can conserve it as hay or silage, then store it and feed it to the animals during the dry season
- Use crop residues (such as maize stovers, rice straw, etc.) as feed. These can be stored and treated with molasses or urea to make them more palatable and improve their quality

Advantages of cut-and-carry

- The animals do not spend energy searching for pastures, and they can be kept out of the sun
- Farmers ensure that their animals get enough good quality feed and less feed is wasted
- A unit of land can produce more total feed because a stand of forage can be harvested repeatedly
- This increases productivity; the animals put on weight more quickly and produce more milk
- The animals do not overgraze pasture, trample fragile soil or cause soil erosion
- The dung and urine can be collected and used as manure or for other uses such as biogas, fish feeds, mortar in building, etc.

Disadvantages and constraints

- Enough feed may not be available to feed the animals (match the number of animals to the amount of feed available)
- Feed may be wasted when it is being transported or sorted. Cutting too much feed at one time may also be wasteful (cut only what is needed each day)
- Feeding unwilted legumes can cause bloating (leave legumes for several hours after cutting to wilt before feeding the animals. Mix grasses and legumes in the feed)
- Cutting feed too early in the season reduces the quantity of the forage (cut forage when the yield is optimal and the quality is high)
- Cut-and-carry requires a lot of labour – to collect the forage and feed to the animals, to fetch water, to keep the shed clean, and to transport manure (match the number of animals to the labour available)
- Cut-and-carry requires more investment than grazing.

Sources of feed for cut-and-carry

Feed may come from the following sources:

Naturally growing vegetation – trees, shrubs, grasses and other vegetation – including grass cut from roadsides, hedgerows, and other wastelands, and weeds removed from fields.

Planted forage – this includes fodder grasses, legumes, trees, and shrubs grown in alley cropping and fields, and planted on soil bunds and terrace risers, grass strips, and other conservation structures. Planted forage is often used to make hay or silage

Crop residues – cereal straw (rice, millet, etc.), stover (maize, sorghum, etc.) and pulse residues (bean, soy bean, etc.).

Agro-industrial products – these include milling by-products, molasses, brewer's grain and oil seed cakes

Crop residues

Livestock can be allowed to graze on cropland immediately after harvest, or the crop residues can be collected and fed to animals. Generally, cereal stalks (wheat, maize, millet, sorghum, rice) make poor quality feed. However, the leaves of these cereals make better quality feed than most natural grasses in the dry season. Mixing cereal stalks and leaves with pulse residues increases the quality of the feed.

However, cereal stalks have other competing demands e.g. as fuel, and as building & mulching materials. When used as feed, they are collected and stored in a suitable place, protected from rain and sun. If they get wet they will grow mould and lose quality. When needed as feed, they are chopped in small pieces and mixed with molasses or treated with urea to make them more palatable and to improve their value as feed.

Treating straw with molasses

Molasses are a sticky, thick, brown liquid, produced when making sugar from sugarcane. Straw treated with molasses is most often used to feed growing and fattening animals. Do not use molasses to feed milking cows.

To treat straw, mix molasses with water in a ratio of 1part molasses to 2parts water, then sprinkle this on the crop residues. Alternatively, one can soak the residues in the water/molasses mixture overnight before feeding the animals. Treat only enough straw required in day. Do not give more than two litres of molasses to each animal each day.

Treating straw with urea

Treating straw with urea before feeding it to animals will help them gain weight.

- Spread a layer of chopped straw on a large, thick plastic sheet and sprinkle the straw with a mixture of urea and water.
- Add another layer of chopped straw and sprinkle with more urea mixed in water. Repeat this to build several layers. As rule of thumb for 100kg of straw, one needs 100 litres of water and 6kg of urea.
- Wrap the plastic sheet over the top and sides of the pile and seal it completely. Put a stone on top to keep it air tight.
- Leave for 3 weeks
- Before feeding the animals, open the sheet and take out enough treated straw for a day or two. Cover the rest of the stack with the plastic sheet.
- Leave the straw you have taken out for several hours (preferably overnight) to let the ammonia smell disappear. Then the following morning one can feed the animals with the treated straw.
- Make sure the plastic sheet is air tight (with no holes in it) otherwise the ammonia gas that is formed will escape, and the treatment will not be as effective.
- Animals may not like to eat the treated straw at first. To begin with, mix the treated straw with other feeds, then you can begin to increase the amount of treated straw gradually. An adult cow can be given about 6 kg of treated straw a day.
- Do not feed treated straw to calves younger than six months old.
- Straw is low in minerals, so provide a mineral lick in the shed.

Using a permanent pit to treat straw

- Dig a pit wide and deep enough to hold the straw you want to treat each day.
- Line the floor and walls with a plastic sheet
- Put layers of straw in the lined pit, and sprinkle on a mixture of urea and water
- Cover the top of the pit with another plastic sheet

Hay

Background

Hay is forage that has been dried in order to conserve it (Figure 40). Good hay has 15-16% moisture content. It is greenish-yellow, with a pleasant smell, and contains a variety of legumes and grasses. It should be cut at the right time for maximum yield and nutritive value. The right time to cut grasses to make hay is when their seeds are at the milk stage. In the case of legumes, it is when they are at the flowering stage.

Figure 40: An illustration of cutting, drying and conserving hay (Source: Uganda Landcare Network)

- Hay can be made from the following types of plants:
- Forage grasses such as Sudan grass and panicum. These should be cut when half of the plants have started to flower.
- Cereal grasses such as millet, maize, and sorghum. Cut them when the grain is at milk stage
- Forage legumes such as alfalfa. Cut them when 10-25% of the plants are in flower, or when the leaves are turning yellow.
- Seed legumes such as cowpeas, pigeon peas, broad bean (mucuna); cut them when the first pods are ripe, or wait when until many of the pods are ripe.
- Hay can be made from a mixture of these types of plants. You can also grow a mixture of these plants in the same field and harvest them together. Forages with a lot of leaves make better quality hay than stalks, so try to prevent the loss of leaves during drying, transportation and storage

Many farmers do not have moisture meters, but there are ways farmers can use to determine whether the hay is dry enough

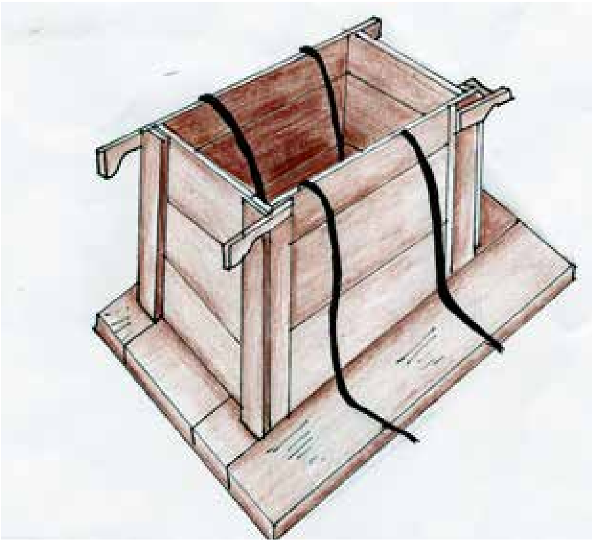
- Scrape the skin from a hay stem with your fingernail. If the skin peels off, the hay is still too wet and needs to be dried some more
- Take a few hay stems and twist them in your hands, if the stems break a little and no juice comes out, the hay is dry enough. If it does not break, or if you see juice, dry it some more.

Haymaking

- Plan to make hay when you can expect two days of good sunshine in order for the hay to dry well. Harvest the forage in the morning, after the dew has dried off. Leave it in the field to dry.
- Before it is completely dry, rake it together into rows. Turn the pile over 2 to 3 times in the course of the day. In the evening, rake the rows together into conical piles to protect as much of the hay from dew. You can also use racks to dry the hay.
- On the second day, wait until the dew has dried off, and then spread the hay out to dry. Turn it over several times in the course of the day so that it dries evenly. The leaves of legumes such as alfalfa and cowpeas tend to fall off when directly exposed to the hot sun, so try to dry them in shaded place.
- When the hay is dry, make it into bales if possible and then carry it away for storage
- Store the hay somewhere where it can be protected from the rain and sun. If possible keep it into a barn or under a roofed place

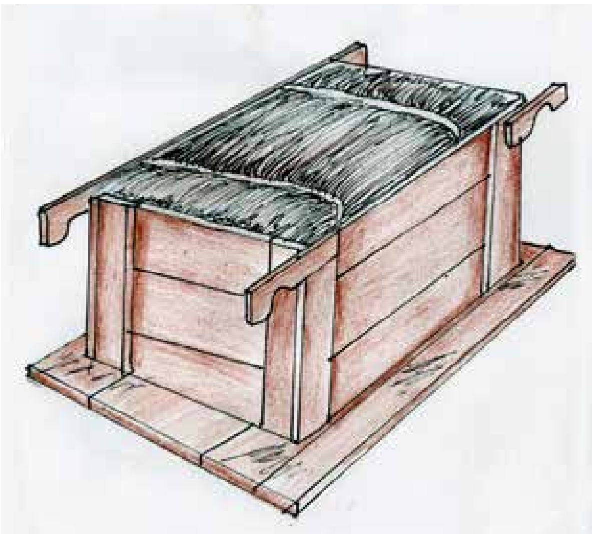
How to make hay bales

You will need to make baling boxes according to the size of the hay bales of your choice. The box is made in such a way that it has no bottom, but it should have handles so you can lift it easily. You will also need enough strong strings to tie the bales.(See Figure 41)

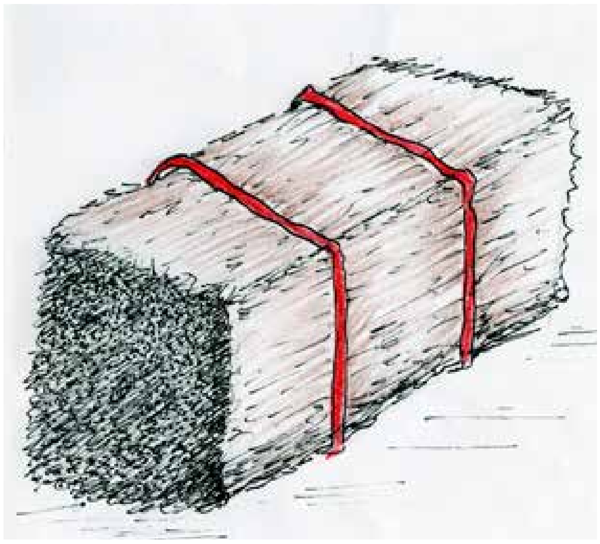


Step 1: Put two strings in the box with both ends hanging out

Step 2: Put the hay into the box and pack it down firmly, you can use a heavy object e.g. a wooden plank to compact the hay in the box



Step 3: When the box is full, tie the strings tightly



Step 4: Lift the baling box and remove the bale

Figure 41: Step-by-step Illustrations of how to make hay bales (Source: Uganda Landcare Network)

Forage conservation (silage)

Background

Silage is conserved feed that has been fermented without allowing air to get to it. It can be made by storing green forage in an airtight condition for 45-60 days. Silage can be stored for many months before feeding it to animals.

Best silage	Feels dry (though it contains 65-75% moisture), has a pleasant, acidic smell, and is green-yellow.
Medium quality silage	Has a sweet smell and is dark-brown
Poor quality silage	Is olive brown, slimy, smell foul, and animals do not like to eat it.

Silage Quality

Suitable crops for silage include maize, sorghum and forage grasses. Using them to make silage means they cannot be used for grain, since the plants have to be harvested before the seeds are mature (preferably at the milk stage). Potato vines can also be used to make silage once the potato tubers have been harvested.

If maize or sorghum is purposely planted for silage, the seeding rate should be increased by 25-50% more than when it is grown for grain.

Silos

Silage is made and stored in what is known as a silo. The silo protects the forage from rain and is made airtight to keep air out in order for the forage to ferment properly to make good quality silage. Since silos are permanent, to be cost-effective the smallest silo should be 4-5 cubic metres (i.e. 2m×2m, and 1m high). Larger silos can be many times this size. The silo should be big enough to feed the animals throughout the dry season (also taking into account the other sources of feeds available, such as hay and fresh forage.

Making a silo

- Select a well-drained site with firm soil
- Mark out the perimeter of the silo 2m×2m×2m×2m
- Dig the silo up to 1-m depth
- Line the floor and sides to make it water tight. This can be done using a thick plastic sheet, concrete or clay. The floor and sides can also be plastered with clay soil or cow dung

Making silage

1. Harvest the crop from which silage is going to made. The harvest time depends on the crop:

Crop	Best harvest time
Maize	50-55 days after silking
Elephant grass	Before it reaches 1.5 m tall
Grasses	Before they flower
Shrubs	At the end of the rainy season

2. Chop the forage into pieces about 3-5 cm long. This can be done using a panga/machete, but this is a slow process. There are different machines which can be used to make the process easier and quicker. One of such machine is a motorized silage chopper.
3. Test the moisture content of the forage. If moisture comes out when the forage is squeezed, it is too wet. Leave it for a few hours in order to dry some more
4. Fill the silo with layers of the chopped forage. Compact each layer well by treading on it. This is important to drive air out, one of the requirements for making good quality silage
5. For grasses, mix some molasses with water in a ratio of 1 part molasses to 2 parts water; sprinkle the mixture/solution on the layers of forage as you lay them out in the silo. You will need 35 litres of the molasses-water mixture/solution for every cubic metre of silage
6. When the silo is full, cover the contents with a layer of straw or a plastic sheet, or any other material that can prevent air and water from getting in. Pile stones or a 30-cm layer of soil on top to keep the pile compacted. The silo should also be protected from rain, either by building a roof (iron sheet or grass thatch) over the silo.
7. Leave the forage to ferment for 45-60 days
8. When ready, remove part of the covering and take out as much feed as needed for the day. Cover the silo again to keep out air.
9. Give an adult cow 10-15 kg of silage per day. The animals may not like to eat the silage at first, but they get used to it quickly.

Biogas

Background

Over 96% of the current energy consumption in Uganda is from wood fuel used by both rural and urban households. This has resulted into rapid destruction of the country's natural forests and woodlots. The country's forest cover has been estimated to have reduced from 10.8 million hectares in the 1980s to 5.0 million hectares currently. The reduction is attributed to uncontrolled forest degradation and heavy demand for wood fuel.

Biogas also known as methane is a gas obtained from organic materials, e.g. livestock dung and human excreta, after fermentation under airtight (anaerobic) conditions. Livestock dung/manure is the most convenient source of biogas production in Uganda. It is readily available, easily digested and culturally acceptable. Energy from biogas can conveniently be used for cooking, water heating and lighting in households. Its heating value is 5½ times better than charcoal. Biogas produces smoke-free flame with burning efficiency of 55% compared to 25% for charcoal and only 12% for wood fuel.

Biogas production is now being promoted and practiced as an alternative energy Source: particularly in intensive livestock areas with benefits not only for climate change mitigation, forest conservation and energy provision but also in terms of reducing the workload and improving the health of women and children. The bio-slurry removed from the digester can also be used as organic fertilizer to improve crop productivity.

Advantages of biogas

- Provides efficient alternative energy source to wood and saves on destruction of forests and woodlots
- Improves women and children health and welfare by reducing workload of collecting firewood
- Eliminates exposure to harmful smoke and fumes from traditional fuels
- Improves household sanitation, health and welfare
- Improves crop-livestock farming systems through nutrient recycling
- It is an environmentally clean and safe energy source for households
- The liquid slurry from biogas production is a high grade fertilizer for crops and fish ponds.

Types of biogas plants

Floating dome digester

This design has an underground cylindrical digester tank made from burnt bricks bonded with sand and cement. The foundation is on large stones with a concrete slab. It has an inlet mixing chamber with a PVC pipe through which the fully digested liquid slurry is discharged. A metallic gas holder floats within the slurry and compresses the biogas coming from the digestion process. The gas is then delivered through pipes to the kitchen and other room where it is going to be used. Available sizes are 12, 14, and 16 m^3, able to generate 3 – 4 m^3 of gas per day, suitable for a household of 8-10 persons.

Fixed dome digester

This design is also underground and made from burnt bricks bonded with sand and cement. It is a half spherical structure acting both as a digester and gasholder. It has an inlet PVC pipe to guide the fresh manure into the tank and an outlet pipe to discharge the digested material. Three designs ranging from 8 – 30 m^3 are available. Fixed dome operates at higher pressure and delivers gas over long distances from the digester than the floating dome.

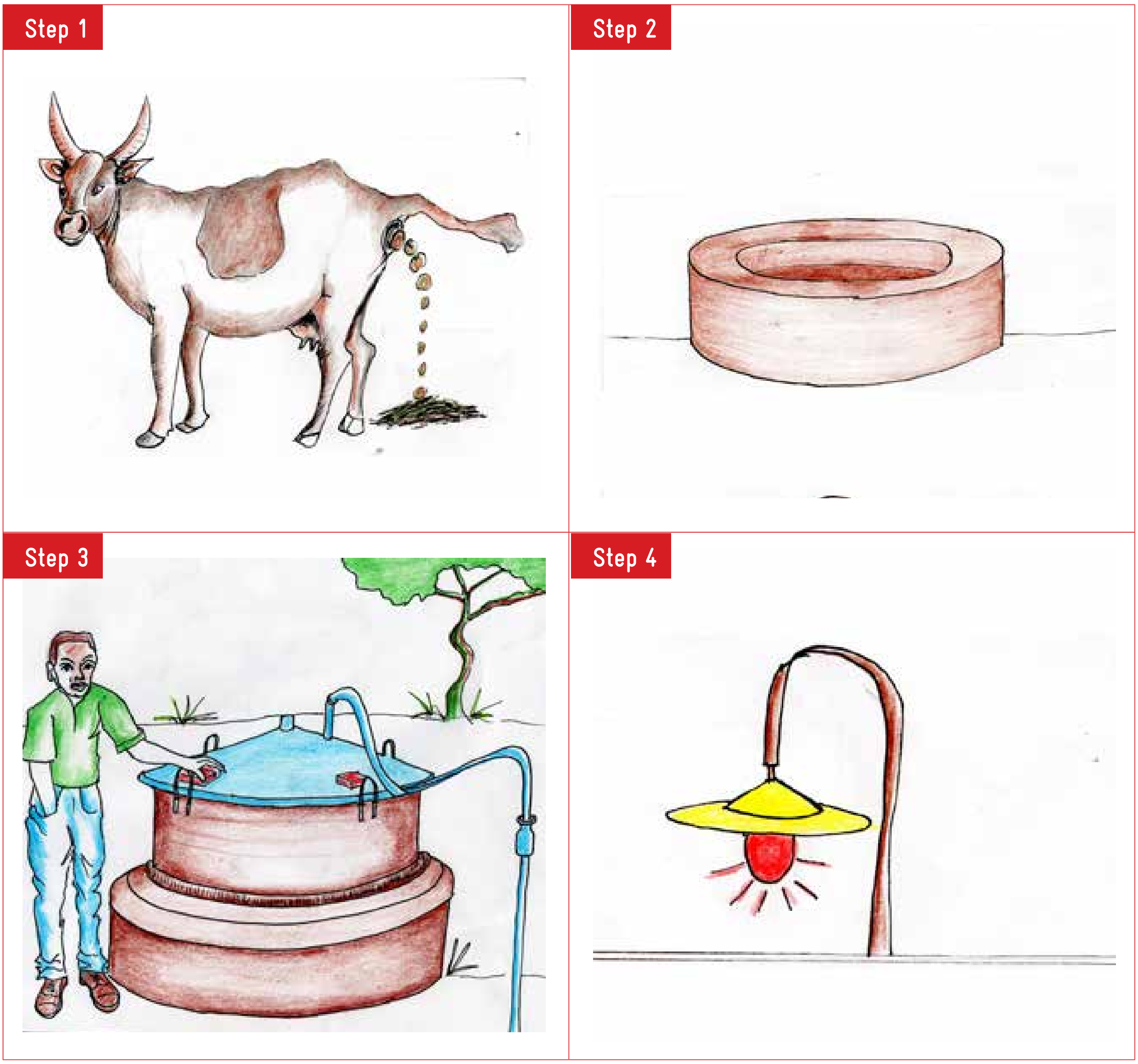


Figure 42: Step-by-step Illustrations of how biogas is produced (Source: Uganda Landcare Network)

Session VI: CSA practices/technologies that reduce/spread risk

CSA practices/technologies that reduce/spread risk	
Estimated duration	3 hours
Session guiding questions	This session is intended to make participants appreciate that extreme weather-events such as prolonged and severe droughts, floods, and pests and diseases outbreaks, caused by climate change, are on the increase and have increased agricultural production risks. It is also intended to provide knowledge and impart skills in agricultural production risk management, using appropriate technologies/practices such as improved seeds, early planting, and irrigation. The key guiding questions are: a. What is agricultural production risk? b. What are the main agricultural production risks and what causes them? c. What are the various CSA technologies and practices that can be used to prevent, reduce or spread agricultural production risks? d. What helps to decide on the technology/practice to be used in preventing/reducing/spreading risk?
Session Objective	• To give a general overview on agricultural production risk; and the main agricultural production risks and their causes, using local examples and experiences • To introduce and explain the various technologies and practices, which are used in preventing/reducing/spreading risk. • To demonstrate the use of appropriate technologies and practices in preventing/reducing/spreading risk.
Preparation	• Prior knowledge and information on agricultural production risk; the main agricultural production risks and their causes • A clear understanding of the appropriate technologies and practices that are used to prevent/reduce/spread risk • Practical knowledge and skills to demonstrate technologies and practices used to prevent/reduce/spread risk • Physical teaching aids, materials and tools. • Visual aids exhibiting different case scenarios of manifestations of agricultural production risks and successful endeavourss of risk management.
Materials/resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Physical teaching aids, materials and tools • Visual aids
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Field excursion to showcase successful agricultural production risk management case scenarios e.g. different irrigation methods • Practical sessions to demonstrate technologies and practices for preventing/reducing/spreading agricultural production risks

CSA practices/technologies that reduce/spread risk	
Take home and follow up	• Agricultural production risks are factors that reduce/decimate crop yields; and livestock, forestry and fisheries outputs, which ultimately threaten food, nutrition and economic security at both micro and macro level. • Extreme weather events such as prolonged and severe droughts, floods, and pests and diseases outbreaks, caused by climate change, are on the increase and have increased agricultural production risks • Agricultural production risks can be successfully addressed with appropriate CSA technologies and practices • Proper management of agricultural production risks can reduce total crop failure, animal morbidity and mortality and increase agricultural production outputs

Overview

As a result of climate change and variability, extreme weather events such as severe and prolonged droughts and above normal rainfall leading to floods are on the increase. Similarly, the onset and cessation of rainfall is now very unpredictable. The extreme weather events and unpredictable weather have increased agricultural production risks. Both extreme weather events and weather unpredictability can reduce crop yields or in extreme cases lead to total crop failure or animal morbidity and mortality.

This section outlines various CSA practices and technologies that can be used to reduce or spread agricultural production risks. These include: Improved seed (drought tolerant, pest and disease resistant), Early/timely planting, Intercropping/diversification, Crop rotation and Crop-livestock integration.

Improved seeds

Background

Some of the impacts of climate change are drought and pest and disease outbreaks. The breeders' objectives to mitigate these impacts include developing crops that are drought tolerant, and pest and disease resistant (Table 15). In most cases, these crops are also developed to be high yielding. In that regard, improved seeds reduce the risk of crop failure; they are water efficient, thus reducing water consumption. They also reduce pest and disease risks.

Table 15: Some improved crop varieties and their attributes

Crop	Variety	Attribute
Maize	Longe 5 (Quality Protein Maize)	Resistant to maize streak virus (MSV), grey leaf spot (GLS); early maturity; drought tolerant; high content of Lysine and Tryptophane
	Longe 7H	Hybridity; resistant to MSV, GLS, the northern corn leaf blight (NLB) and Turcicum; drought tolerant; and maturity of 120 days
	Longe 10H	Hybridity; resistant to MSV, GLS, NLB and Turcicum; drought tolerant; and maturity of 120 days
Beans	NABE 15	Resistant to anthracnose, red seed colour
	NABE 16	Marketable, suitable for all regions, tasty and swell when cooked
	NABE 19	Highly marketable, tasty and cooks well
	NABE 20	Highly marketable, tasty and cooks well

Crop	Variety	Attribute
Soybean	Maksoy 2N	Tall variety reaching 1m, resistant to shattering and bacterial pustule
	Maksoy 3N	Resistant to soybean rust, protein content 48%
	Maksoy 4N	Tolerant to soybean rust, early maturing
	Maksoy 5N	Tolerant to soybean rust, early maturing
Rice	NERICA 6	Tolerant to RYMV, blast, BLB, long soft but no sticky grains when cooked
	Komboka	Tolerant to RYMV, blast, BLB, long soft but no sticky grains when cooked
	Okile	Tolerant to RYMV, blast, BLB, long soft but no sticky grains when cooked
	Agoro	Tolerant to RYMV, blast, BLB, long soft but no sticky grains when cooked
Sorghum	Epuripur	Resistant to shoot fly and stem borers, white seeded and good for brewing
Groundnuts	Serenut 2	Resistant to Rosette and drought, tan seeded with average 42% oil content
	Serenut 3R	Resistant to Rosette and leaf spots, red seeded with average 47% oil content
Cassava	NASE 17	
	NASE 18	
	NASE 19	Resistant to Cassava Brown Streak Disease (CBSD)
	NASE 20	Resistant to CBSD and high yielding
Sweet potato	NASPOT 12	High vitamin A content, resistant to sweet potato weevil, low dry matter
	NASPOT 13	High vitamin A content, resistant to sweet potato weevils, low dry matter
Irish potato	Kachpot 5	High yielding, resistant to late blight
	Kachpot 6	High yielding, resistant to late blight, good processing quality
Plantains	KABANA 6H (Kiwangazi)	Resistant to banana weevils, Sigatoka and nematodes, long lasting i.e. mat disappearance is over 5 years

Early/timely planting

Background

Planting early reduces the risk of crop failure due to drought if the rainy season ends early. Early planting is possible if land-preparation is done early, or if conservation agriculture techniques are used e.g. not ploughing saves time because the farmer does not have to wait until the soils is moist and soft enough to plough. This practice improves efficient use of rainwater, thus reducing the risk of crop failure.

Multiple cropping/Intercropping/diversification

Background

Multiple cropping means growing two or more crops on the same field at the same time. It increases total production because it optimizes the use of natural resources e.g. it increases landuse efficiency. Different crops grow at different heights and have different rooting systems, so can exploit the available light, water and nutrients better than a monocrop. They grow at different rates (or are planted at different times), so they can use these resources maximally.

Growing several types of crops spreads the risk of one crop failing. However, care must be exercised to mix the crops properly, otherwise it may fail to meet the objective. Judicious intercrops include annuals with annuals, annuals with perennials or perennials with perennials (Table 16).

Table 16: Judicious intercrops involving annuals with annuals, annuals with perennials and perennials with perennials

Main crop	Intercrop
Annual with annuals	
Cereals e.g. maize, sorghum, upland rice	Legumes e.g. field beans, soy bean, cow peas, groundnuts; horticultural crops e.g. pumpkins, water melon, cucumbers
Annuals with Perennials	
Fruit trees e.g. mangoes, citrus; coffee, banana	Legumes e.g. field beans, soy bean, cow peas, groundnuts; horticultural crops e.g. pumpkins, water melon, cucumbers
Perennials with Perennials	
Fruit trees e.g. mango, citrus	Banana, coffee
Coffee/ Banana	Coffee/ Banana

Multiple cropping can be applied in all APZs. However, it may not be well suited to areas where there is limited soil nutrients and soil moisture due to the competition that might arise between the intercrops.

Advantages of multiple cropping

- Planting crops with different growth habits on the same field at the same time makes more efficient use of soil nutrients. There is less leaching of nutrients because of deeper and denser crop roots
- Multiple cropping provides better and longer soil cover, reducing soil erosion
- If one of the crops is a legume, it fixes nitrogen in the soil, which the other crop can use
- Growing several crops with different growth habits (e.g. requirement for water and nutrients, growing period length, etc.) reduces the risk of crop failure. If one crop fails or it is attacked by pests and diseases, the second or third crop often succeeds.
- The higher crop population squeezes out weeds
- Some crops can repel or trap pests
- The farming household gets food, nutrition and income security

Disadvantages and constraints

- The crops compete with each other for space, light, water and nutrients. This can cause the crops to yield less (per unit area) than if they were grown in a pure stand. However, the combined benefits including food variety, total yield, and monetary value is higher than a monocrop
- Management including planting/sowing, weeding, and harvesting is more laborious or difficult than for monocrops
- Controlling weeds with herbicides may not be feasible because the intercrops might be damaged.

What to consider before using multiple cropping

- Intercropping should use crops that have different growth habits e.g. length of growing period, and nutrient and water requirements – such as cereals and legumes.
- When choosing different crop species, it is important to understand the planting times and how the different crops affect each other. Consider the indigenous methods used by farmers because more than often, the farmers have excellent knowledge about the crop combinations suited to their needs and locality.

Crop rotations

Background

Rotating crops maintains soil fertility and reduces the risk of pests and diseases. Judicious crop rotations include cereals and legumes, root crops and either cereals and legumes. As a rule of thumb, never rotate crops which are in the same family e.g. cereals with cereals; legumes with legumes; or root crops with root crops. This is because crops in the same family usually have similar nutrient requirements and may also have similar disease and pest burdens. Therefore continuously growing crops in the same family may lead to nutrient exhaustion and increase the disease and pests burden.

Farmers might grow cereals in the first season, followed by a legume in the second season, then an oil crop or tuber crop in the third season. They can then plant cereals again in the following season. Leguminous crops are important in rotation because they fix nitrogen. Cereals are also important because they generate more crop resides which can be used as mulch

Factors influencing crop rotation

The choice of the crop depends on many factors. Farmers should consider the following when planning crop rotation:

- **What crops grow well:** this depends on the soil fertility and the expected rainfall
- **The farmer's needs and objectives:** including the staple food and the market value of crops.
- **The previous crop:** try to change it, especially if pest and disease attacks were severe.

Advantages of crop rotation
• Crop rotation helps control pests and diseases • It restores and maintains soil fertility and improves the productivity of the land • It provides different sources of income and nutrition
Disadvantages and constraints
• It may be difficult to rotate crops if there is not enough land to grow the staple crop, or if seeds of other crops are not available

Crop-livestock integration

Background

Crop-livestock integration brings with it diversification of the commonly specialized/linear production systems; this has helped smallholder farmers to achieve resilience amidst the effects and impacts of climate change. It is considered as the optimal approach to improve the long-term intensification and sustainability of agriculture. Integrating livestock and crop production means shifting from the traditional systems focused exclusively on livestock or crop to a new approach which sustainably combines both.

The integration helps in improving resources utilization efficiency. For instance, crop residues can be fed to livestock and in turn the manure produced by livestock can be utilized in crop production. The integration also brings with it draught power.

Some of the key aspects of crop-livestock integration, and the trade-offs to farmers they entail include:

Manure: Utilization of manure is considered the critical technological component driving agricultural intensification (Turner, 1995). According to Steinfield and De Haan (1997), manure from livestock may contribute as much as 35% of soil organic matter.

Crop residues: crop residues are used for a variety of purposes including as fuel, mulch, building, compost making and as livestock feed. The straw of cereals and legumes provides valuable feed after harvest. According to Sandford (1988), in integrated farming systems, cattle derive up to 45% of their total annual feed intake from crop residues and up to 80% during critical periods. Crop residues can be grazed in situ or gathered for stall feeding.

Animal traction: Livestock in mixed farming systems offer the additional potential benefits of draught power for cultivation, weeding and transport. According to McIntire et. al. (1992), farmers who adopt animal traction can expand area under crops by 25% or more.

The benefits of integrating crop and livestock can include:

- Reduce animal feed costs
- Reduce labour
- Improve soil health
- Increase farm biodiversity
- Utilization of marginal lands

Irrigation

Background

Erratic rainfall, and prolonged and severe droughts lead to water shortages and low soil moisture. This has impeded both agricultural production and productivity. These days it is not uncommon to experience unseasonable droughts in the middle of the growing season, a phenomenon that has severely affected crop yields, sometimes leading to total crop failure (Mubiru *et al.*, 2012). To avert this scenario, supplemental irrigation has become imperative, because an adequate water supply is important for plant growth. When rainfall is not sufficient, the plants must receive additional water from irrigation.

Various methods can be used to supply irrigation water to the plants. Each method has its advantages and disadvantages. These should be taken into account when choosing the method which is best suited to the local circumstances

Full or supplementary irrigation is necessary in most APZs and all soils can benefit from irrigation. However different irrigation methods are appropriate for different soil types.

Advantages of irrigation

- In dry areas and in the dry season, crop production may not be possible without irrigation. In relatively wetter areas, growing crops without irrigation is possible, but supplementary irrigation helps guarantee a good yield.
- Irrigation increases the intensity of cropping; therefore it raises the productivity of the farm. This can limit area expansion for farmland, which helps promote soil conservation and afforestation programs

Disadvantages and constraints

- Irrigation is not possible everywhere because there may not be enough water, slopes may be too steep or/ and soils may be unsuitable
- If it is not managed properly, irrigation may pollute the groundwater with nitrates from fertilizers. Also nearby wells used for drinking water may be contaminated
- Over-irrigation, poor water management, and leaky canals may cause water-logging and drainage problems.
- Salt may build up in the soil
- Mosquitoes can breed in the stagnant water
- Weeds may grow more quickly
- The irrigation infrastructure and operations are expensive
- Irrigation can make the soil salty, especially in dry areas. Crops grown on saline soils may grow stunted; producing low yields or may wilt and die off completely.

Irrigation methods

Irrigation water must be moved from where it is collected or stored to the field where it is needed to be used. A simple irrigation method is to bring water from the source of supply, e.g. a well, to each plant with a bucket or a watering can; this is a very time-consuming method and involves very heavy work. However, it can be used successfully to irrigate very small plots of land, such as vegetable gardens, that are close to the water source.

More sophisticated methods of water application are used when larger areas require irrigation. There are three commonly used methods: surface irrigation, sprinkler irrigation and drip irrigation.

Surface irrigation	Basin
	Furrow
	Flooding
Sprinkler irrigation	
Drip irrigation	

Surface irrigation

In surface irrigation (flooding, basin and furrow), water can flow by gravity in open channels/canals or closed conduit, or can be pumped through pipes.

Furrow irrigation

Furrows are narrow ditches dug in the field between rows of crops. Water is led into the field from the irrigation channel through a gap in the bank of the channel (Figure 43).

Figure 43: A farmer demonstrating how furrow irrigation works (Source: Observer Newspaper, June 11 2018)

The water then flows through a series of furrows laid out at right angles to the slope. Short furrows are best on sandy, porous free-draining soils. Long furrows can be used on heavy clay and poorly draining soils. Furrow irrigation is well suited to flat landscapes or slopes gentler than 0.5%. It can be used on most soil types, but not on coarse sand. It is suitable for row crops such as maize, sunflower, sugarcane, beans, soy bean, etc. The crop is usually grown on the ridges between the furrows (see Figure 44). This method is suitable for all row crops and for crops that cannot stand in water for long periods (e.g. 12-24 hours).

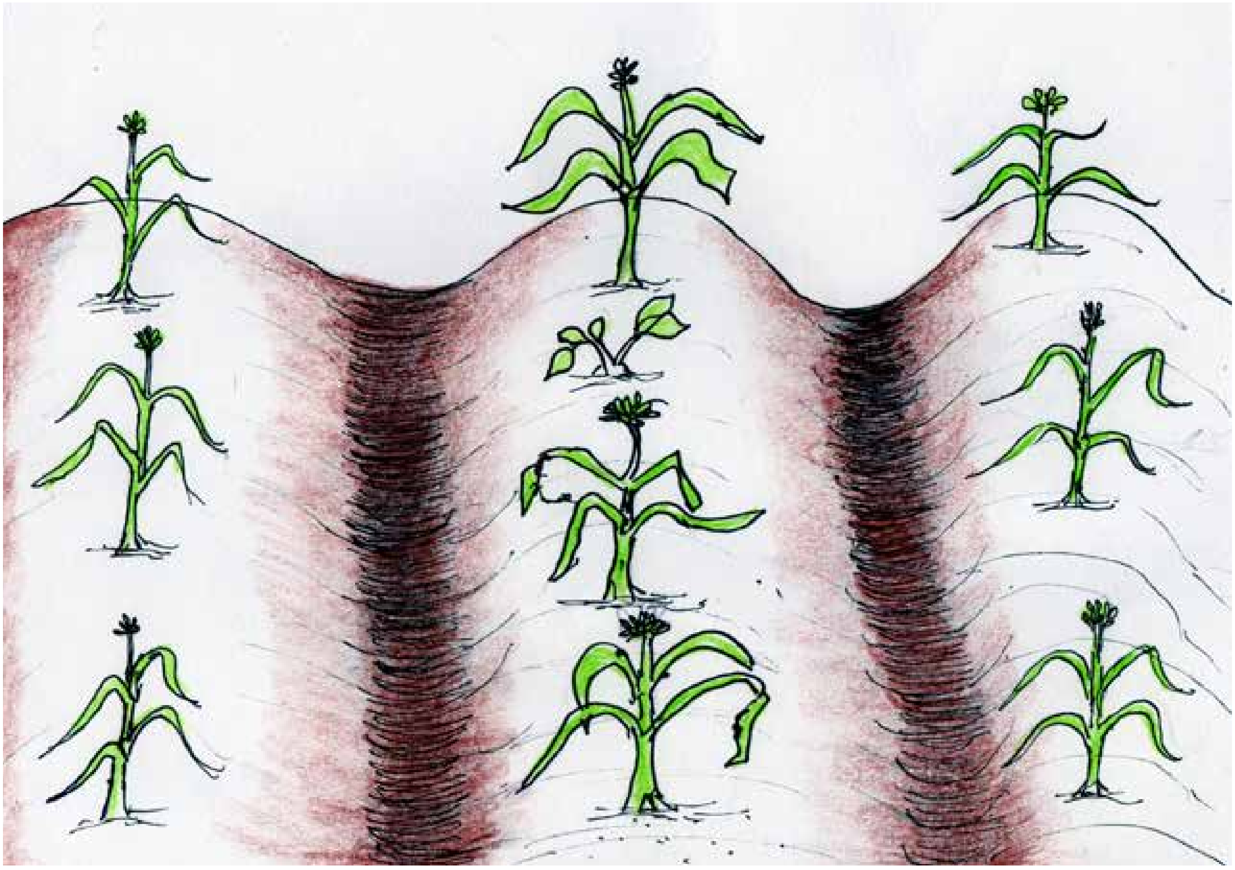


Figure 44: Furrows with crops grown on the ridges
(Source: Uganda Landcare Network)

Advantages of furrow irrigation
• Furrow irrigation does not need the field to be level, so less soil has to be moved • Little water is wasted • All types of row crops that need well drained and aerated soils can be grown • The farmer has good control over the irrigation water and water can be applied uniformly.
Disadvantages and constraints
• Furrow irrigation is labour intensive, especially on slopes • Furrows and ridges must be continuously reshaped • The farmer must be around to control the distribution of water in the furrows

Irrigation by flooding

This is the simplest form of irrigation. Water is led unto the field and allowed to seep into the soil (Figure 45). This method is good where there is more than enough water. Irrigation by flooding is generally not suited to crops which cannot stand in wet or waterlogged conditions for periods longer than 24 hours. These are usually root and tuber crops such as potatoes, cassava, beet and carrots which require loose, well-drained soils.

Advantages of irrigation by flooding
• Flooding is simple and easy to do
Disadvantages and constraints
• Flooding can lead to over-irrigation and water logging • Water is applied unevenly over the field; some place may get more than others • The method is very wasteful in terms of water

Figure 45: Farmers working in a rice field where irrigation is by flooding (Source: www.www.unep.org)

Sprinkler irrigation

Sprinkler irrigation is similar to natural rainfall (Figure 46). Water is pumped through a pipe system and then sprayed onto the crops through rotating sprinkler heads.

Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy. However, large sprinklers are not recommended for irrigation of delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop.

Sprinkler irrigation is adaptable to any farmable slope, whether uniform or undulating. The lateral pipes supplying water to the sprinklers should always be laid out along the land contour whenever possible. This will minimize the pressure changes at the sprinklers and provide a uniform irrigation.

Sprinklers are best suited to sandy soils with high infiltration rates although they are adaptable to most soils. Sprinklers are not suitable for soils which easily form a crust. If sprinkler irrigation is the only method available, then light fine sprays should be used. The larger sprinklers producing larger water droplets are to be avoided.

A good clean supply of water, free of suspended sediments, is required to avoid problems of sprinkler nozzle blockage and spoiling the crop by coating it with sediment.

Figure 46: Demonstrations of sprinkler irrigation (Source: www.pmldaily.com)

Drip irrigation

Drip irrigation (Figure 47) uses small amounts of water to wet the soil just where plants need it. It does this by using special low-pressure pipes with holes called emitters. The water drips out through the emitters into the soil near the plant roots. A farmer puts water into a large container e.g. jerrycan or tank connected to the pipes. It is important to put a filter at the bottom of the tank to prevent silt from getting into the pipes as this can clog the holes (emitters).

Drip irrigation systems can be used at small scale, for example, using a jerrycan and hose pipe to water a vegetable garden or at large scale using a big water tank to cover several hectares.

Drip irrigation can be used on sloping or undulating landscapes. It can be used on any kind of soil. On light textured soils, the holes in the pipes must be spaced closer together (every 10-15 cm) than on heavy soils (20-30 cm). It is suitable for small areas and for high value crops, such as vegetables and fruit trees.

Figure 47: Examples of drip irrigation

Advantages of drip irrigation

- Drip systems use little water and there is little water wastage because evaporation and percolation losses are low; this makes them to be very efficient.
- Crops can be grown in the dry season; this can help farmers to get premium prices for their produce
- Water of low quality (e.g. pond water) can be used, since the filter in the water reservoir keeps silt out of the pipes
- Once the system is set up, drip irrigation take little time and work
- Farmers can decide when to water the crops
- Soluble fertilizer (such as animal or human urine) can be mixed with the water in the reservoir.

Disadvantages and constraints

- The system – water reservoir, filters, pipes and emitters – has a high initial cost
- Skilled labour is needed to set up, operate and maintain the system
- Dissolved minerals, mould or silt may clog the pipes, holes and filters, shortening the durability of the system
- Care is needed when cultivating to avoid damaging the pipes

Bottle irrigation

Bottle irrigation can be considered as a rudimentary form of drip irrigation as illustrated in Figure 48.

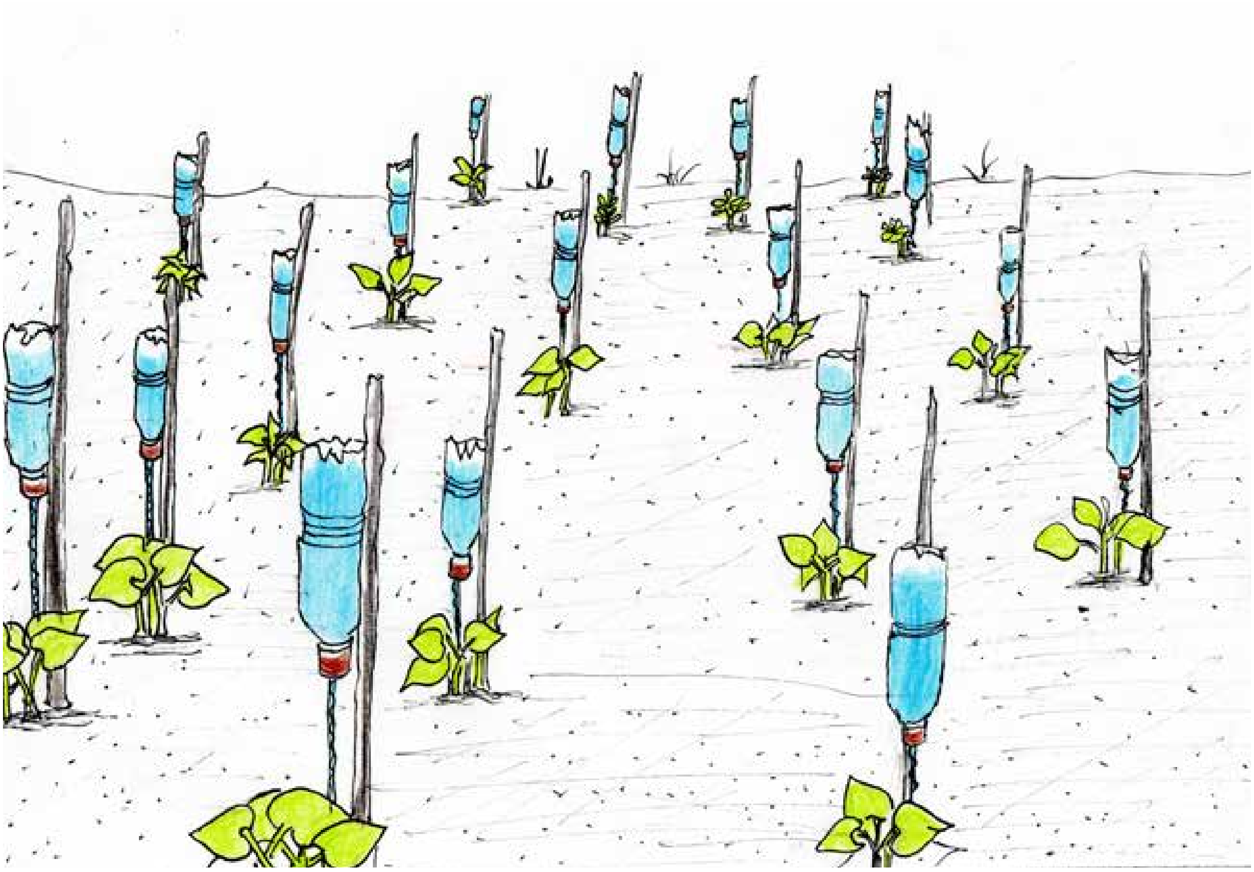


Figure 48: An illustration of bottle irrigation (Source: Uganda Landcare Network)

This method was made popular by H.E. President Yoweri K. Museveni in 2016 at his farm at Kawumu, Makulubita sub county, Luwero District . Since that demonstration by the president, several farmers realized that it is possible to save their crops from the effects of drought by using this simple and non-expensive method of irrigation. Bottle irrigation can be used on all types of soils and slopes. It is useful for small areas or individual plants, such as vegetables and fruit trees.

How to use bottle irrigation

Fill an empty bottle with water, turn it upside down and stick the open end about 8 cm into the soil close to the plant. The water will slowly seep into the soil close to the plant roots. Air from the soil will slowly bubble into the bottle, as the air from the soil moves into the bottle; water is let out into the soil.

Some of the advantages of bottle irrigation
• Empty bottles are cheap and easy to find • Farmers do not have to water their plants every day. When the bottle is filled it can last from a few hours up to several days, depending on the bottle volume • There is little or no water wastage.
Disadvantages and constraints
• Bottle irrigation is not suitable for large areas

Session VII: CSA practices/technologies for post-harvest handling

CSA practices/technologies for post-harvest handling	
Estimated duration	3 hours
Session guiding questions	This session is intended to make participants appreciate that without appropriate technologies and practices, farmers can lose all or a greater part of their agricultural outputs after harvest. During this session participants will also be equipped with knowledge and skills on post-harvest handling systems and introduced the technologies and practices, which prevent or minimize post-harvest losses and improve quality. The key guiding questions are: a. What is post-harvest handling? b. What are some of the main stages and tasks for management of agricultural outputs after harvest? c. How has climate change affected the main post-harvest tasks and what have been the consequences? d. What are the appropriate CSA technologies and practices that can be used to prevent/reduce post-harvest losses and improve quality of agricultural outputs?
Session Objective	• To give a general overview on the importance of proper handling of agricultural outputs after harvest • To introduce the appropriate CSA technologies and practices, which are used to prevent/reduce post-harvest losses and improve quality of agricultural outputs. • To demonstrate the use of appropriate CSA technologies and practices used to prevent/reduce post-harvest losses and improve quality of agricultural outputs
Preparation	• Prior knowledge and information on the agricultural production value chains • A clear understanding of the appropriate technologies and practices that are used to prevent/reduce post-harvest losses and improve quality of agricultural outputs • Practical knowledge and skills to demonstrate technologies and practices used to prevent/reduce post-harvest losses and improve quality of agricultural outputs • Physical teaching aids, materials and tools. • Visual aids exhibiting different case scenarios of agricultural production outputs management.
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Physical teaching aids, materials and tools • Visual aids
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Practical sessions to demonstrate technologies and practices used to prevent/ reduce post-harvest losses and improve quality of agricultural outputs

Take home and follow up	• In agriculture, post-harvest handling is the stage of crop production immediately following harvest, including threshing/shelling, drying, cleaning, sorting and packing. • The moment a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. • Post-harvest treatment largely determines final quality, whether a crop is sold for fresh consumption or processed for later use. • In Uganda, it is estimated that 30% of the agricultural produce is lost during the post-harvest period. • Effects of climate change such as above normal rainfall, floods, and rainstorms during the dry season, have increased post-harvest loss and reduced the quality of agricultural outputs. • There are appropriate CSA technologies and practices, which reduce drudgery in post-harvest operations and also reduce losses, while improving the quality of agricultural outputs. • Appropriate post-harvest CSA technologies and practices increase food security and income

Overview

In agriculture, post-harvest handling is the stage of crop production immediately following harvest, including threshing/shelling, drying, cleaning, sorting and packing. The moment a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. Post-harvest treatment largely determines final quality, whether a crop is sold for fresh consumption or processed for later use.

In Uganda, annual food losses in the post-harvest phase have been estimated to range from 12 to 18% for crops such as maize, millet and rice (FAO, 2020). However, over the years, NARO and other agricultural research institutions have developed practices and technologies aimed at reducing drudgery in post-harvest operations and also to reduce losses. The practices and technologies are now even more important as farmers grapple with the effects and impacts of climate change. The effects and impacts of climate change are not only experienced during crop production (e.g. when there is not enough rainfall) but also during the post-harvest period. These days it is not uncommon to have rainstorms during the dry season – a phenomenon that disrupts post-harvest operations.

This section outlines a variety of practices and technologies including machines used in post-harvest operations, their attributes and benefits.

- Drying pads/yards
- Maize shellers
- Groundnut and rice threshers
- Cassava chippers
- Grain storage cribs
- Silos
- Perdue Improved Crop Storage (PICS) bag

Drying pads/yards

Drying pads/yards can be constructed for the purpose of drying agricultural produce using natural sunny conditions. To practice this method, hot days are desirable with minimum temperatures of 35°C with low humidity. Poor quality produce cannot be used for natural drying to achieve good quality dried product. The lower limit of moisture content by this method is approximately 15 per cent. Problems of contamination and intermittent drying may be encountered with this method.

Advantages	Disadvantages
• Depends on sun's energy	• Slow drying process • Time taking • Molding of food may occur due to slow drying • Cannot be carried out in dust, rainy weather

Maize Shellers

A major issue for maize value chain actors, from village agents to traders, apex farmer organizations, processors, and exporters is that quality product is often hard to come by, even when farmers increase yields through use of improved seed, inputs, and technologies and large maize exporters are willing to pay farmers a price premium for high-quality product. The impacts on quality occur at post-harvest level due to use of rudimentary tools and methods for shelling, the process where maize kernels are separated from the cob. The difficulty of the process depends on variety, maturity, and moisture content. Women, who already have significant duties in agricultural production, water collection, child rearing, and cooking, tend to be responsible for this labor intensive task.

Traditional shelling issues include:

- Stick method shelling, where a bag of maize cobs is hit repeatedly, is slow. Shelling one bag takes eight hours of a woman's time and leads to kernel breakage and contamination, contributing to post-harvest loss and reducing the shelf life and value of the grain.
- Hand shelling to obtain kernels for maize seed produces unbroken grain but the process is tedious. A few kilograms can be shelled in an hour, taking a toll physically on shellers' hands.
- Drying maize directly on the ground and storage in damp, warm conditions at the household level before and after shelling leads to deterioration, discoloration, aflatoxin growth, and further post-harvest loss.
- There is limited access to stationary maize shelling machine processors due to remote locations of many farmers. While household-level mechanical hand shellers exist, there is limited financing for farming families to purchase them.
- To reach remote farmers on poor roads, small stationary maize shellers are trucked to farmer communities; this brings additional costs to service providers that are passed on to farmers. This approach is not always successful as many roads are impassable for trucks.

NARO Bench Manual Maize Sheller

The NARO bench manual maize sheller (Figure 49) has an output of 50 – 60 kg/hr of clean grain. The level of broken grain is 0%. It is ideal for small scale farmers who grow a maximum of 3 acres. It is suitable for all gender (women, youth, men and the disabled especially the blind).

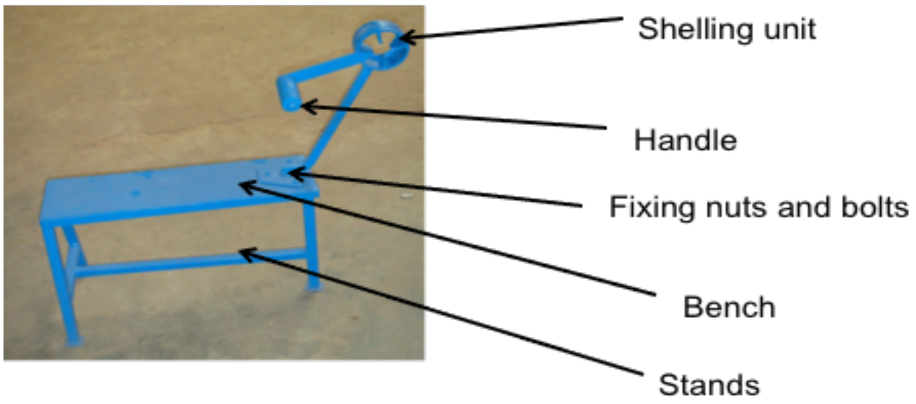


Figure 49: NARO Bench Manual Maize Sheller (Source: NARO)

Maintenance
- The shelling unit should be oiled with cooking oil regularly to reduce wear and tear
- All the nuts and bolts should be checked and tightened before use

NARO motorized maize sheller

The NARO motorized maize sheller (Figure 50) has an output capacity of 1,450 – 1,650 kg/hr of clean grain, for 1 litre of fuel. Its shelling efficiency is 99.5%. It is easy to move from one place to another. It has 90% minimum seed germination level of shelled grain. It is ideal for large commercial farmers, seed industry and exporters.

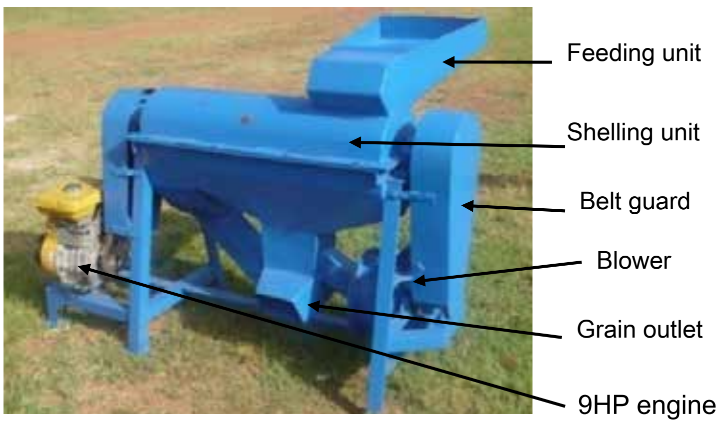


Figure 50: The NARO motorized maize sheller (Source: NARO)

Maintenance
- Check belt tension before shelling, adjust if necessary
- Remove trapped grains & cobs from shelling unit
- Clean & grease bearings at least once a month
- Routine servicing of engine as prescribed by manufacturer
- Grease pillow bearing to reduce wear and tear
- Check V-Belts, replaced if won out
- Check engine oil, change if it loses its viscosity
- Tighten all nuts and bolts before use

NARO Manually Operated Cassava Chipper

The NARO manually operated cassava chipper (Figure 51) has an output capacity of 50-100kg/hr. It is capable of chipping thin cassava pieces that take short time (1-2 days) to dry under sunshine. The chipping plate and feed hopper are made out of stainless steel to prevent rust, while the main body/frame is made of mild steel.

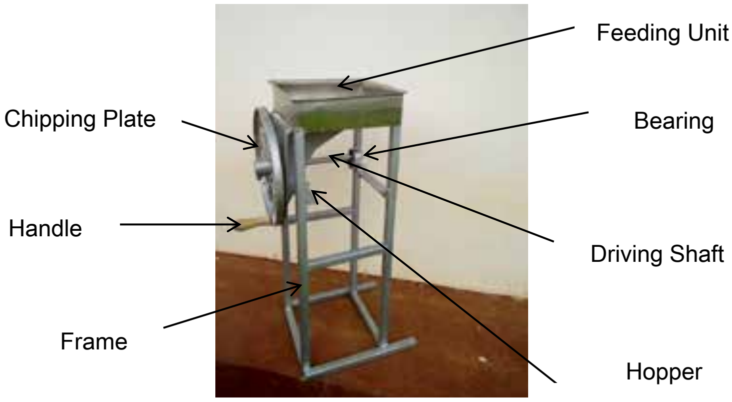


Figure 51: The NARO manually operated cassava chipper (Source: NARO)

Maintenance

- Thoroughly clean chipping machine before and after use.
- Check belt tension before chipping and adjust if necessary
- Remove trapped fiber from the chipping plate.
- Clean and grease bearings at least once a month.
- Pillow bearing should be greased to reduce wear and tear
- Tighten all nuts and bolts before use.

NARO Motorized Cassava Chipper

The NARO motorized cassava chipper (Figure 52) has an output capacity of 400-500kg/hr for 1litre of fuel. It is engineered to slice cassava tubers into thin pieces that take short time (1 to 2 days) to dry under sunshine. The chipping plate, feed hopper and part of the main body are made out of stainless steel to prevent rusting.

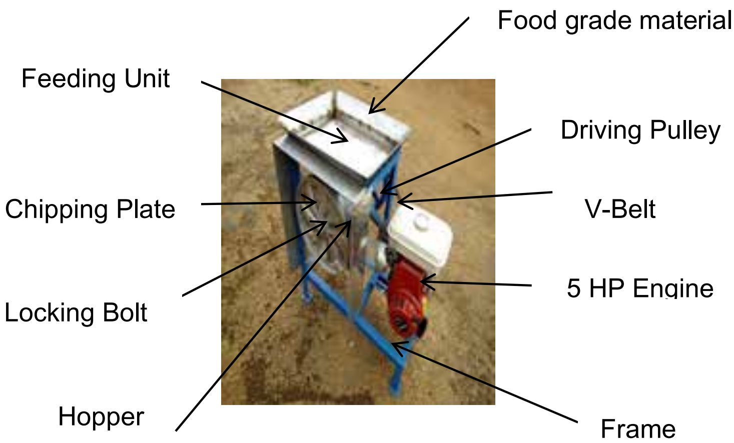


Figure 52: NARO Motorized Cassava Chipper (Source: NARO)

Maintenance

- Clean chipping machine before and after use
- Check belt tension before chipping, adjust if necessary
- Remove trapped fiber from the chipping plate
- Clean & grease bearings at least once a month
- Routine servicing of engine as prescribed by manufacturer
- Grease pillow bearing to reduce wear & tear
- Check V-Belts, replaced if won out
- Check engine oil, change if it loses its viscosity
- Tighten all nuts and bolts before use

Groundnut thresher

There are two types of groundnut threshers: manually operated and motorized thresher. Both types are reducing drudgery for women farmers in rural Uganda. While on-farm operations are primarily carried out by men, post-harvest operations are mostly done by women and children. Shelling groundnut (for seeds, grains or both) is not only an expensive operation; it eats into a substantial chunk of women's valuable time.

The motorized groundnut thresher has the following attributes:

Parameters	Estimated performance indicators
Output	120 kg/hr
Shelling efficiency	98%
Cleaning efficiency	97%
Grain damage	<3%
Scattered grain	4%

Grain storage cribs

A grain storage crib is a storage structure used for temporary storage of grains. It is usually rectangular with ventilated sides and is raised about a meter from the ground and with rodent guards (see example in Figures 53-55). The framework for the storage cribs is constructed using poles (e.g. bamboo, eucalyptus, or timber), the sides are constructed using materials that can freely allow air to circulate inside the crib; these include grass straw or wire mesh.

The roof should be constructed to prevent rainwater from entering the crib; this is done using materials such as grass thatch or iron sheet. The roofs are made to overhang to shield the grains in storage against rainfall.

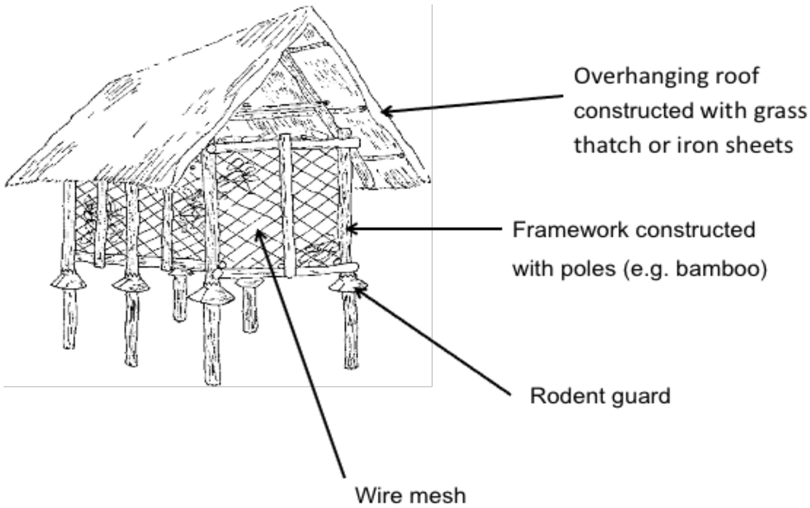


Figure 53: An example of a grain storage crib (Source: www.nzdl.org)

Figure 54: A traditional grain storage crib (Source: Uganda Landcare Network)

Figure 55: Locally made grain storage crib (Source: Uganda Landcare Network)

PICS Bags

Perdue Improved Crop Storage (PICS) bag – is a woven bag with two plastic liners inside. It can store all grain – maize, beans, peas, etc. Before storing grain in the PICS bag, the grain is first dried to the recommended moisture level, i.e. 12-14%. The bag is then closed by tying a string to make it airtight. Since there is no oxygen in the bag; this stops grain spoilage by keeping off storage pests and the growth of fungus that causes the aflatoxin chemicals.

MODULE VII: BLENDING INDIGENOUS KNOWLEDGE AND SCIENCE TO MAXIMISE BENEFITS

Blending indigenous knowledge and climate science to maximise benefits	
Estimated duration	60 minutes
Session guiding questions	This session is intended to promote recognition and use of indigenous knowledge to strengthen CSA interventions. The key guiding questions are: a. What are the common indicators observed in your area used to refer to climate change and variability and its impacts in relation to agriculture? b. What are the key local terminologies used to refer to unpredictable and extreme weather events of prolonged droughts, extreme rainfall events and disease and pest prevalence? c. What are the common traditional interventions used to address climate change events at farm and landscape levels? d. How can different indigenous knowledge practices in response to climate change be integrated in CSA technologies and practices mentioned in this manual?
Session Objective	• To make participants appreciate that climate change and variability have always been appreciated by different communities and have always been successfully addressed using indigenous knowledge • To share approaches traditionally used to address climate change challenges • To make use of traditional CSA technologies and approaches for strengthening uptake of other new and upcoming interventions
Preparation	• A clear understanding of use of indigenous knowledge in management of impacts of climate change and variability in agriculture • Prior knowledge and information on approaches that can be used for climate-smart agriculture in the local context • Prior knowledge and information on how local communities have been integrating new information and approaches to CSA • Illustrations/charts of any available case scenarios on the local approaches to climate-smart technologies and approaches
Materials/ resources	Materials needed/checklist • Flip charts/Newsprint paper • Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper • Pieces of paper for the trainer/trainees to draw a. Seasonal calendars and climate change and variability (language -(Luo/ Akaramojong), situation) [check the English equivalents] b. Case scenarios
Session type and delivery methodology	• Presentations • Plenary discussions • Interactive drama on traditional approaches to impacts of climate change • Group work

Take home and follow up	• Indigenous knowledge is the unique knowledge confined to a particular culture or society. • Development activities that work with and through indigenous knowledge have several important advantages over projects that operate outside them. • Benefits of blending indigenous knowledge with scientific knowledge include sustainability, production stability, minimization of risk, minimization of pest and diseases incidences, efficient use of labour, intensification of production with limited natural resources and maximization of returns under low levels of technology

Indigenous knowledge is the unique knowledge confined to a particular culture or society. It is also known as local knowledge, folk knowledge, people's knowledge, traditional wisdom or traditional science. This knowledge is generated and transmitted by communities, over time, in an effort to cope with their own agro-ecological and socio-economic environments. It is generated through a systematic process of observing local conditions, experimenting with solutions and readapting previously identified solutions to modified environmental, socio-economic and technological situations.

Indigenous knowledge is considered as the social capital of the poor. It is their main asset to invest in the struggle for survival, to produce food, to provide for shelter and to achieve control of their own lives (Senanayake, 2006).

Indigenous knowledge is passed from generation to generation, usually by word of mouth and cultural rituals, and has been the basis for agriculture, food preparation and conservation, health care, education, and the wide range of other activities that sustain a society and its environment in many parts of the world for many centuries (Senanayake, 2006).

Indigenous knowledge covers all fields of human endeavor including, but not limited to, agriculture, environment, pharmacology, health, trade, economics and political systems (Ezeanya-Esiobu, 2019).

Several observers (Brokensha *et al.*, 1980; Compton, 1989; Gupta, 1992; Niamir, 1990; Warren, 1990) have intimated that indigenous knowledge is pivotal in sustainable resource use and balanced development. Brokensha *et al.* (1980) asserted that to ignore people's knowledge is almost to ensure failure in development.

Shiferaw *et al.* (2014) and Welderufael *et al.* (2013) observed that it is of advantage if technological solutions build on existing local knowledge and are perceived as affordable. Several studies indicate the importance of involving stakeholders in transparent farmer-centred decision-making. Merging local knowledge with external expertise ensures local adaptability of practices, and involvement builds trust, which encourages willingness for change (Amarnath *et al.*, 2018; Dougill *et al.*, 2017; Mutambara *et al.*, 2016; Wilk *et al.*, 2017).

With all the above considered, appropriate technology needs to be situated in the preexisting technological knowledge or environmental reality of the innovator. This is where blending indigenous knowledge with scientific knowledge to maximize benefits is of essence.

Senanayake (2006) observed that development activities that work with and through indigenous knowledge have several important advantages over projects that operate outside them. The lessons the local people have learned through millennia of accumulated experience and survival are invaluable in designing modern development plans.

Most development actors have now recognized the value of participatory approaches in decision-making for sustainable development. Indigenous knowledge provides the basis for grassroots decision-making. Furthermore, this knowledge offers new models for development that are both ecologically and socially sound.

Benefits of blending indigenous knowledge with scientific knowledge include sustainability, production stability, minimization of risk, minimization of pest and diseases incidences, efficient use of labour, intensification of production with limited natural resources and maximization of returns under low levels of technology.

Such technology is user-derived and tested through time. On the other hand, the critical strength of the indigenous knowledge is its ability to see the interrelation of disciplines, and then integrate them meaningfully. This holistic perspective and the resulting synergism show high levels of developmental impact, adaptability and sustainability. Therefore, it is a very good source of readily available and already tested appropriate technology for policy makers to use in their planning process.

Blending indigenous knowledge and science does not impede but rather enhances development through synergy. Many field commentators (Brokensha *et al.*, 1980; Compton, 1989; Gupta, 1992; Niamir, 1990; Warren, 1990) have intimated that indigenous knowledge is pivotal in sustainable resource use and balanced development. It has permitted its holders to exist in harmony with nature, using it sustainably (Agrawal, 2004). This orientation is in stark contrast to the views of many earlier theorists, who saw traditional knowledge and institutions as obstacles to development (Agrawal, 1995).

Some of the development challenges, especially in smallholder farming are:

- Low adoption rates;
- Technological challenges;
- Inadequate skills;
- Lack of sustainability.

However, literature is replete with empirical evidence of how blending indigenous knowledge and science can address some of these development challenges, thus maximizing benefits

Enhancement of adoption

Indigenous knowledge is either transmitted orally or through imitation and demonstration or both. It is empirical rather than theoretical knowledge. Development agents know that one of the best approaches to enhance adoption, especially among smallholder farmers is through demonstrations and hands-on experiences as is the case with Farmer Field Schools.

Indigenous knowledge is the consequence of practical engagement in everyday life, and is constantly reinforced by experience with trial and error. The experience is characteristically a product of many generations of intelligent reasoning. It is tested in the rigorous laboratory of survival (Senanayake, 2006). Since its failure has immediate consequences for the lives of its practitioners, there is no room for complacency. The success of IK is also rooted on the fact that repetition aids retention and reinforces ideas. Repetition is an essential characteristic of tradition, even when new knowledge is added.

The top-down approach has been implicated as one of the culprits of low adoption among smallholder farmers. It is argued that with this approach the moment the field extension worker departs the farmers return to their old practices. In contrast, participatory approaches have proved to be more cost-effective.

All development actors have now recognized the value of participatory approaches in decision-making for sustainable development. Indigenous knowledge provides the basis for grassroots decision-making (Senanayake, 2006).

Enhancement of sustainability

Extrinsic practices/technologies and development concepts often provide short-term gains or solutions to problems without being capable of sustaining them. However, if IK is combined with the extrinsic practices/technologies, intrinsic skills, practices/technologies, artifacts, problem solving strategies and expertise are preserved, which maximizes benefits.

Indigenous knowledge systems have a broad perspective of the ecosystems and of sustainable ways of using natural resources. Today, there is a grave risk that a lot of indigenous knowledge is being lost, and along with it, valuable knowledge about ways of living sustainably both ecologically and socially (Senanayake, 2006). Indigenous knowledge has permitted its holders/practitioners to exist in harmony with nature, using it sustainably, and in that regard it is seen as being vital in sustainable resource use (Moock, 1992; Sen, 1992)

MODULE VIII: SCALING CSA

Scaling CSA	
Estimated duration	"Class"– 120 minutes Field– 120 minutes Competition Assessment – 120 minutes
Session guiding questions	This session is intended to introduce to participants approaches of scaling up CSA in the region and the tools to be employed in scaling up. The key guiding questions are: a. What do you understand by "Scaling up CSA"? b. What is the enabling environment for scaling up CSA? c. What are the approaches that can be used to scale up CSA? d. Are there any experiences in scaling up CSA technologies in the area that have been shared or can be shared?
Session Objectives	• To make participants appreciate that CSA technologies can be adopted with ease when there is an enabling environment. • To make participants appreciate that learning from each other and practicing together CSA technologies enhances adoption and improves agricultural production both at family and community levels.
Preparation	• A clear understanding of approaches used in scaling up CSA technologies and practices • A clear understanding of the tools that are normally used in scaling up CSA. • A clear understanding of the CSA technologies and practices to be scaled up. • Illustrations/charts of any available case scenarios on the local approaches to adaptation of CSA technologies
Materials/resources	Materials needed/checklist a. Flip charts/Newsprint paper b. Marker pens, masking tape; cards of various colours; about eight (8) sheets of manila paper
Session type and delivery methodology	• Presentations • Plenary discussions • Group work • Field excursion to showcase some Farms /Farmers who have adopted significant CSA technologies
Take home and follow up	• Scaling up CSA technologies and practices means increasing the number of people using them and the extent at which they are used • There are several approaches used in scaling up CSA technologies and practices both at small and large scale • There are several tools used in scaling up CSA technologies and practices • Scaling tools are different from scaling approaches • Individual farmers have different capabilities to adapt and adopt climate Smart Agriculture technologies. • The environments in which farmers operate affect their levels of adoption. • Working together as farmers in the same crop enterprises enhances the practices and levels of CSA adoption.

Overview

Scaling up CSA technologies and practices means increasing the number of people using the technologies and practices and the extent at which they are used. In order for a scaling initiative to be successful, there should be an enabling/conducive environment. This often requires a variety of actions e.g. mainstreaming and integration.

There are several approaches used in scaling up technologies and practices. Climate Smart Agriculture (CSA) scaling approaches are defined as means used to promote and implement CSA technologies at a wide scale. These can be implemented through a project/program, an indigenous system, a local initiative/innovation that aim to support achieving better and more widespread adaptation to climate change. CSA scaling approaches include different levels of intervention, from the individual farm, through the community level, and the extension/advisory system at regional or national levels. They should assist in answering questions about how land users learn about improvements or 'new' technologies, how they obtain skills to apply them, how they are stimulated to adapt technologies and innovate, and how they gain access to required inputs, equipment and financial resources. A successful approach is usually characterized by being people-centered, responsive, participatory and dynamic. Other attributes include: hands-on, multilevel and multi-stakeholder, part of a partnership, and sustainable (in its socio-economic, institutional and ecological dimensions).

Learning/Removing Barriers; Enabling Environment for Adoption

Creating and strengthening an enabling environment essential for effective scaling up of CSA requires a variety of actions e.g. mainstreaming and integrating CSA into policies and frameworks at various governance levels, using a multi-sector, multi-discipline and multi-stakeholder approach, harmonizing policies and regulatory frameworks in support of CSA, and institutional coordination.

An enabling environment is described as a combination of contextual elements allowing progress to be made towards a clearly defined goal. Steps to improve the enabling environment for scaling CSA entail overcoming institution, financial, legal and science-policy challenges and finding solutions that cut across multiple levels and sectors (Akhtar-Schuster *et al.*, 2011).

Mainstreaming and integrating CSA into policies and frameworks at various country governance levels is encouraged by international mechanisms such as the United Nations Convention to Combat Desertification (UNCCD) and the Sustainable Development Goals (SDGs). This is due to an increasing emphasis on a country-driven approach towards the environment and development goals (Akhtar-Schuster *et al.*, 2011).

Mainstreaming is defined as a systematic practice to integrate CSA issues into decision-making processes, policies and laws, institutions, technologies, standards, planning frameworks, educational curricula and sensitization activities (UNDP, 2008). Mainstreaming has the benefit of reducing costs, increasing economies of scale, and reducing duplication (Akhtar-Schuster *et al.*, 2011)

Approaches and tools for scaling up CSA

In the context of this manual, scaling approaches have been divided into two categories: Micro and Macro. Micro scaling approaches are those that are considered small-scale and may be confined to one community or two. On the other hand, Macro scaling approaches are large scale, targeting entire landscapes/catchments/watersheds. There are also what are considered to be tools for scaling; these are employed in both micro and macro scaling endeavourss, but often confused with scaling approaches.

Micro Scaling Approaches

- Farmer Field Schools (FFS)
- Innovation Platforms (IP)
- Facilitated Adoption
- Participatory Research and Development (PRD)

Macro Scaling Approaches

- Community-Based Natural Resource Management (CBNRM)
- Landcare Approach
- Landscape Approach

Scaling Tools

- Farmer Exchange Visits
- Field Days
- Information Communication Technologies (ICT) and Agro-advisory Services
- Technical Service Units (TSUs)

CSA-Farmer-to-Farmer Learning Innovations – Demonstrations and Exchange Visits

Farmer Exchange Visits

Exchange visits, which are also called study tours, are considered to be one of the key scaling tools. The main purpose of exchange visits/study tours is to improve the knowledge and practices of the visitors and their organizations, and to integrate the experience gained from the visit into their daily lives. Exchange visits involve organizing a meeting between a group of visitors made up of about 4 to 30 people, both men and women, and a host group or community. The aim is to exchange experiences and discover new viewpoints and approaches for a specific theme. The geographical location of these visits varies according to the expectations of the participants. A visit may take place within or outside the community, area or country, or between different communities, areas or countries of a region or continent. Exchange visits have been tried and tested among both illiterate and more literate farming communities and have been found as an effective approach in scaling up of SLM technologies. From visits attended, farmers are able to effortlessly implement the learnt skills on their own farms.

8.2.1.2 Field Days

Field days are organized for farmers to showcase their skills in the implementation of learned concepts/ technologies/practices. Field days can be carried out near demonstration plots to show farmers the differences between novel agricultural principles/technologies/practices and conventional farming techniques. They are organized to target stakeholders at all levels including; district technical staff, politicians, NGOs, traders, input dealers, processors, transporters, farmers, school children, etc. The objective of a Field Day is to expose the guests to new technologies/practices and innovations.

8.3 The lead farmer approach

The agricultural extension service in Uganda is fraught with challenges including low Field Extension Work to farmer ratio, low morale and incentives. However, due to the many agricultural production challenges that farmers face, especially the emerging ones due to climate change, have made the need for training farmers in new technologies very imperative.

The lead farmer model of technology dissemination where lead farmers are trained and then pass on the technologies to their peers is considered one of the best approaches in scaling endeavourss.

Lead farmers, also known as contact or model farmers, have been part of most extension models for decades. In the past, the lead farmer approaches have been criticized for the selection of richer and progressive farmers, as well as for limited productivity and development impact. More recently, a revived lead farmer approach has contributed to new farmer trainers, who are more representative of the community, with closer ties to social networks, motivated volunteers, and are voted for and chosen through participatory processes within the community. The lead farmer approach works with groups of 15 to 30 smallholder farmers. The lead farmer is the main contact for the project and partner organizations.

> What Defines an Effective Lead Farmer?
> An effective lead farmer is the one who always produces the best crop in his/her field, takes up new innovations as quickly as possible and is willing to train other farmers. In that regard, the field of the Lead farmer becomes a learning centre, where other farmers can come and learn. For the lead farmer to be effective in a community, he/she should first be accepted by the farmers he/she is going to mentor.

What are the responsibilities of lead farmers?

- Lead farmers play an important role as an Information Bridge between farmers (demand) and extension workers and service providers (supply).
- Lead farmers play a crucial role in supporting and assisting agricultural extension activities in the communities. This includes farm demonstrations and community and group meetings.
- Lead farmers motivate other farmers to try new technologies
- They must always lead by example by practicing what they are taught in their own fields.
- Lead farmers are farmer chosen by other farmers to represent them in agricultural development and train them to use new technologies.

How are lead farmers selected?

Selection is generally based on their technical expertise, their role in the community and their level of literacy

How to maintain and incentivize quality lead farmers

- Lead farmers need training and retraining on Lead Farmer concepts, communication, and agricultural management systems.
- To ensure inclusive and quality of participation in the selection process, greater sensitization of and ownership by communities of the Lead Farmer approach is needed.
- To do their work effectively and sustainably Lead Farmers need support from agricultural extension system, community and local leaders, and other service providers.

GLOSSARY OF TERMS

Adoption – The act of starting to use a particular plan, approach, technology, practice, method, etc

Adaptation – The process of change by which an organism/ species/ system becomes better suited to its environment. Adaptation aims at reducing the negative effects of climate change and how to take advantage of any opportunities that arise.

Afforestation – Establishing new forests on lands that historically have not contained forests (un-forested land). Afforesting large areas of land so that trees will absorb and store carbon from the atmosphere could slow carbon dioxide build-up.

Agriculture (also called farming or husbandry) – The growing of crops, livestock or fish.

Agricultural Extension Services – These include interventions/activities by government and NSAs that facilitate the access of farmers, their organizations, and other value chain actors to knowledge, information, and technologies; mediate their interaction with other relevant organizations; and assist them to develop their technical and management capacity in agriculture and family life. Agricultural Extension System: The agricultural extension system includes the entire set of organizations and institutions (public, private, civil society), that are involved in providing agricultural extension services.

Agricultural sector – Includes crops, livestock, agro-forestry and fishing activities.

Agricultural Production Zones – Are geographical areas determined by soil types, climate, topography, and socio-economic and cultural factors and contribute to the diversity of farming systems across the country

Agro forestry – Cultivated mixtures of trees, crops and/or livestock

Biodiversity – The total diversity of all organisms and ecosystems at various spatial scales (from genes to entire biomes).

Chlorofluorocarbons - any of several simple gaseous compounds that contain carbon, chlorine, fluorine, and sometimes hydrogen, that are used as refrigerants, cleaning solvents, and aerosol propellants and in the manufacture of plastic foams, and that are believed to be a major cause of stratospheric ozone depletion — abbreviation CFC

Climate change – Refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Climate Smart Agriculture – Climate Smart Agriculture (CSA) is defined as agricultural practices that sustainably increase productivity and system resilience while reducing greenhouse gas emissions

Climate variability – Refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Conservation Agriculture (CA) – It is a farming method with three important elements: continuous minimum soil disturbance combined with direct seeding, maintenance of a permanent or semi-permanent organic soil cover and diversification of crop species grown in sequence or associations. It aims to make better use of agricultural resources through the integrated management of soil, water and biological reSource: combined with limited external inputs. It enhances crop yields while reducing production costs, maintaining soil fertility and conserving water. It is a way to achieve sustainable agricultural production and improve livelihoods. CA aims to make better use of agricultural resources through integrated management of available soil, water and biological resources, combined with limited external inputs.

Conservation farming – It entails the recently introduced CA package for renovation of degraded landscapes through the use of planting stations (basins) and ripping technology.

Cover crops – The main purpose of cover crops is to keep the soil covered and in the process conserve soil and water, and suppress weeds. Farmers prefer multipurpose cover crops that perform their primary functions but also serve as food or feed to those that do not. Such crops improve soil quality and fertility, control erosion, suppress weeds and control insects.

Crop rotation – The practice of growing a series of different types of crops in the same area in subsequent seasons for various benefits, such as to avoid the build-up of pathogens and pests that often occur with continuous cropping of one crop or growing different crops in a haphazard order. Common crop rotations involve sequential cropping of cereals and legumes.

Deforestation – Natural or anthropogenic process that converts forest land to non-forest. Cutting most or all of the trees in a forested area. Deforestation contributes to warming by releasing carbon dioxide, changing the albedo (amount of sunlight reflected from the surface) and reducing the amount of carbon dioxide taken out of the atmosphere by trees.

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

Ecosystem – The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, biomes at the continental scale or small, well-circumscribed systems such as a small pond.

Ecosystem services – Ecological processes or functions having monetary or non-monetary value to individuals or society at large. There are (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fibre, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation.

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

Extension Worker – Personnel employed by agricultural extension service provider organizations (Government and Non State Agencies [NSAs]) deployed to work directly with beneficiaries. Such personnel can be from a range of disciplines including agriculture, agricultural engineering, nutrition, agribusiness and related areas.

Famine – A famine is a widespread scarcity of food, caused by several factors including war, inflation, crop failure, population imbalance, or government policies.

Farmer – A person who grows crops, or rears livestock or fish. (Person who grows crops, or rears livestock fish, bees, silkworms and other productive insects)

Food insecurity – A situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life. It may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level. Food insecurity may be chronic, seasonal, or transitory.

Food security – A situation that exists when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life. Food insecurity may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level.

Gender – Expected behavior and social characteristics (roles, responsibilities, decision making powers, status, access, and control over resources) of men and women as determined by cultural norms in a particular community

Gross Domestic Product (GDP) – is the monetary value of all goods and services produced within a nation.

Intercropping – Intercropping is the practice of growing more than one crop simultaneously in alternating rows of the same field.

Minimum tillage – Minimum tillage means reducing tillage operations to the minimum required to plant a crop. For hoe and ox farmers it usually involves scratching or ripping out the row where the crop is to be planted and leaving the rest of the land untouched until weeding is required. Alternatively, hoe farmers may just dig holes where the seed will be sown.

Mitigation – Mitigation aims at tackling the causes and minimising the possible impacts of climate change e.g. reducing GHG emissions

Mixed cropping – Mixed cropping is the practice of growing more than one crop in a field at a given time.

Mulch – Any material such as straw, sawdust, leaves, and plastic film that is spread upon the surface of the soil to protect the soil and plant roots from the effects of raindrops, soil crusting, evaporation, freezing, etc.

Permanent Planting Basins (PPBs) – Permanent Planting Basins (PPB), as used in conservation farming, is a crop management method which enhances the capture and storage of rainwater and allows precision nutrient application of limited resources.

Plant biomass - is the weight of living plant material contained above and below a unit of ground surface area at a given point in time.

Resilience – The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.

Rip-lines – In soil ripping, a narrow slit or furrow 15-20cm deep is opened in the soil surface where seeds are planted directly. Soil ripping breaks up a surface crust or a shallow hardpan.

Soil health – Is a state of a soil meeting its range of ecosystem functions as appropriate to its environment

Subsoiling – Breaking of compact sub soils, without inverting them, with a special knife like instrument (chisel), which is pulled through the soil at depths usually of 30 – 60cm and at a spacing usually of 1 – 2 m.

Stakeholders – Person or entity holding grants, concessions, or any other type of value that would be affected by a particular action or policy.

Sustainable Land Management (SLM) – SLM is defined as a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods.

Tillage – Tillage refers to all the work a farmer does to prepare land for planting.

CONVERSION FACTORS

Area	
1 hectare	10,000 m^2
	2.471 acres
1 acre	0.4047 hectares
	4.480 sq. yards
Distance	
1 metre	1.0936 yards
	3.2808 feet
	39.37 inches
1 foot	12 inches
	0.3048 metre
1 yard	3 feet
	0.9144 metre
Weight	
1 kg	1,000 g
1 metric ton	1000 kg
1 litre	1,000 ml
1 kg/ha	1000g/ha
Fertilizers	
Phosphorus To change P_2O_5 (phosphate) to P	Multiply P_2O_5 by 0.4364
To change P to P_2O_5	Multiply P by 2.2915
Potassium	
To change K^2O (potash) to K	Multiply K_2O by 0.8302
To change K to K_2O	Multiply K by 1.2046

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