MAAIF
Ministry of Agriculture,
Animal Industry and Fisheries

Sesame Value Chain

A CLIMATE SMART AGRICULTURE APPROACH

AN EXTENSION WORKERS MANUAL

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MAAIF
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CRAFT
Climate Resilient Agribusiness for Tomorrow

Ministry of Foreign Affairs of the Netherlands

SNV

WAGENINGEN UNIVERSITY & RESEARCH

CGIAR

AICCRA
Accelerating Impacts of CGIAR Climate Research for Africa

AGRI TERRA

ACKNOWLEDGEMENTS

The development of the manual has been achieved by Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) with support from the Netherlands government through CRAFT project.

Appreciation also goes to MAAIF team led by Directorate of Agricultural Extension Services (DAES) throught the Department of Agricultural Extension and Skills Management (DAESM), Makerere University College of Agricultural and Environmental Sciences (CAES) team and the National Agriculture Research Organisation (NARO), Uganda National Meteorological Authority (UNMA), SNV CRAFT project, Sesame value chain stakeholders and the consultants for the technical expertise offered.

FOREWORD

MAAIF is implementing her sectoral objective of the NDPIII through the agroindustrialisation (AGI) program under the Parish Development Model Approach. The goal of NDPIII is to increase household incomes and improve the quality of life of Ugandans. The AGI program aims at increasing household incomes through promoting agro-enterprises.

Sesame is one of the priority oil crop commodities which will contribute towards the attainment of the AGI goal. The commodity is a multipurpose oil crop used for food, industrial processing, and source of income.
Uganda's sesame production is about 247,000 metric tonnes per year (UBOS 2019/2020). The major sesame growing areas are the north-eastern and northern parts of the country.

This low production is attributed to a number of challenges including: high cost of quality inputs, inadequate extension services, declining soil fertility, pest and diseases and price fluctuations. However, the recent climatic changes have exacerbated these existing challenges. In response to the climatic change, National Semi Arid Resources Research Institute(NaSARRI), has developed and released improved sesame varieties Sesim 1 and sesim 2 in Uganda to boost the sesame productivity and resilience.

I wish to thank everyone who contributed to the development of this document, particularly, MAAIF technical staff, researchers, stakeholders that provided input into the drafting and validation of this manual and SNV Netherlands CRAFT project for the collaboration in the development of the manual.

It is my hope that this manual will be resourceful and used adequately by extension service providers and other value chain actors to strengthen the Sesame value chain in Uganda.
FOR GOD AND MY COUNTRY

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Maj. Gen. David Kasura-Kyomukama
Permanent Secretary,
Ministry of Agriculture, Animal Industry and Fisheries

EXECUTIVE SUMMARY

Sesame (locally known as simsim) production in Uganda is increasingly becoming popular because of its wide benefits. Sesame production is equally being affected by several factors including climate change. Climate change is associated with changing precipitation patterns, rising temperatures and prolonged dry spells. This manual therefore provides detailed information on sesame growing in times of climate change. The manual is structured in five chapters which are summarized as follows.

Chapter one includes the overall introduction which comprises the background, the different context of sesame production, sesame marketing and uses. The chapter discusses the crop morphology and characteristics including the different growth and development stages. This section also highlights sesame production constraints in times of climate change.

Chapter two discusses the concept of climate change and how it affects sesame production. It further defines climate change and illustrates its causes. The section also explains the effects of climate change, the trends of climate change over the years as well as the impact of climate change on sesame production.

Chapter three expounds on the sesame production constraints in the face of climate change. The constraints include socio-economic constraints, economic constraints, agronomic constraints as well as environmental constraints.

Chapter four explains sesame production practices and technologies. In this chapter, climate mart agriculture is defined, and its three pillars elucidated. The chapter also highlights the production practices, opportunities, and challenges in sesame farming.

Chapter five introduces the reader to record keeping and record management in sesame production. The section highlights the importance of farm records, the characteristics of good records and types of farm records. The chapter includes an indicative cost benefit analysis to help determine profitability of sesame production.

With the highlighted content, the manual will facilitate knowledge and skills transfer as a way of promoting adoption of climate smart agriculture (CSA) technologies and practices in sesame growing among farming communities.

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ABBREVIATIONS

CRAFT: Climate Resilient Agribusiness for Tomorrow

CSA: Climate Smart Agriculture

EWS: Early Warning System

GHG: Green House Gas

IPM: Integrated Pest Mangement

MAAIF: Ministry of Agriculture Animal Industry and Fisheries

NARO: National Agricultural Research Organisation

SSP: Single Super Phosphate

UAIS: Uganda Agriculture Insurers Scheme

UNMA: Uganda National Meteorological Authority

CHAPTER 1

BACKGROUND

1.1 Background

Chapter one includes the overall introduction which comprises the background, the different context of sesame production, sesame marketing and uses. The chapter discusses the crop morphology and characteristics including the different growth and development stages. It also highlights sesame production constraints in times of climate change.

1.2 Sesame production in Uganda

Uganda's sesame production is about 247,000 metric tonnes per year, mainly from sesame growing areas in eastern and northern parts of the country. Several varieties of sesame are available in Uganda; the traditional and new improved varieties. The new improved varieties are Sesim 1, Sesim 2 and Sesim 3. The new varieties are shattering and tolerant to the gall midge and web worm. Average maturity is attained at 90 -110 days after planting..

1.3 Sesame Marketing

Sesame has a high local demand considering that it is a staple crop in Uganda. Small scale dealers dominate the processing business. They produce pastes and press oil from sesame and sell it in local markets across Uganda or sometimes sell seeds to bakeries in the confectionery industry.

The growth of the livestock sector in Uganda presents a new market for sesame as animal feed. Out of the 77% sesame that reaches the market, 42% is exported, 10% is sold to urban consumers, and 25% to rural consumers (See Fig below). 23% of the sesame is lost through post harvest losses across the supply chain.

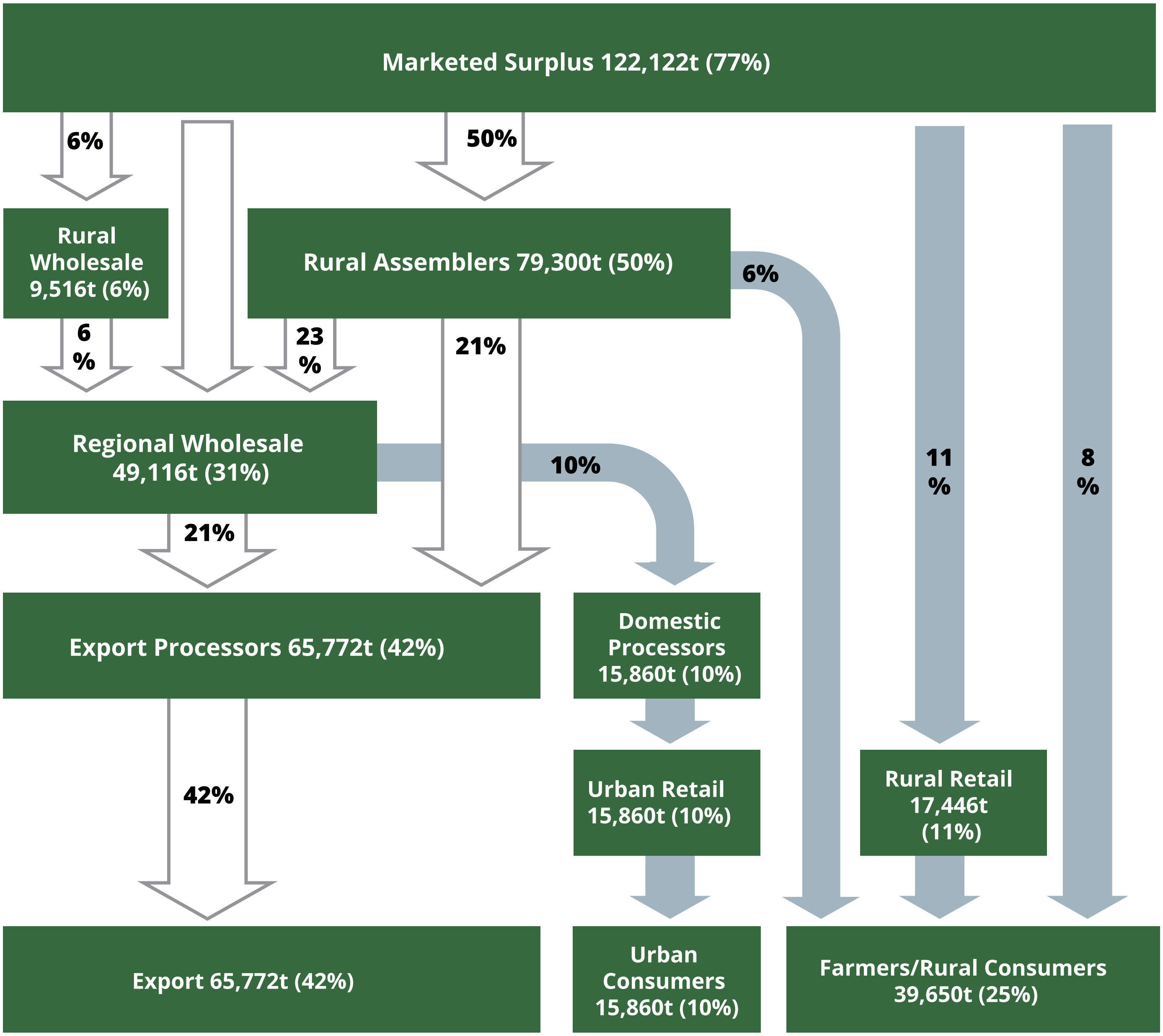

Figure 2: Sesame marketing chain (ICRISAT, 2013)

Table 1: Species : Sesame indica

Variety name/ code	Year of release	Owners	Maintainer and seed source	Optimal production altitude range	Duration to maturity (days)	Grain yield (T/ Ha)	Special attributes
1.Sesim 1	2006	NARO	NARO	1000-1600	135-145	0.7	Drought tolerant
2.Sesim2	2006	NARO	NARO	1000-1600	130-142	0.7-1.0	Drought tolerant Resistant to lodging
3.Sesim3	2013	NARO	NARO	1000-1600	120-130	0.7-1.0	White seeded Tolerant to gall midge

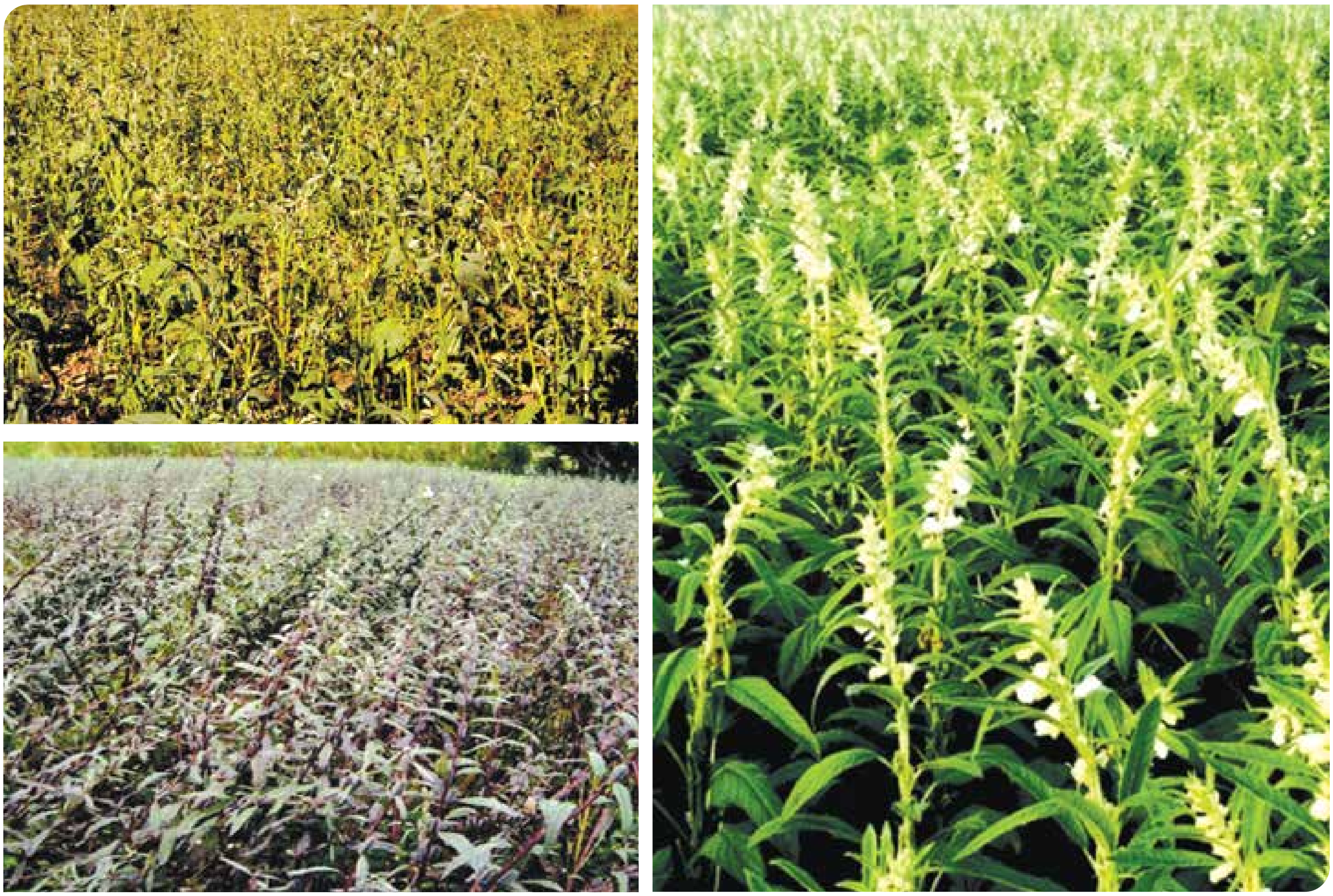

Figure 3: Improved sesame varieties

1.4 Uses and importance of sesame.

Sesame is a very important crop, due to the high oil content from its seed of 30-50% and protein 20-25%.

Other importances of sesame include.

- Source of food and food security.
- Source of income.
- Manufacturing of confectionery, margarine, soap, and perfume.
- Pharmaceutical industry: sesame oil is used in pharmaceuticals.
- Fodder; protein supplement in livestock and poultry feed (cake).
- Green manure and cover crop.

Figure 4: Some of the by-products of sesame

Figure 4: Some of the by-products of sesame: Sesame paste, sesame oil, sesame coated cookies.

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1.5 Crop morphology and growth characteristics

The sesame plant is erect with a characteristically woody stem. The plant can grow up to 1.5meters producing an average of about 55 capsules each containing 15-20 seeds. The deep-rooted plant can survive harsh environmental conditions such as water shortage. This, among other characteristics makes this crop popular among the farming communities.

It takes sesame five to eight days to germinate after planting. From germination, the plant only shows vegetative growth up to about 40 days from planting where flowering begins. The reproductive (flowering and seed formation phase) takes the next 40 days after the beginning of flowering. Maturity and drying of the seeds lasts about 20 days and that marks the end of the crop cycle(110 days).

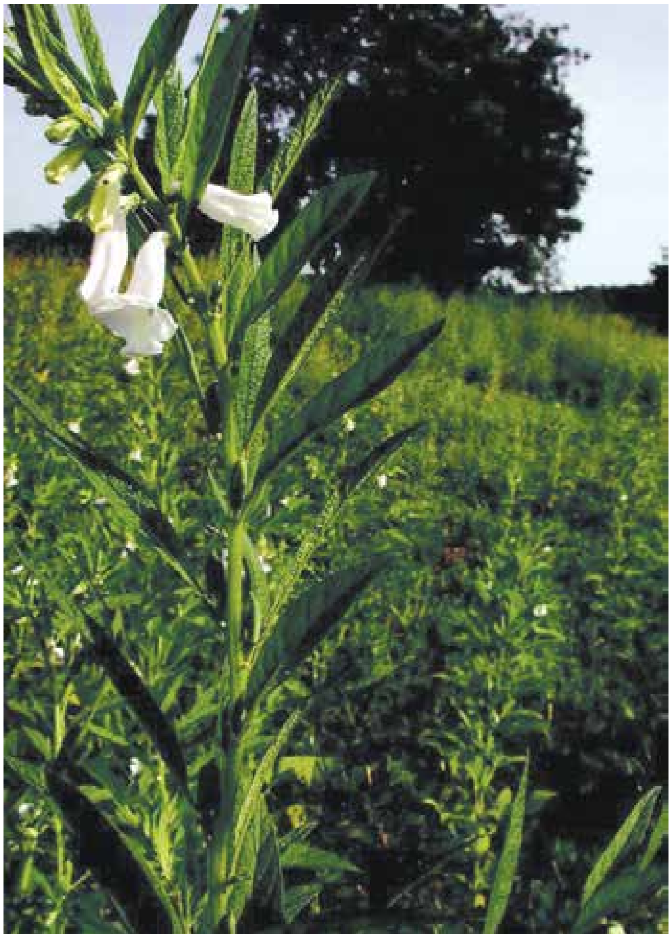


Figure : The sesame plant

CHAPTER 2

SESAME PRODUCTION AND CLIMATE CHANGE

2.1. Introduction to climate change

Climate change refers to significant change in global temperature, precipitation, wind patterns and other measures of climate change that occur over several decades or longer.

2.2. Causes of climate change

Both human and natural factors contribute to climate change. Human activities, such as agriculture and deforestation, are the primarily causes of climate change. They emit greenhouse gases mainly carbon dioxide into the atmosphere. The burning of fossil fuels, such as oil and coal, also contributes to the production of greenhouse gases that cause climate change. Key greenhouse gases include carbon dioxide, methane, and nitrous oxide. However, some quantities of these gases occur naturally and form a critical part of the earth's temperature control system.

Carbon dioxide is the best-known greenhouse gas, with natural sources including decomposition and animal respiration. The main source of excess carbon dioxide emissions is the burning of fossil fuels, while deforestation has reduced the amount of plant life available to turn CO2 into oxygen. The atmospheric concentration of CO2 has been steadily increasing over the years from 300 parts per million to about 400 ppm.

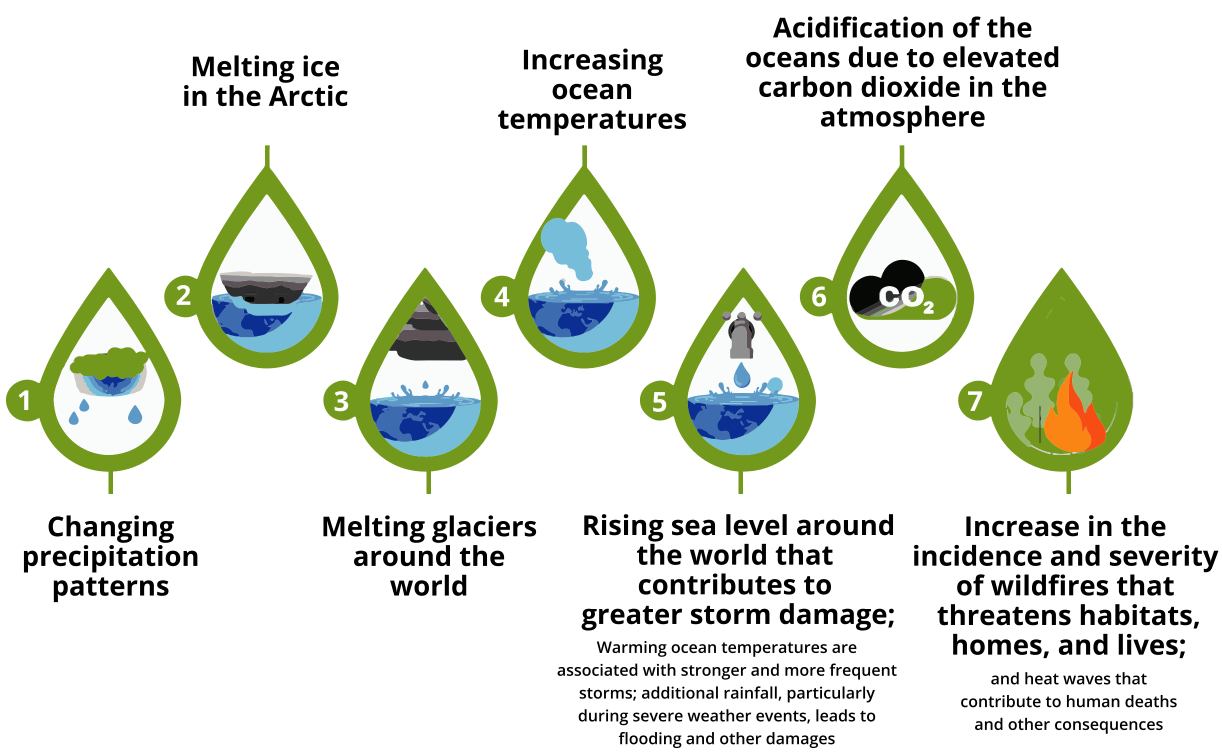
Methane is a more potent but less abundant greenhouse gas. It enters the atmosphere from farming both from animals such as cattle; arable farming methods including traditional rice paddies; fossil fuel exploration; and abandoned oil and gas wells. There are also Chlorofluorocarbons and hydrofluorocarbons that were once widely used in industrial applications and home appliances such as refrigerators during the 20th century. They are now heavily regulated due to their severe impact on the atmosphere, which includes ozone depletion, as well as trapping heat in the lower atmosphere.

2.3. Impact of climate change

There are several effects of climate change. While some effects can be beneficial, particularly in the short term, current and future effects of climate change pose considerable risks to human health and welfare, and to the environment. Even small increases in the earth's temperature caused by climate change can have severe effects. The evidence of climate change extends well beyond increases in global surface temperatures.

2.4. Climate change trends in Uganda

Climatic projections show that by the 2050s, the entire country will have overall increased temperatures. The projections show that temperature increases will be higher in the south-west and western regions of the country where temperatures are predicted to rise by 3.2°C during the long rains [March, April, and May (MAM)] and 2.8°C during the short rains [September, October, November and December (SOND)] compared to 2.8 and 2°C for the rest of the country during the same periods. Projections show increased rainfall particularly in the northern and north-eastern parts of the country by as much as 40-50%. These changes will affect the yield of sesame. Practice of Climate Smart Approaches (CSAs) needs therefore to be adopted.



2.5 Socio-economic constraints

Socioeconomic factors, such as economic growth, population, demographic factors, technological changes, lifestyle changes and policies, are the driving forces for future emissions. They greatly influence mitigation challenges and the costs of achieving a stringent climate goal (Ying–Yu Liu et al., 2018). Climate change could alter the growing regions and suitability of zones for the varieties that were formerly cultivated hence influencing economic growth. The demographic changes can occur due to landslides and floods that alter rural farming settlements. Lifestyle changes and food consumption pattern due to changes in cropping systems.

Other factors such as monocropping results in exhaustion of soil nutrients and depletion of soil fertility, quality, mixed varieties in the market, significant fluctuations of market prices, inadequate supply of clean seed, high cost of inputs, Poor marketing channels, and impassable roads.

2.6 Environmental constraints

Environmental constraints vary from one place to another and are mainly caused by variations in rains and temperatures. These include: declining soil fertility, soil erosion, environmental pollution, erratic rainfall, moisture and heat stress:

Biotic constraints of climate change

Climate change influences the virulence of various pests and diseases for instance the occurrence of fungal and bacterial diseases. This will imply more frequent use of pesticides. There is expected emergence of new invasive weeds, pests and diseases.
Pesticide resistance due to very frequent use and condusive conditions for the pests will occur. Distortion of the known pests in an area will influence the phytosanitary measures and regulations more frequently due to climate change. For instance, the migratory pests like African army worm and desert locust that attacked and destroyed crops.

CHAPTER 3

CLIMATE RESILIENT SESAME PRODUCTION

3.1 Introduction

The chapter explains concepts of a resilient system and the three pillars of climate smart agriculture. It also describes the key characteristics of climate smart agriculture. The chapter also highlights the production practices, opportunities, and challenges in sesame farming.

3.2 Climate Smart Agriculture (CSA)

Climate-smart agriculture may be defined as an approach for transforming and reorienting agricultural development under the new realities of climate change (Lipper et al. 2014). According to the Food and Agricultural Organisation of the United Nations (FAO), CSA is defined as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes greenhouse gases (mitigation) where possible, and enhances achievement of national food security and development goals". The primary aim of CSA is identified as food security and development while productivity, adaptation, and mitigation are the three interlinked pillars necessary for achieving this goal (Lipper et al., 2014).

3.3 Pillars of CSA

CSA is based on three pillars: mitigation, for example, of greenhouse gas (GHG) emissions from agriculture, adaptation of agricultural practices to climate change, and sustainable maintenance or increase of agricultural productivity.

3.3.1 The three pillars of CSA

01 **PRODUCTIVITY:** CSA aims to sustainably increase agricultural productivity and incomes from crops, livestock, and fish, without having a negative impact on the environment. This, in turn, will raise food and nutritional security. A key concept related to raising productivity is sustainable intensification

02 **ADAPTATION:** CSA aims to reduce the exposure of farmers to short-term risks, while also strengthening their resilience by building their capacity to adapt and prosper in the face of shocks and longer-term stresses. Particular attention is given to protecting the services which ecosystems provide to farmers and others. These services are essential for maintaining productivity and our ability to adapt to climate changes.

03 **MITIGATION:** Wherever and whenever possible, CSA should help to reduce and/or remove greenhouse gas (GHG) emissions. This implies that we reduce emissions for each calorie or kilo of food, fibre and fuel that we produce. We should avoid deforestation from agriculture and manage soils and trees in ways that maximise their potential to act as carbon sinks and absorb CO_2 from the atmosphere.

Figure 14: The three pillars of CSA (Source: https://csa.guide/csa/what-is-climate-smart-agriculture 9/7/20)

3.3.2 Sustainable increase in production

Ensuring food security for future generations relies on increasing productivity in a sustainable manner. This sustainably increases agricultural productivity and incomes. With the expected population increase in Uganda, there is need to provide enough food rich and balanced in different nutrients such as: vitamins, trace elements and amino acids. Food security is not only a matter of increasing production, but also avoiding spoilage or waste of food along the value chain.

3.3.3 Adaptation

Extreme weather conditions such as severe rainfall, storms, high temperatures, drought, and floods pose numerous challenges to agriculture. Globally, there are changes in seasonality and average temperatures. While climate change might favour agriculture, for example, by longer growing seasons or higher temperatures, in many countries, the effects of climate change on agriculture will be negative.

The need to adapt farming to ensure the resilience of agricultural systems to the changing climate cannot be avoided. Adaptation can involve changes in practices such as changing the crops that are grown, use of new technologies and, applying climate or weather data to make decisions for the future. CSA reduces the exposure of farmers and agri-businesses to short-term risks, while also strengthening their resilience by building capacity to adapt and prosper in the face of climatic shocks.

3.3.4 Mitigation

Adapting agriculture to climate change and maintaining food production could help to solve the current problems. However, with rising levels of greenhouse gases, climate change and its consequences will continue to impact our lives and pose new challenges. Currently agriculture, and related sectors, contribute about a quarter of human induced greenhouse gas emissions, so there is a higher potential to reduce these emissions, and to mitigate other detrimental effects of agriculture on the environment through reducing greenhouse gas emissions; and increasing water and energy efficiencies.

Very often, mitigating resource input and increasing efficiency goes hand in hand with mitigating emissions. The more the concentration of greenhouse gas in our atmosphere can be reduced, the less likely the extreme climate scenarios will be for the future, and the easier it will be to adapt to climate change. Another important aspect of mitigation is the uptake of carbon in plants and soils, which can help to reduce the concentration of carbon dioxide in our atmosphere.

3.4 Production practices

Figure 15: Field clearing (Source: Author)

3.4.1 Field preparation

Sesame is often sown as an opening crop in a rotation, because it requires fertile soil. In this case, grasses must be eradicated, sesame being a poor competitor with weeds. A fine seedbed is required as the seed is very small. Starting with a clean field can help minimise the growth of weeds. Early good land preparation is essential for a good stand since sesame seed is small. Having a proper seedbed with sesame is always critical. There should be a fine seedbed that is ploughed at least twice prior to the rain onset. The site of the field/garden should be suitable for sesame crop considering soil fertility, flood risk, previous crop, and topography. Sesame is adapted to various soils, but grows best on medium to light, well drained soil with enough rainfall. Burning of trash is discouraged.

Field clearing

The land can be cleared by slashing the weeds either manually or mechanically. Another option for clearing is to safely use herbicides. Clear the land free of weeds and gather the debris to the side of the field before the onset of rains. The debris can be buried under the soil during ploughing

Ploughing

For sesame, which has an extensive root system, good ploughing is critical for the effective performance of the crop. First ploughing should be carried out after the first set of rains to ensure that the land is soft enough for penetration by implements. The ploughing can be done using the hoe, animal-drawn or tractor-drawn plough. Where possible, ploughing with a tractor drawn plough is recommended. Second ploughing should be carried out 14 days after the first ploughing

Table 1: Improved sesame varieties and their attributes

Variety	Maturity period (days)	Yield (kg/acre)	Attributes
Sesim I	90-110	200-320	42% Oil content, Green stem, white seed, none shattering, tolerant to gall midge
Sesim II	100 - 110	240- 360	38% oil content, purple stem when mature, white seed. It is shattering, tolerant to the gall midge, drought tolerant and resistant to lodging. It has a white coloured seed preferred by consumers.
Sesim III	90 – 100	240 - 360	Over 41% oil content, green stem, white seed. It is shattering, hairy and resistant to the gall midge. It is also early maturing.

3.4.2 Planting

Planting must be done as early in the rains as possible. This should be guided by weather information from Uganda National Meteorological Authority (UNMA).

Figure 16: Sowing sesame.

The rainfall pattern in Northern and Eastern Uganda regions is bimodal. The first rains start in March to May and the second rains start around August. Sesame is grown twice a year to coincide with these two rainy seasons.

The recommended method is planting in lines (rows). Mix the seed with dry sand and spread the mixture along the furrows to ensure even distribution (drill planting). Place seeds in a drill using recommended spacing of 30 x 10 cm or 30 x 15 cm depending on soil fertility when grown in pure stand at a seed rate of 2-3 kg/acre. Use a seed rate of 3 - 4 kg/acre depending on row spacing and planting conditions. Placement must minimise seed depth to reduce the amount of time for emergence.. The seed needs to have enough moisture around it to facilitate germination

3.4.3 Soil improvement management practices

Most soils in Uganda are depleted of essential soil nutrients. Good management of crop residue like returning the stalks of the sesame to the field after drying can help maintain and improve the soil fertility. Some of the practices appropriate for sesame are:

- Improvement of nutrient-retaining ability of soil by adding organic manures (cow dung, and goat droppings) to the soil.
- Improvement of soil drainage.
- Control of soil erosion by using live barriers and stone bands.

Banding

This is the construction of the different biophysical structures for soil and water conservation.

- There are many types of bands including terraces, grass bands, agroforestry tree hedges, trash lines and stone lines.
- Grass bands, trash lines, stone lines and tree hedges are simple to make once contouring is complete.
- Contour bands are useful in minimising soil water loss due to uncontrolled movement.
- Bands improve humus content and hence soil structure especially grass bands and trash lines when used for green manuring.
- Bands can appropriately demarcate crops and in so doing they ease the management of pests and diseases as part of the Integrated Pest Management (IPM) programme.
- Banding also eases cropping pattern, crop rotation and enhances land utilisation.

3.4.4 Soil fertility management

To achieve maximum yields under climate smart agriculture, the use of organic and inorganic fertiliser is recommended. Examples are:

- Single Super Phosphate (SSP), a source of phosphorous can be applied and incorporated in the seedbed during final land preparation at a rate of 40 – 80 kilograms per acre just before planting. This helps in root formation.
- 40 kilograms per acre of Urea can be applied after first weeding (2 - 3 weeks after planting) as a source of nitrogen but it is advisable to practise split application to avoid leaching (20 kg during planting and 20 kg after planting). New fertilizer blends such as NPK 24;17;10 are available for use at planting and top dressing before flowering at a rate of 50kg/acre.
- Muriate of potash (24 kg/acre) as source of potash is applied just before flowering to enhance fruiting.

N.B: Fertiliser application should be done after soil testing to determine the soil nutrient requirements..

3.4.5 Weeding and thinning

Weeding is critical and must be done as soon as weeds emerge. It is done once or twice depending on the field conditions.

Weeds may be controlled by hand weeding which is the most common method used by small-scale farmers. Cultural methods can also help to control weeds, for example, good seedbed preparation, proper spacing, timely planting, improving soil

Figure 17: Hand weeding (Source: Ngetta ZARDI Sesame Production Manual, 2018)

fertility and good seeds as well as crop rotation can help minimise growth of some weeds. A combination of methods can help give best results. As a climate smart practice, weeds removed from the garden should be left in the garden as mulch. Keep sesame fields weed free as much as possible.

Thinning

Thin to one plant per hole when the crop is 15 centimeters high. Thinning can be done immediately after first weeding.

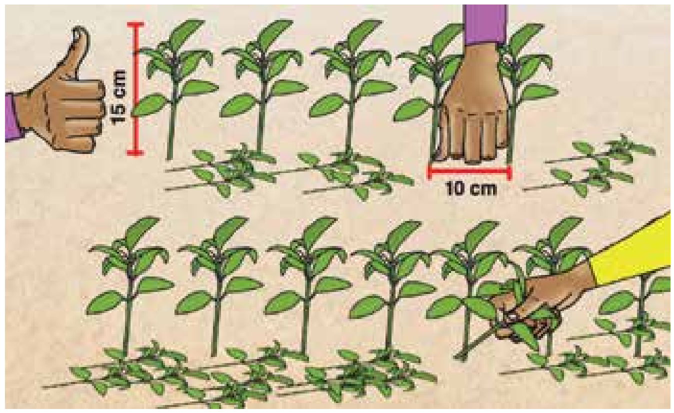


Figure18: Thinning and weeding (Source: Ngetta ZARDI Sesame Production Manual, 2018)

3.5 Pests and Diseases

3.5.1 Common pests of sesame and their control measures

3.5.1.1 Sesame webworm (Antigastra catalaunalis}

It is a widely distributed insect pest of sesame that causes greatest damage during the seedling and flowering stages, and may continue until harvest, feeding on mature seeds hidden inside capsules. It also eats leaves leading to webbed leaves. Generally, the webworm can cause yield losses of between 25 and 35% and the critical period for control action is the flowering stage. Nevertheless, webworm damaged capsules may inflict up to 100% seed loss.

Control measures:

- Timely planting at the onset of rains

Figure11: Sesame pests (A) Webworm and (B) Gall midge

- Follow recommended good agricultural practices such as field hygiene and crop rotation (that is cultural practices).
- Spray with Azadirachtin (neem) at two weeks after crop emergence.
- At four weeks after crop emergence apply flubendiamide following the instructions on the label.

3.5.1.2 Sesame gall midge (Asphondylia sesami)

Gall midge is one of the most serious insect pests of sesame. It causes extensive damage, and the larvae are the damaging stage. Eggs are laid in ovaries of flowers and the gall begins to develop before the petals wither or become twisted and stunted and do not develop into flowers or capsules. Even though not yet quantified, estimated yield reduction could reach more than 30% in heavy infestation years.

Control measures:

- Crop rotation
- Use of torelant varieties like Sesim III.
- Spray with Azadirachtin (neem) at two weeks after crop emergence
- At four weeks after crop emergence, apply flubendiamide following the instructions on the label.

3.5.2 Common diseases of sesame and their control measures

3.5.2.1 Fusarium wilt (Fusarium oxysporum)

This is one of the diseases devastating sesame production in Uganda. Affected plants develop wilt symptoms, and then they dry and die.

Control measures:

- field sanitation,
- crop rotation,
- field drainage to avoid water logging conditions.
- Chemical control using fungicides like Propamocarb, Azoxystrobin Minimun C

3.5.2.2 Angular leaf spot

Figure 12: Wilting sesame plant due to Fusarium (A) and Angular leaf spot symptoms (B)

This is caused by the fungus Cercospora sesame; it infects all above ground parts of the plant, resulting in complete defoliation, which leads to severe economic losses.

Control measures:

- Field sanitation,
- crop rotation,
- Chemical control using fungicides like Azoxystrobin, Difenoconazole

3.5.2.3 Anthracnose (Colletotrichum sp.)

This disease causes dark brown lesions on the leaf stem and capsules with black acervuli (round sunken round leaf spot) in the central portion of the leaf.

Control measures:

- Field sanitation Crop rotation
- Spray with protective fungicides like chlorothalonil and copper Hydroxide before the disease attacks the crop. Apply Fludioxonil incase of the presence of the disease .

3.5.3 Integrated Pest and disease management

In CSA, plant resistance, crop rotation, fallowing, right spacing are emphasised. A combination of different control measures (IPM) is the best win. Chemical control should be used only as a last resort, as it is expensive and often detrimental to the environment.

IPM involves the integration of mechanical, chemical, biological and the cultural approaches in the control of pests and diseases and it includes the following:

- Use of resistant varieties.
- Use of early maturing varieties that are high yielding, cold or drought tolerant. Early maturing varieties contribute to disease escape.
- Biological methods will control the

multiplication of the pests and the causative agents.

- Cultural methods will not favour the predisposing factors of the crop to the pest and disease attacks.
- Chemical methods will kill the pathogens or the pests.
- Host resistance will encourage crop inbuilt modification to escape or tolerate the remaining effects of the disease agent.
- Webworm and gall midge are managed by growing tolerant varieties (Sesim 2 and Sesim 3) and when necessary, spray against pests using recommended pesticides.
- • Leaf spot disease can be controlled by spraying with fungicides.
- Fusarium wilt disease is controlled by crop rotation.

3.5.4 Safe use and handling of agrochemicals

Agrochemicals on the farm can be dangerous. Common agricultural chemicals (agrochemicals) include insecticides, herbicides, fungicides, and fertilisers. Farmers need to take care when storing, transporting, using, and disposing of chemicals to ensure their own safety, that of their neighbours and the environment. Use of protective gear is highly recommended for safe use of all agrochemicals. Instructions for application as shown on the labels should be followed and there should be proper disposal of containers after use.

3.5.5 Harvesting

Timely detection of maturity

Sesame matures between two to four months. Determinants of crop maturity are length of the growing season, variety, and indeterminate nature of the crop. At maturity, leaves and stems tend to change from green to yellow, then to dark red in colour and then the leaves will begin to fall off. They will normally dry up in two to three weeks depending on climatic conditions. Self-defoliation and seed maturity begin as the flowering stops. The plants normally hold on to the top leaves until the upper capsules mature. Sesame plants physiologically mature when 75 percent of the seeds in the capsules on the capsule zone have turned from milky white to an off-white colour.

Timely harvesting

Timely harvesting will always maximise yield because it ensures quality harvest and decreases losses due to shattering. Harvest when the capsules are mature. This is realised when the leaves have dropped or shed off. Harvesting is therefore done as soon as the lowest seeds on the plant are ripe. The plants are cut. Harvesting starts when 75% of the pod/capsules are ripe (when the seed in the capsules turns to off-white colour). Harvest when 10% of the plants have dry brown capsules and leaves have dropped off. The mature plants are cut and bundled to dry.

Post-harvest handling - drying and storage.

After harvesting, the plants are tied together and left to dry. This process is called stooking. The best practice is to bring the stooks to a stooking fence or a threshing floor rather than leaving the stooks in the field. When the plants are dry, the seeds are removed using manual or mechanical methods (threshing) on a clean surface. As the plants dry, the capsules open and some of the seed can fall out. While drying and during threshing, the stooks can be moved, and the seeds collected. If in the field, the fallen seed may be lost, unless plastic cover is used. Stooks is also more prone to pest attacks. Sesame will be ready for threshing and winnowing within two weeks after harvesting. In areas with termite infestation, it is important not to allow extended drying in the field. Monitor the field frequently and thresh as early as possible.

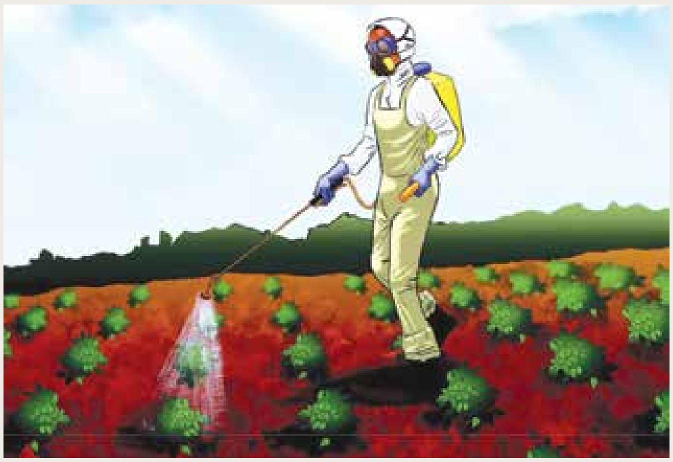


Figure 19: Safe use and handling of agrochemicals (Source: Author)

Figure 20: Drying sesame on racks

- Clean the facility properly before storage.
- Sesame should be stored in hermetic bags and silos.
- Protect the grains from rodents, moisture, variations of temperature and humidity.
- Put the bags on pallets (off the ground), one metre away from the wall to avoid rodents, moisture pick up and to allow for easy inspection.

The major factors affecting the maturity period of sesame.

- More moisture will shorten germination and seedling stages but will lengthen the rest of the stages.
- Higher soil fertility will shorten seedling stage but will lengthen the rest of the growth stages.
- Higher temperatures than normal (25 - 27°C) will shorten the vegetative and reproductive phases.
- Cool night temperatures (18 - 25°C) will lengthen the ripening phase and full maturity stage.
- Low humidity, wind, and/or heat will shorten all of the drying stages.

3.5.6 Marketing and value addition

- Conduct market survey to establish the marketing requirements in terms of quality, quantity, seasonality, and price.
- Provide market information and linkages.
- Encourage contract farming and promote bulk marketing.
- Add value to sesame; make sesame rolls, pasted sesame and sesame oils for local and regional markets.

Storage should be done in a clean, dry, aerated place on pallets.

Figure 21: Hermetic bags on pallets

3.6 Opportunities and challenges of CSA in sesame farming

3.6.1 Opportunities of CSA in sesame farming in Uganda

There are several opportunities presented by climate smart agriculture in sesame farming in Uganda. These include.

- Insurance services
- Weather information
- Soil testing
- Agriculture extension services
- Agriculture credit facility
- National Oil Seed Project (NOSP)

3.6.2 Challenges of CSA in sesame farming in Uganda

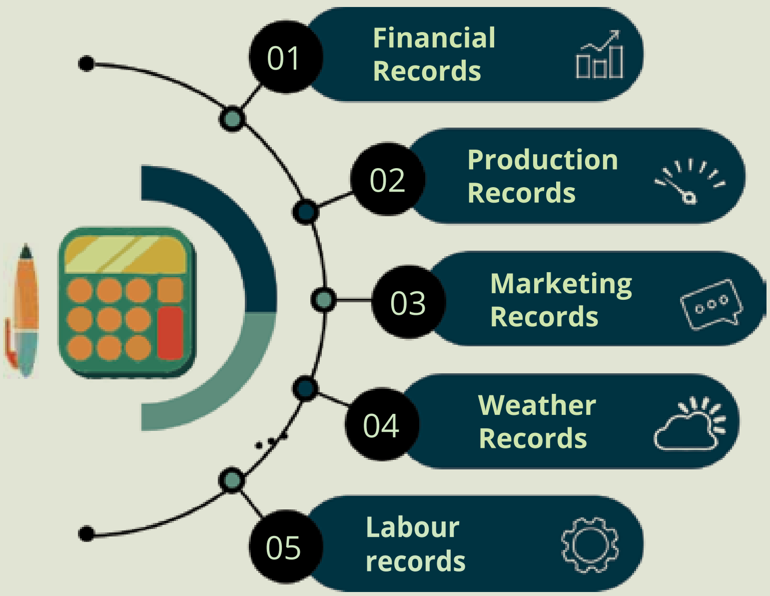
The promotion of sound agricultural practices to adapt to climate change faces a few barriers and challenges. Barriers that are preventing adoption of Climate Smart Agriculture practices in sesame farming can be divided in two broad categories:

a) Physical barriers such as limited access to appropriate farm equipment and tools; and inadequate farm inputs.

b) Non-physical barriers such as inadequate knowledge and information.

Although CSA may not necessarily require more equipment and tools than conventional agriculture, the adoption of CSA practices results in costs, which can be divided into three categories:

- Investment costs for equipment, machinery, or on-farm structure.
- Maintenance costs, such as recurrent expenses to purchase inputs required to maintain climate smart agricultural practices and technologies.
- Opportunity costs, those that farmers forego to adopt CSA practice and technologies.



The use of climate smart agriculture practices and technologies is highly limited among sesame farmers in Uganda and below are some of the factors limiting the adoption of these practices:

- Limited appropriate information about climate change.
- Limited affordable sources of finance to invest in climate smart infrastructure.
- Insufficient sources of improved seed.
- Unreliable sources of inputs.

Bridging this gap and seeking to fill knowledge gaps requires deliberate efforts to stimulate adoption and scaling of CSA among sesame farmers. Additionally, adaptation strategies with potential benefit for the entire value chain in Uganda have been reported. Examples of climate smart Agri-business ideas to address high climate related risks and with the potential to improve the viability of the sesame value chain in Uganda are:

a) Bundled services which provide access to drought-tolerant varieties, relevant information, finance, and creation of market linkages.
b) Provide available and affordable water for production.
c) Provide high yielding varieties to farmers.
d) Agro-input supply including seed supply.
e) Climate information services and soil testing services.
f) Viable weather-related agricultural insurance products and programmes for sesame farmers in Uganda.

3.6.3 Risk management: Crop insurance

Encourage sesame farmers to adopt climate smart insurance for weather risks to enhance smallholder farmers' adaptive capacity. Such insurance covers farm crops against various perils such as losses due to drought and uncontrollable pests. The sum insured can be the farmers' input costs, expected yield, or both. Crop insurance is provided by Uganda Agriculture Insurers Scheme (UAIS), which is a Public-Private Partnership (PPP) between the Government of Uganda, represented by the Ministry of Finance Planning and Economic Development (MoFPED) and Agro Insurance Consortium, a coalition of insurance companies, licensed to underwrite agriculture insurance in Uganda.

CHAPTER 4

RECORD KEEPING AND MANAGEMENT

4.1 Introduction

Sesame growing like any other enterprise recommends that various proper farm records are kept and managed. Records help and are utilised for effective planning, implementation of the CSA interventions and mitigating the negative effects due to climate change that occur on the farm. Chapter four introduces the reader to record keeping and record management in sesame production. It highlights the importance of farm records, the characteristics of good records and types of farm records. It also includes an indicative cost benefit analysis to help determine profitability of sesame production.

4.2 Importance of farm records

A farm record is a document that is formatted to contain information about the farm. This is the documentation of all farm activities, operations, plans, challenges, and opportunities. Records facilitate quick reference to previous activities, and this enables quick and informed decision making. Record keeping also provides useful information for assessing the performance of a business at any time. Record keeping enables development of financial analysis and budgeting. Information to be recorded includes that for human resource, finance, production, operations, storage, and marketing.

4.3 Characteristics of good records

- Records should be simple and easy to use.
- The financial records maintained should have appropriate level of detail depending on the type of business.
- Provides essential information in a timely manner.
- Records must be easy to understand and written in such a way that they can easily be accessed for analysis.

4.4 Types of farm records

Human Resource records: These include details of the labour force, leave calendar and profiles of the workers for the farm.

Financial record

- Invoice: A document issued by the seller to the buyer demanding payment for the goods and services offered. It indicates the quantity, unit price, taxes, and details of the payee.
- Payment voucher: A document prepared to pay service providers after invoices have been received and verified.
- Receipt: A document issued acknowledging payment.
- Pay-in books: Document indicating money you have paid in the bank.
- Cash-book: This contains information of the money banked, received, and spent.

Farm operations records: These records contain all activities taking place on the farm.

Storage recods

- Stock card: A document in form of a card hung on a batch of grain indicating the quantity of stock you have at that time. You can also have stock card for all inputs at your farm. Keeping track of stock helps with identifying theft, guarding against wastage and unnecessary purchases, and planning for production.
- tack Card: A card fixed to a bag stack used to keep a tally of the number and weight of bags of grain either added or removed from the stack.
- Goods Received Note (GRN): A document issued out to acknowledge receipt of goods.
- Received Stock ledger books: Records of the stock that has been received in the store/ warehouse.
- Outgoing stock ledger books: Records of stock that has been removed from the store.
- Quality control records: Records for quality status of the stored grain.
- Fumigation records: Records indicating fumigation activities carried out on the premises.

Marketing

- List of customers
- Price lists
- Details of buyers and quantities desired by the market.

5.5 Cost benefit analysis

Item	Physical	Unit cost	Cost (UShs)
A) Inputs			
Improved Seed (kg)	2	8000	16,000
Fertilizer (kg)	0	0	0
Bags (empty)	2 bags	1200	2,400
Average cost of transport to buy seed from agent	2kg from agent	1000	1000
Sub-total			19,400
B) Labour	Man day	Unit cost	Total
Land preparation (x2)	20-man days	2000	80,000
Planting (sowing)	Done during land preparation		
Weeding once	20	2000	40,000
Application of fertiliser	-	-	-
Harvesting	10	2000	20,000
Drying (poles and Stacking)	10	2000	20,000
Threshing/cleaning	5	2000	10,000

Marketing	Transport (2 bags)	1000/bag	2000

Sub-total	**172,000**

Total cost of production		194,400
Cost of production (UShs/kg)	Total cost of production divide by yield per acre	1023
Expected yield from one acre (200)	200kg minus 5% PH loss (marketable grains)	190
Average farm gate price	Price at harvest	3,200

C) Profitability

Gross value of output		190kg x 3,200	608,000
Expected net income	**608,000 -194,400**		**413,600**

Source: MAAIF Agribusiness Investment Book, 2021

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ACKNOWLEDGEMENT OF KEY PARTICIPANTS

Thanks to Ministry of Agriculture Animal Industry and Fisheries, MAAIF technical Working Group: Dr Nakelet Henry: Dr. Patience Rwamigisa, Ms. Oyuru Jennifer, Ms. Namaloba Beatrice, Mr. Gumisiriza Chris, Mr.Cyprian Ssekubulwa, Mr. Okee Joseph, Mr. Damba Charles, Dr. Sarah Kagoya, Mr. Damuzungu Peter, Mr. Odong Kizito, Mr. Stephen Katabazi , Mr Wamatsembe Isaac. Ms Sylvia Nantongo, Mr Acuti Godfrey and Ms. Olivia Bonabana

Special thanks equally go to SNV CRAFT project team led by Kasekende Bashir the project manager, the consultants Dr. Namugga Prossy and Dr. Kumakech Alfred for the initial content and Dr. Walter Anyanga for his input. Recognition also goes to the CRAFT project consortium partners for their review, and Uganda sesame value chain stakeholders for their contribution in refining the content.

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ANNEX 1: ACCESSING FINANCIAL RESOURCES.

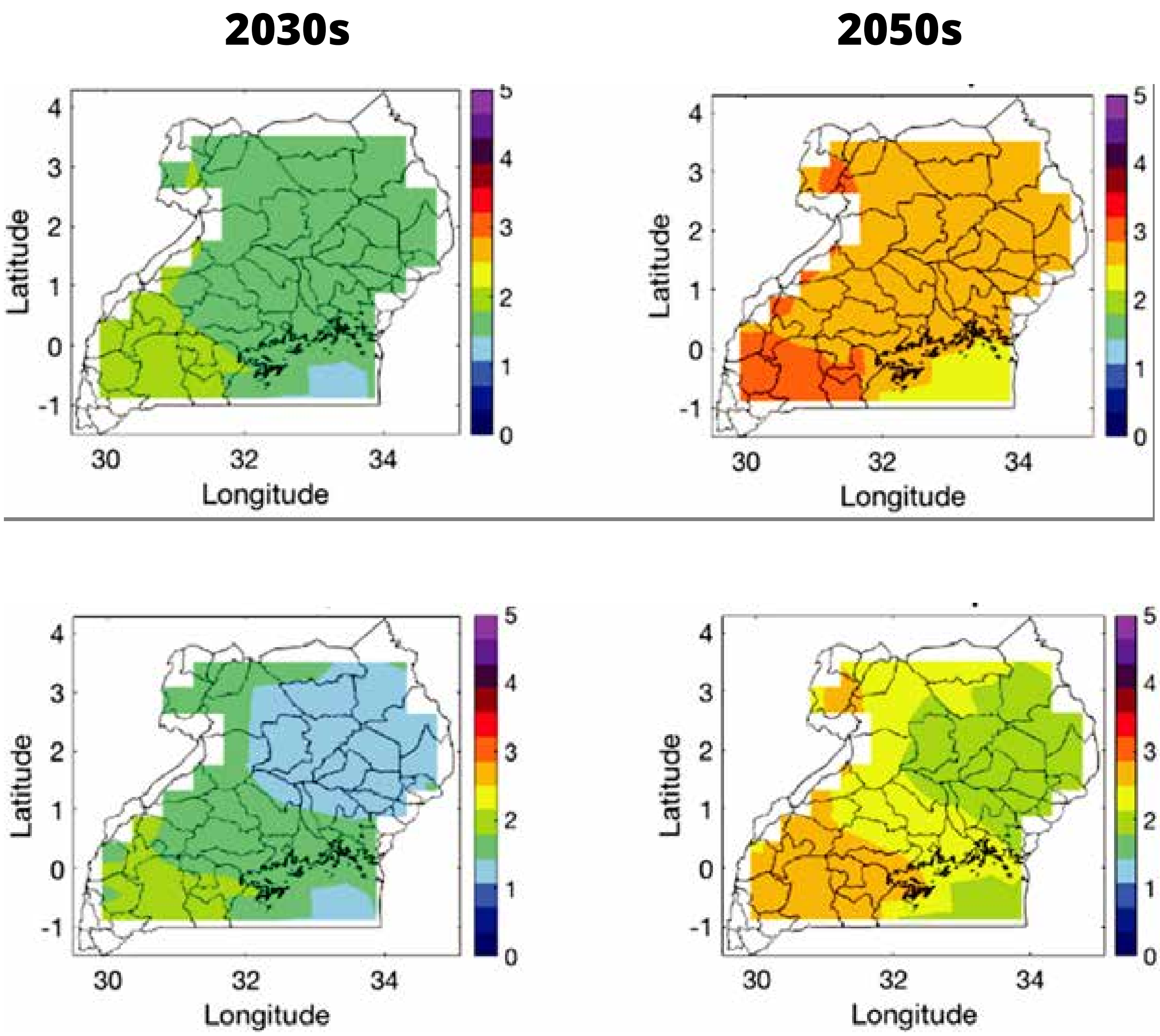
Accessing credit increases the capacity to adopt technologies such as resistant and high yielding varieties for sustainable production in the context of climate change adoption. Information is provided below on the types of credit packages provided by government and some finance institutions in Uganda.

Finance and financial products in Uganda can be accessed through internal resource mobilization through own equity or retained earnings, commercial banks, development banks, microfinance, micro deposit taking institutions, Savings and Credit Cooperative organisation, Village Savings and Loan Associations, fund managers, impact investors, and through government development programs such the parish development model.

Parish Development Model

Under the parish development model, the government has recently set up structures and frameworks for planning, budgeting, and delivery of public services. People at the parish level are to decide development priorities under the policies formulated at the national level. Under this arrangement each parish will receive funds that groups can access under a loan revolving fund for production of commodities, processing, marketing, and other income generation activities that the parish would have prioritised.

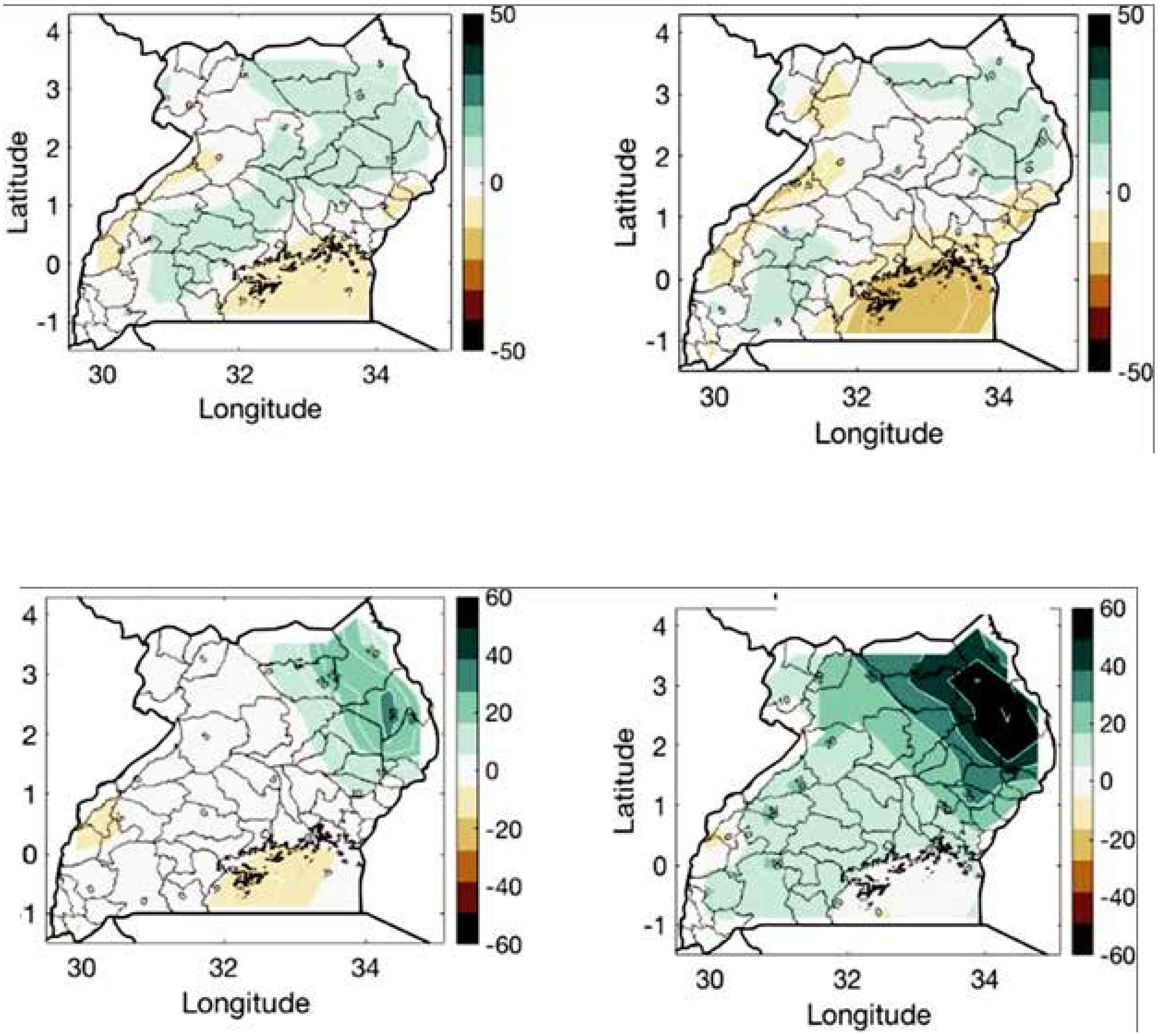
ANNEX 2 CLIMATE PROJECTION MAPS



Figures in degrees

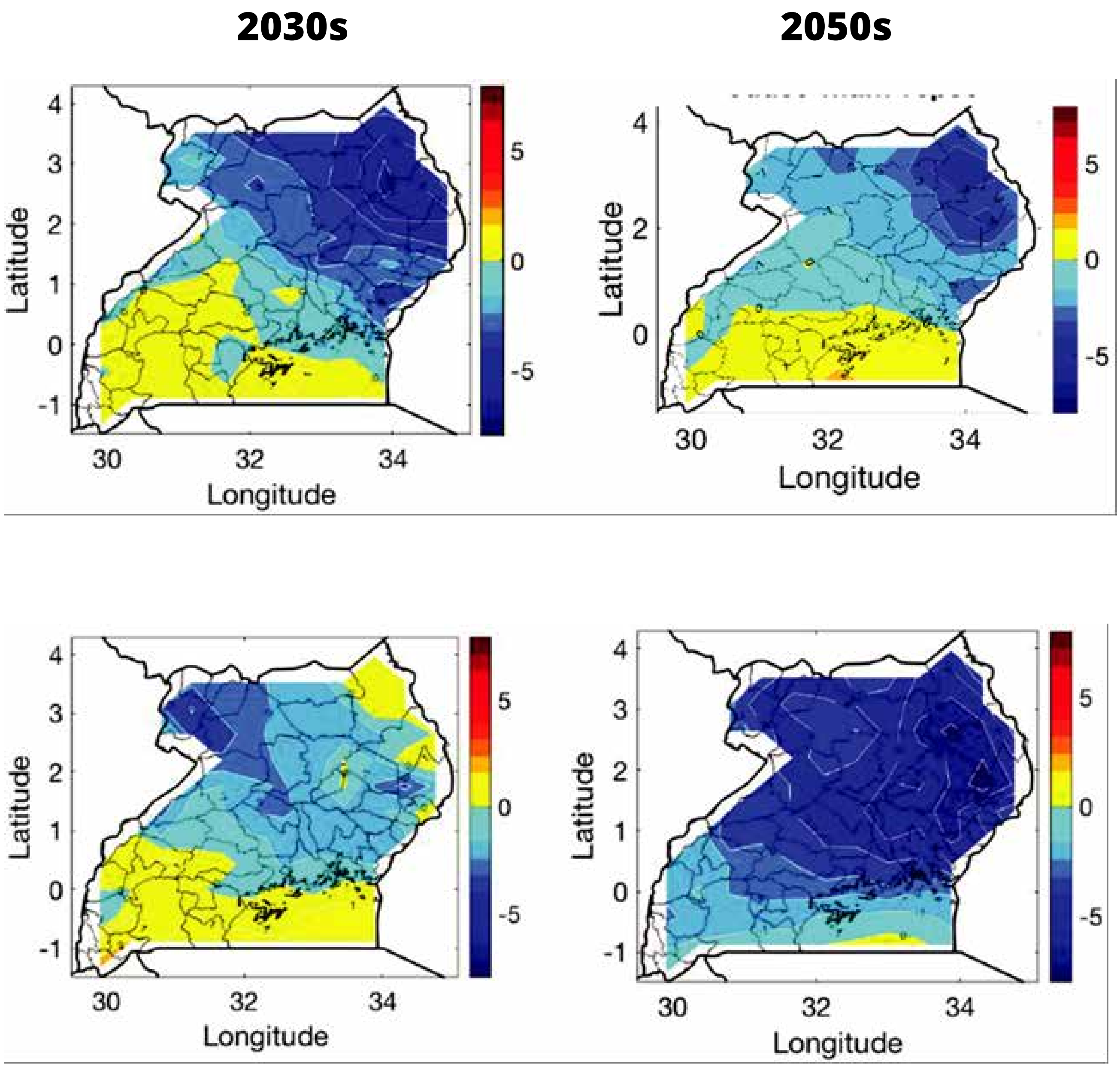
Figure 6: Projected mean changes in temperature for 2030s (Left) and 2050s (Right) under the RCP8.5 emission scenario (worst-case scenario), relative to the reference period (1961-2005).

2030s **2050s**



Figures are in millimeters

Figure 7: Projected seasonal mean changes in rainfall (in percentage) for 2030s (Left) and 2050s (Right) under the RCP8.5 emission scenario relative to the reference period (1961-2005).



Figures are in millimeters

Figure 8: Projected seasonal mean changes in consecutive dry days (CDD) for 2030s (Left) and 2050s (Right) under the RCP8.5 emission scenario, relative to the reference period (1961-2005).

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