Malawi Climate Smart Agriculture Handbook for Frontline Agricultural Extension Staff

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Government of Malawi

Ministry of Agriculture, Irrigation and Water Development

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Acronyms

Acronyms	Long Form
CA	Conservation Agriculture
CO_2	Carbon Dioxide
CSEP	Climate Smart Education Policy project
DLRC	Department of Land Resources Conservation
CSA	Climate Smart Agriculture
EPA	Extension Planning Area
FAO	Food and Agriculture Organisation
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gas
GoM	Government of Malawi
IPM	Integrated Pest Management
MoAIWD	Ministry of Agriculture, Irrigation and Water Development
MoECCM	Ministry of Environment and Climate Change Management
MoNREE	Ministry of Natural Resources Energy and Environment
NCATF	National Conservation Agriculture Task Force

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Foreword

Climate change is a serious challenge for developing countries around the world, including Malawi. It threatens to increase vulnerabilities, destroy economic gains, and hinder social and economic development. In addition, it fundamentally threatens food security and is a significant cause of extreme hunger. The most vulnerable people to the negative impacts of climate change are the vast majority of smallholder producers such as farmers, herders, fishers, and forest dependent communities. In addition, women are disproportionately impacted negatively by climate change.

Building resilience in the agricultural sector and adapting to climate change is a high priority for Malawi. The Government of Malawi through the Ministries of: 1) Agriculture, Irrigation and Water Development (MOAIWD); and 2) Natural Resources, Energy and Environment (MONREE), is working to address climate change. MOAIWD has a mandate to promote and accelerate broad-based, sustainable agricultural development policies to enhance economic growth and contribute to poverty reduction. MONREE has a Department of Climate Change and Meteorological Services, that is responsible for all matters on climate change. Both MOAIWD and MONREE, in partnership with key stakeholders, have prioritised national actions that build climate resilience, lower the country's greenhouse gas emissions (GHGs), and contribute to sustainable development. Therefore, the Government of Malawi is active in the promotion and up scaling of innovations and programmes such as Climate-Smart Agriculture (CSA). CSA practices are expected to sustainably increase productivity and resilience (adaptation), reduce GHGs (mitigation), and enhance achievement of national food security as well as sustainable development goals. Implementation of CSA practices are expected to help Malawi to achieve Paris Agreement by enhancing climate change adaptation.

The agriculture extension service is a key sector in promoting technologies in Malawi. Therefore, training of extension workers on CSA is prioritised as a sustainable method to enhance adoption of CSA technologies in the country. The development and design of this CSA handbook is an important step for the Government of Malawi in providing the necessary locally specific CSA guidance for smallholder producers. This handbook will be a great resource for frontline agricultural extension staff in Malawi. The frontline extension staff will be equipped with knowledge on how to implement and upscale CSA practices which can be shared with farmers in various parts of the country.

The handbook presents various climate change issues and the implications for Malawi, such as effects of climate change experienced, risks that climate change poses to agriculture and livelihoods of farming communities and adaptation and mitigation measures which farmers can adopt to tackle climate change. The use of this handbook is expected to transform the country's agriculture sector into a sustainable production system by maximising the climate opportunities and reducing climate change related risks on the agriculture sector, thus addressing poverty and food insecurity.

The Government of Malawi would like to thank CSEP (DFID-funded regional Climate Smart Education and Policy project) and all those who made this CSA handbook possible.

Executive Summary

Malawi is one of the most vulnerable countries to climate change impacts. In Malawi, climate change has caused variability in temperatures and rainfall; frequent, widespread and intense droughts and floods; resulting in reduced productivity of the crop, livestock and fisheries sub-sectors; threatening livelihoods of subsistence farmers. It has become increasingly evident that the traditional/conventional farming practices used by the majority of farmers in Malawi are not suitable for use under the changing climatic conditions, which are experienced throughout the country. The Government of Malawi (GoM) has recognised the need for farmers to switch to climate smart agriculture (CSA) practices that build resilience of the farming systems and enable the farmers to produce under anticipated or experienced climate risks, while also reducing emissions of Greenhouse Gases (GHGs).

While many policy makers, researchers and senior agricultural extension staff are well informed and have a clearer appreciation of the extent and impact of climate change on agriculture; and also have knowledge and skills on suitable adaptation and mitigation measures that can be adopted by farmers to address climate change impacts, many of the frontline extension staff that interface with the smallholder farmers have limited knowledge and skill on climate change issues and potential solutions. Farmers are aware, from their own field experiences, that the climate has been changing over time. However, many do not link the declining agricultural productivity to climate change. The evidence of significant changes that have occurred in the climate and the risks these changes pose to agriculture have been presented in this handbook to highlight the magnitude of the threat faced by smallholder farmers.

It is the farmers who are experiencing the challenges and risks that climate change is causing in their farms. As they struggle with the impacts of climate change in their agricultural production systems, smallholder farmers are looking for solutions to improve productivity. It is crucial that farmers are empowered with knowledge and skills for addressing the challenges posed by climate change. This handbook presents suitable farming practices which can enable farmers in different agro-ecosystems to: adapt to climate change and its associated impacts, improve agricultural productivity and also enable farmers to intervene on causes of climate change. Information on the benefits of adopting the different CSA technologies is also provided to show the range of advantages for farmers who chose to adopt CSA practices. It is anticipated that this handbook will be a valuable resource for frontline agricultural extension staff and to farmers who want to adopt CSA practices.

Introduction

Malawi is a landlocked country with a population of 18 million people. About 90% of the population are smallholder subsistence farmers who own less than a hectare of land each in rural communities. Agriculture is the most important sector of the Malawi economy. The sector includes crops, livestock and fisheries sub-sectors. It is dominated by the rain-fed smallholder farming system and is the major source of livelihoods for rural communities, contributing significantly to the household and national food security. It provides 64% of the total income of the rural population. Most farmers primarily rely on rain-fed agricultural systems, which are highly vulnerable to climate change. The negative impacts of climate change on agriculture have resulted in food insecurity at the local community level as well as at the national levels.

Climate change threatens agricultural productivity and poses challenges to the stability of the agricultural sector in Malawi (Ministry of Agriculture, Irrigation and Water Development (MoAIWD), 2016). Therefore, it is important to invest in climate resilience in the farming systems and promote approaches such as climate smart agriculture (CSA) that are designed to reduce the impact of climate change on livelihoods of the resource-poor smallholder farmers.

Rationale for the development of the handbook

Malawi has taken significant steps to respond to climate change. However, despite efforts made so far, evidence exists indicating that there is a general lack of technical knowledge and skill on how farmers can adapt and mitigate against climate change while ensuring food security. Capacity building of front-line agricultural extension staff is critical to effective implementation of CSA by farmers. Existing training materials on CSA are very technical, complicated and not user-friendly for front-line agricultural extension staff and/or the majority of farmers.

Target group

This handbook is simplified for use in capacity building of front-line agricultural staff based in rural Extension Planning Areas (EPAs) and farmers on CSA.

Objectives of the handbook

The purpose of this handbook is to build capacity of front-line staff and farmers. It is expected that the use of this handbook will:

- Increase adoption of CSA practices by farmers;
- Improve the dissemination of available information about climate, climate change and CSA to farming communities; and
- Enhance farmers' capacity to adapt to and mitigate against climate change.

Evidence that climate change is occurring in Malawi

Before explaining the meaning of climate change, it is necessary to clarify the differences between weather and climate.

Weather describes environmental/atmospheric conditions prevailing outdoors in a given place at a given time. It is what happens from minute to minute. The weather can change a lot within a very short time.

Climate refers to the average weather experienced over a long period, typically 30 years. The weather elements, which change, include: temperature, wind and rainfall patterns.

By its nature, the climate is constantly changing (Figure 1). This is known as climate variability.

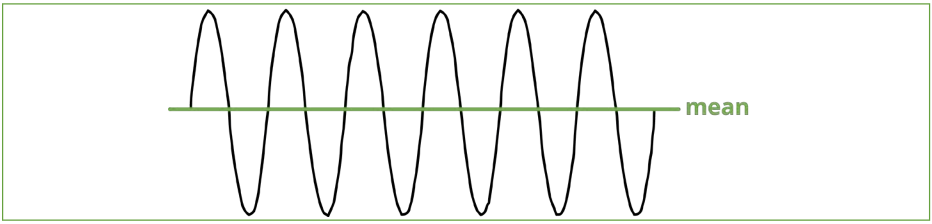

Figure 1: Climate variability illustration

Climate variability involves short term variations (daily, seasonal, inter-annual or over several years) around a mean.

Climate change: Climate change can be detected if standard variations (patterns of climate variability and means) experience significant measurable changes in the long term. A change in the mean state is shown in Figure 2.

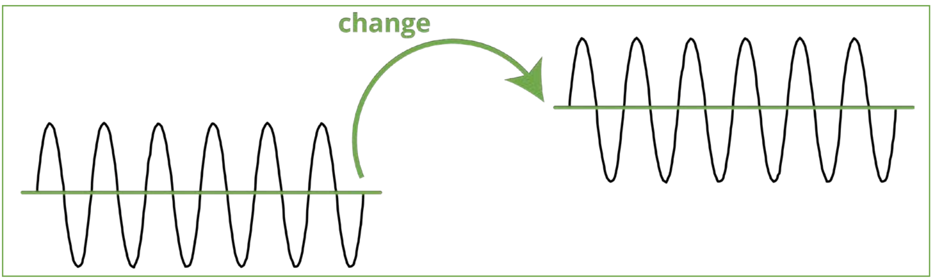

Figure 2: Climate change illustration

Long-term variations (over the past decades and centuries) are due to climate change. The changes in climate have resulted in changes in temperature and in rainfall patterns experienced in Malawi.

Significant changes in temperature characteristics

Between 1960 and 2006:

- The average temperatures increased by 0.90°C (GFDRR, 2017).
- The average number of HOT DAYS per year increased by 30.5 days.
- The average number of COLD DAYS per year decreased by 16.0 days.
- The average number of HOT NIGHTS per year increased by 41.0 days.
- The average number of COLD NIGHTS per year decreased by 33.0 days

Significant changes in rainfall characteristics

- The onset of rains has become more unpredictable with the changing climate.
- During the 1970s, the first rains used to fall in October. The coming of the first rains has shifted to late November or even December. For example: The planting rains started late (in mid-December 2015), the amount of rainfall was below normal and its distribution erratic (GFDRR, 2016).
- The rainy season has become shorter (late November to March instead of October to March), reducing the growing period for crops. This has affected farming activities in the country.
- In recent years, the total daily, monthly or annual rainfall has varied from year to year, thus, there have been wet years and dry years. Some years have been wetter than others. This has determined the types of crops grown by farmers.
- At present, the rainfall distribution in Malawi varies from place to place and has been variable within a specified period, i.e. within a week, a month or a year. The rainfall pattern has been erratic; and has had adverse impact on farming activities.

The risks climate change poses to agriculture in Malawi

The most serious weather conditions that have negatively affected agricultural productivity in Malawi are dry spells, seasonal droughts, intense rainfall, riverine floods and flash floods.

Box 1: Drought and floods experienced in Malawi

Drought, dry spells, riverine floods and flash floods

Dry spell is a period of dryness that has little or no effect on soil moisture or water levels. It is caused by deficiency of precipitation over a short period of time. Dry spells turn into droughts when they last 3 to 4 months.

Drought is a result of a prolonged deficiency of precipitation over an extended period of time usually over a season or more. It is a reduction in moisture availability to levels that are significantly below the normal during the cropping season of November to March (in Malawi). Drought occurs in Malawi when rainfall is less than 75% of normal.

Riverine flood: Occurs when excessive rainfall over an extended period of time causes a river to exceed its capacity. Area along the Shire river in the Shire valley of Malawi are prone to frequent riverine flooding.

Flash flood: Is a sudden local flood due to heavy rain. It is rapid flooding of low lying areas along river banks, in dry lakes and basins following heavy rain or severe thunderstorm. In Malawi, areas around lake Chilwa are prone to flash floods

Source: *Weather watch.co.nz*

- Droughts and floods are the most severe of hazards experienced and the most serious obstacles to agricultural productivity and food security in Malawi.
- Of the two, drought has greater impact on agriculture and livelihoods than floods.
- The whole country is vulnerable to droughts.
- They have increased in frequency, intensity and magnitude over the past 20 years (GFDRR, 2017).

Effects of climate change on crop production

Maize is the dominant crop in Malawi. It is planted on 70% of the available agricultural land. Climate change has resulted in shifting planting dates of maize. Maize productivity has been erratic over the last decades, because of changes in weather conditions due to climate change. Recently:

- Seasonal dry spells have tended to occur at critical stages of crop development, often during seedling or at flowering (GFDRR, 2016);
- Changes in rainfall patterns have resulted in changes in the growing season (from November to March to December to March) and
- Changes in the maize varieties grown (from medium to late maturing to short maturing varieties).

Important predictions of future impacts of climate change on crop productivity

It is predicted from scientific studies that:

- Sustainable areas for cultivation of the two staple crops (maize and beans) in Malawi will decline due to decline in rainfall by 20% to 40% by 2050 compared with the period 1970 to 2000 (Dinesh et al 2015).
- Suitable area for cultivation of groundnuts in the Lilongwe area will decline by 33% between 2046–2065 compared to a baseline of 1961–2000 (Zinyengere et al., 2014).
- On the other hand, suitable area for cultivation of the other staples (sorghum, cassava, yam and pearl millet) will experience little loss (or may even increase).

Therefore, expanded cultivation of the other staples could be the most strategic adaptation measure to adopt in response to climate change.

Effects of climate change on livestock production

Livestock production in Malawi is seriously affected by climate change.

The impacts of climate change on livestock production are:

- The animals reduce their food intake because of the higher temperatures;
- The lower food intake and a poorer nutrient supply caused by droughts have compromised growth and reproduction of the animals;
- Areas suitable for grazing and availability of forage have declined due to dry spells and droughts, leading to reduction in livestock production and deaths;

- Rangelands that are persistently affected by drought are producing inadequate pasture which is deficient in nutrient content to sustain livestock production;
- The drought conditions are increasing mortality of animals due to increasing emaciation and increased incidences of livestock diseases;
- Inadequate availability of feed and water due to droughts are causing decreased milk production (GFDRR, 2016).

Effects of climate change on pests and diseases

Pests and diseases are major constraints to farm productivity in Malawi. Lack of rain or too much rain is frequently accompanied by increased pest infestations, development of weeds and increased disease infections.

With climate change:

- The rates of development of some of the crop and livestock diseases are increasing more rapidly because of increased temperatures and greater humidity. Aphid problems on kidney beans have increased in the field for example ;
- Infestations, development and intensity of weeds are increasing more rapidly because of increased temperatures and greater humidity; weeds worsen the problem as they compete with crops for moisture. Higher concentrations of CO_2, one of the GHGs enables strong growth of weeds, making them a bigger challenge to farmers.
- New pests, weeds and diseases are emerging as a result of the changing climatic conditions;

Unfortunately, most farmers in Malawi have inadequate access to pest, weed and disease control services because veterinary and crop protection services are severely under-resourced.

Effects of climate change on fisheries

Fish contribute 60 to 70% of the protein consumed by the local population in Malawi annually. Unfortunately, the fisheries sub-sector in Malawi is seriously affected by climate change.

Effects of climate change on lake fisheries in Malawi include:

- Drying up of lakes and temperature changes, which have affected aquatic life and resulted in declining fish stocks and fish catches (Msiska et al. 2017, MoECCM, 2013);
- Lake Chilwa dried up in 1995 due to drought, resulting in total loss of the fish stocks (Chabvunguma et al., 2014);
- Lake Malawi has experienced a rise in temperatures in the surface a well as in deep waters as a result of climate change resulting in changes in the

dominant fish species being caught (Msiska et al. 2017, MoECCM, 2013);

- Malawi has reported a 93% decline in catches of Oreochromis species (locally called Chambo) from Lake Malawi due to a combination of overfishing and adverse effects of climate change since 1990 (Msiska et al. 2017);
- A significant change in fish biodiversity in Lake Malawi resulting in the disappearance of the predatory species Labeo mesopis (locally called Nchila in Tumbuka) and the decline in the species Oreochromis spp. (Chambo) and Rhamphromis spp. (locally called Mcheni);
- The smaller and faster breeding sardine type Angraulicypris sardella (locally called Usipa) has replaced Chambo as the dominant species.

Effects of climate change on aquaculture

Climate change has negatively impacted aquaculture productivity in Malawi as follows:

- The frequent and severe drought conditions are causing decreases in water levels and drying up of fish ponds; resulting in declining productivity of fish farming in the country;
- Most fish ponds are drying up for long periods in a year, leading to premature and unscheduled harvesting of the fish;
- Frequent, severe droughts are causing water sources to dry up, resulting in insufficient water in fish ponds;
- Farmers are abandoning fish farming activities because of water shortages (SSC, 2005).

Effects of climate change on food security and livelihoods

Drought and floods are the leading causes of chronic food insecurity in many parts of Malawi (Irish Aid, 2016).

Their impacts on the most vulnerable members of communities include risks of:

- Food insecurity
- Extreme hunger; and
- Malnutrition (GFDRR, 2017).

Apart from agriculture, climate change is also impacting human health by increasing outbreaks of diseases such as malaria, diarrhoea and cholera as the incidences of droughts, floods and higher temperatures increase (Irish Aid, 2016).

Climate Smart Agriculture

Understanding the linkages between agriculture, climate change and food security is essential for the formulation of suitable strategies to address challenges imposed by climate change. There are various factors to consider when discussing the relationship between agriculture and climate change. The first is that agriculture is largely dependent on weather patterns. This is particularly the case in Malawi where the predominant agricultural systems are rain-fed and are subjected to increases in mean temperatures, changes in rainfall patterns, increased variability in both temperature and rainfall, changes in water availability, frequent and intense extreme events and disturbances in the ecosystems.

Transformation of agriculture is required for the sector to feed the growing population, reduce poverty and contribute fully to the economic growth of the country. It is estimated that agricultural productivity will need to increase by 60% by the year 2050 for the sector to meet the demand for food by the rapidly growing population. There is an urgent need to adopt climate smart agriculture (CSA) practices in order to address this challenge. CSA is not an entirely new agricultural practice in Malawi. It is an approach designed to help farmers adapt and mitigate the effects of climate change and achieve long-term food security.

Box 2: What is Climate Smart Agriculture?

Definition of CSA

"CSA is agriculture that sustainably increases productivity, promotes resilience through adaptation practices and reduces/removes GHGs through mitigation actions, thereby contributing to the achievement of national food security (Food and Agriculture Organisation – FAO, 2012). The specific objectives of CSA are to:

- Help communities adapt to climate change;
- Contribute to climate change mitigation; and
- Improve food security.

It is important when implementing CSA that natural resources are preserved. Therefore, it is essential that when implementing the most suitable agricultural production systems in the face of climate change, approaches that minimise impact on natural resources be selected. The main goal of CSA is to promote adoption of suitable agricultural production systems that improve food security.

Adaptation is one of the two approaches farmers can adopt in order to address negative impacts of climate change in Malawi.

Box 3: What is adaptation to climate change?

Definition of Adaptation to Climate Change

Adaptation to climate change is defined as: "Responses by individuals, groups governments to actual or expected changes in climatic conditions or their effects to reduce the vulnerability of human or natural systems to the impact of climate change and climate related risks, by maintaining or increasing adaptive capacity and systems resilience" (FAO,2012).

Agriculture plays an important role in the national economy of Malawi, and plays a key role in ensuring food security. However, some agricultural activities contribute to climate change.

Box 4: What is mitigation of climate change?

Definition of Mitigation

Mitigating climate change involves "implementation of processes that reduce or limit emission of Green House Gases (GHGs) or enhance GHG absorption". Climate change can be mitigated through the use of low GHG emitting or use of GHG absorbing farming systems.

The main goal of CSA is to promote adoption of suitable agricultural production systems with the aim of improving food security. Sustainable agricultural productivity, climate change adaptation and mitigation contribute to this basic goal.

Box 5: What is food security?

Definition of Food Security

"Food security exists when all the people have physical and economic access to sufficient, safe and nutritious food, that meets their dietary needs and food preferences for an active and healthy life, at all times" (Food and Agriculture Organisation (FAO), 2012). Thus, for a community/population to be regarded as food secure, it must have:

- Physical availability of food: The people must have sufficient supply of food. This depends on production levels; levels of food stocks and net trade in food;
- Economic and physical access to food: The people must have income to purchase food and access to food markets;
- Efficient utilization of the food: Exploitation of various nutrients in the food; which may depend on the nutrient composition in their diets and the health status of the peoples; and
- Stability of food security: Food security existing at all times and for all the people. This emphasizes the importance of reducing the risk of adverse effects on: food availability, access and utilization.

Best CSA practices in crop production:

The best CSA practice is one that achieves all three objectives of CSA (i.e. adaptation, mitigation and increased productivity). To achieve all three CSA objectives a crop farmer must:

1. Improve management of croplands;
2. Plant perennials and agroforestry species in crop fields;
3. Plant adaptive crop varieties;
4. Plant energy crops (such as maize)
5. Use improved storage facilities for the harvest; and
6. Practice Integrated Pest Management (IPM) to control crop pests (weeds, invertebrate and vertebrate pests and diseases).

A crop farmer who uses pesticides and fertilizers will only two of the three CSA objectives (adaptation and increased crop productivity)while the one who uses water resources and plant nutrients efficiently will only achieve adaptation and mitigation of climate change.

Best CSA practices in livestock production:

To achieve all three CSA objectives at the same time, a livestock farmer must:

1. Improve pasture management;
2. Improve grazing management; and
3. Manage manure efficiently.

Best CSA practices for the forestry sector:

To achieve all three CSA objectives at the same time, a forestry farmer must:

1. Practice agroforestry
2. Practice afforestation, reforestation and forest restoration; and
3. Practice sustainable forest management.

To achieve only one CSA objective (mitigation against climate change), a forestry farmer must:

1. Practice integrated fire management.

Best CSA practices for lake fisheries:

To mitigate against climate change a fisherman must:

1. Improve energy efficiency;
2. Decrease use of fish meal and fish feeds;
3. Practice integrated coastal zone management

Best CSA practices for aquaculture:

Apart from the species of fish that are being cultured, fish farming in Malawi tends to be sensitive to availability of water. Frequent droughts experienced under climate change conditions have caused decreases in water levels and increased water temperatures, resulting in reduced productivity of the aquaculture sector (Cai, 2013).

To be climate smart a fish farmer in Malawi must:

1. Use fish species that are tolerant of changing climatic conditions;
2. Use integrated fish-crop-livestock farming systems;
3. Use weather and early warning information;
4. Buy risk insurance against effects of extreme weather events.

Figure 3: An integrated fish-crop farm in Lusangazi 10 km outside Mzuzu city

Photo by O. Mwangonde. Fishponds stocked with Chambo and Milamba with bananas and other horticultural crops planted in surrounding fields

Adaptable species for fish farming under the variable climate change conditions

The most suitable fish species to breed under climate change conditions are those that:

1. Grow well under frequently changing climatic conditions and/or under drought conditions;
2. Are adaptable to changing weather patterns; and
3. Are fast growing, and reach maturity before the pond water levels are critically low and/or the pond dries up (e.g., ***Clarius gariepinus***, locally named Mulamba).

Figure 4: Mulamba and Chambo harvested from a fish pond

Photo by O. Mwangonde

Fish-crop-livestock integrated farming systems (integrating fish with crop, vegetables and livestock production):

1. Increase the resilience of smallholder fish farming households to climate change impacts;
2. Diversify farmers' sources of income by selling fish as well as crop and livestock products; and
3. Make the farmers more food secure compared to those who do not practice integrated fish-crop-livestock farming.

Empowering farmers:

To effectively empower farmers to adopt CSA practices, agricultural extension staff must:

1. Support technology development;
2. Improve farmer access to CSA information; and
3. Improve farmer access to climate information

Farm-level CSA actions

Climate Smart input use

The genetic make-up of plants and animals determines their tolerance to shocks such as temperature extremes, drought, flooding and pests and diseases. It also regulates the length of growing season/production cycle and response to inputs such as fertilisers, water and feeds.

Certified improved seeds

To ensure high productivity and profitability, farmers must use certified seeds that have higher germination percentages and higher yield potential per hectare than the locally sourced uncertified seeds which most smallholder farmers in rural locations currently plant.

For example, the germination percentage for the certified kidney bean (variety Chuma) is 92% while that for uncertified local beans is 70%; and the yield potentials for certified seeds of Chuma is 50 kg per hectare while that for local beans is less than 30 kg per hectare.

Drought tolerant crops and livestock

- Farmers must keep and use seeds and breeds of indigenous crops and livestock that are tolerant to shocks such as temperature extremes, drought, flooding and pests and diseases and adapt to effects of climate change that way.
- In areas prone to drought famers must cultivate staple crops like sorghum, cassava, and pearl millet which are tolerant to drought.

Improved maize varieties that address adverse effects of climate change

In an area where the rainy season has been shortening because of climate change, resulting in maize crop failure due to insufficient moisture, the farmer must:

- Plant very early or early maturing maize varieties such as: SC 301 (which takes 80 days to maturity); ZM 309 (which takes 80 to 90 days to maturity);

In an area where the rainy season has been getting longer due to climate change the farmer must:

- Plant late maturing maize varieties such as: SC 719 which takes 158 days to maturity or local maize.

If a farm is located in an area which is prone to drought, the farmer must:

- Grow drought tolerant maize varieties such as: ZM 523 or MH 26.

If the incidences and intensity of diseases on maize has been increasing as a result of climate change, the farmer must:

- Plant disease tolerant maize varieties such as: SC 301 (Kalulu), CS 403 (Kanyani), CS 537 (Mbizi), CS 627 (Mkango), CS 719 (Njovu), MZ 301, MZ 523, MZ 623, or MH 26.

If post-harvest losses from storage pests have been increasing as a result of climate change the farmer must:

- Shift to growing maize varieties that are tolerant to weevil damage, such as: ZM 523, ZM 623 and SC 719 (Njobvu).

Improved kidney bean, cowpea, soya bean and ground nut varieties that address adverse effects of climate change

If a farm is located in an area where the rainy season has been shortened and pest and disease outbreaks have been increasing due to climate change the farmer must:

- Grow the medium maturing kidney bean varieties: Kholopete and Chuma (which take 115 days to maturity);
- Grow disease tolerant cowpea varieties: Sudan 1 (Nseula) and IT82E-16 (Khobwe);
- Grow the early maturing and disease tolerant soya bean variety: Tikolore (which takes 90 days to maturity)
- Grow the early maturing ground nut variety: Chitala (which takes 95 to 105 days to maturity) or the medium maturing variety CG-7 (which takes 120 to 135 days to maturity).

If a farm is located in an area prone to drought the farmer must:

- Grow the drought tolerant ground nut variety: CG-7

Climate smart manure management

Production and use of compost

In Malawi, manure is one of the main sources of GHG emissions from agriculture, but also enhances crop production. To be climate smart in manure management a livestock farmer must:

1. Treat manure through anaerobic digestion and store it as a liquid or slurry to lower methane emissions and produce useful energy (e.g. biogas);
2. Compost solid manure to lower methane emissions and produce useful organic amendments for soils;
3. Substitute the use of inorganic fertilisers with use of manure to lower emissions of GHGs and improve soil condition and productivity;
4. Use intensive livestock production units and enhanced manure processing; and
5. Integrate livestock with crop production.

Figure 5: Condition of coffee before (L) and one month after application of Chicken manure (R)

Photos by DCM. There was improved growth of the coffee and the quantity of inorganic fertilizer used was reduced by more than 50%.

Climate Smart Farm Practices

Water harvesting and conservation technologies

Water conservation and rainwater harvesting technologies are important CSA practices that can be adopted by farmers in areas where there is water scarcity.

Pit-Planting

In some parts of Malawi, smallholder farmers must use pit-planting as a practice for adapting to dry spells and maximising the use of limited water (NCATF, 2016). On a farm in an area prone to unpredictable rains.

If a farm is located in an area that is prone to crop failure due to unpredictable rains the farmer must:

1. Dig a 30 cm deep circular or square hole or a square hole measuring 30 cm deep with 75 x 75 cm on the sides
2. Mix top soil from the pit with farm yard manure at the rate of 4::1 and return into the pit.
3. Space the basins at 75 to 90 cm between rows and 70 cm within rows
4. Plant the crops early to benefit from the available rain

Why the use of pit-planting is a climate smart practice:

1. Pit-planting is a rain water harvesting technology;
2. It is effective in holding rain water in the soil;
3. The moisture from the captured rain water helps crops in the event of dry spells.

Swales for water harvesting

A swale is a technology used to harvest rainwater in a farm located on a slope and allow the water to seep through the farm over time.

A farm on a sloppy terrain

On a farm that is located on a sloppy terrain the farmer must:

1. Dig 1.0 metre deep and 1.0 metre wide trenches along the contour at regular intervals;
2. The length of the swales must be equivalent to the length of the ridges; with breaks inside that are dug at a gradient to ensure a steady flow of water.
3. When the ridges are too long, the trenches must be dug with a 1.0m break in between.
4. The steeper the slopes, the closer the trenches to one another

Figure 6: Swale prepared in a field on sloppy terrain (L). Swale in a cotton field (R)

Left photo by Enock Whayo. Right photo by Kamoto, J. and Kazembe, J. 2016

Why the use of swales is a climate smart practice:

1. A swale is a soil and water conservation technology;
2. It holds rain water and reduces effects of surface runoff;
3. The moisture from the captured rainwater helps crops in the event of dry spells.

Soil and water conservation technologies

A farm on sloppy terrain, in an arid/semi-arid area or on marginal land

On a farm that is located on a sloppy terrain; or in an arid area; or on marginal land; a farmer must construct soil and water conservation structure such as:

1. Contour bands;
2. Vetiver grass along contours;
3. Terraces; and
4. Grassy waterways and drainage channels.

 

Figure 7: Contour ridges with vetiver hedge bands in a farm with sloppy terrain (L). Macadamia nuts planted on terraces in a farm on sloppy terrain (R)

Left photo by Enock Whayo. Right photo by DCM.

Why the use of soil and water conservation structures is a climate smart practice:

1. They reduce soil erosion (ensuring adaptation/resilience);
2. Improve water & soil quality (ensuring adaptation/resilience);
3. Reduce loss of soil carbon (ensuring mitigation);
4. Promote formation of natural terraces over time (ensuring adaptation/ resilience);
5. Result in higher yields (ensuring resilience/adaptation and food security)
6. Reduce variability in yields (ensuring food security); and
7. Increase soil carbon absorption (sequestration) (ensuring mitigation).

Conservation agriculture

Conservation agriculture (CA) is a form of CSA because some of the practices increase resilience of farming systems and improve the capacity of farmers to adapt to climate change. CA is currently practiced in many parts of Malawi (NCATF, 2016). To practice CA a farmer must:

1. Use minimum tillage (i.e. zero or reduced tillage and direct seeding);
2. Maintain a mulch of carbon-rich organic matter covering that also feeds the soil (e.g. straw and/or other crop residues including cover crops); and
3. Practice rotation or sequencing and association of crops including trees, which could include nitrogen-fixing legumes.

A farm with infertile soils and/or bare soils or prone to excessive soil moisture loss

On a farm, which has infertile soils, and/or bare soils that are prone to excessive soil moisture loss the farmer must implement short-term CA practices such as:

1. Mulching;
2. Composting;
3. Targeted fertiliser use;
4. Planting leguminous cover crops; and
5. Diversification of the production system.

Figure 8: Mulching in conservation agriculture (L); Intercropping maize with beans with the legume sown as a relay crop and a cover crop in a maize field (R)

Left photo by Enock Whayo. Right photo by DCM, July 2018. Because of the intercropping practice used in this area, inorganic fertilizers were never applied in this field in the past. The beans fix nitrogen which is utilized by maize in the following season.

Figure 9: Faidherbia albida (Winter thorn) (Msangu in Chichewa) trees in a field prepared for crop production (L) and Maize growing under Msangu trees (R)

Left photo by Enock Whayo. Right photo by Kamoto J. and Kazambe J.

Why the use of CA is a climate smart practice:

- Reduces carbon losses that occur with ploughing;
- Increases carbon sinks and carbon capture in the soils;
- Increases soil organic carbon, which improves nutrient and water intake by plants and in turn increases yields and resource utilisation efficiency of the land;
- Absorbs (sequesters) carbon through residue incorporation;
- Increases carbon absorption (sequestration) through reduced use of fossil energy;
- Reduces soil erosion and increases water retention (especially when the practice is combined with added soil cover);
- Reduces nitrate leaching because of minimal mechanical disturbance of soil;
- Reduces mineralisation and subsequent production of nitrates because zero-tillage leaves the soil undisturbed;
- Replenishes soil nutrients through use of leguminous species in cereal-legume intercropping practices;
- Cover crops take up nitrogen from the soil and reduce its loss from the soil into the atmosphere;
- Reduces crop pests and diseases through rotation and crop diversification and
- Improves nutrition (food security).

CA has the potential to achieve triple-win impact (ie. food security, adaptation and mitigation)

Agroforestry

Agroforestry is the practice of planting perennial trees and shrubs within a farm.

A farm with infertile soils or bare lands prone to wind erosion or used for keeping livestock.

On a farm, which has infertile soils, or is on bare land that is prone to wind erosion or is for livestock production, the farmer must practice agroforestry by:

1. Planting crops under Msangusangu trees;
2. Planting Msangusangu trees in the farm - where the trees don't occur;
3. Intercropping crops with other agroforestry trees/bushes.

Box 6: Suitable Agroforestry species for farmers to use in Malawi

Examples of agroforestry species farmers can integrate into crop farms in Malawi include:

(i) Azadirachta indica (neem):

A fast growing, large tree that grows well in low altitudes in Malawi and is common in the Shire valley. Its leaves are commonly used to protect stored grains against insect pests. Neem seed extracts are also effective against a wide range of pests in the field as well as in storage. The leaves can also be used as green manure. Neem trees can be planted in the boundary around gardens and homesteads or as woodlots.

(ii) Cajanus cajan (Pigeon Pea) (Nandolo in Chichewa):

A small sized shrub that grows well in a wide range of altitudes in Malawi. Its seeds are a highly nutritious, high protein food that is utilised in Malawi. Apart from its importance as a food crop, pigeon pea improves soil structure and fertility through its deep root system that has nitrogen-fixing nodules and through green manure from abundant leaf fall. Pigeon pea can be used in alley cropping, under-sowing crop systems, fallows and in contour vegetation strips.

(iii) Faidherbia albida (Winter thorn) (Msangu in Chichewa):

An ideal agroforestry tree species that is widely appreciated by farmers in Malawi. It is an indigenous tree species that grows well in a wide range of altitudes in Malawi. Msangu is a deciduous tree that losses nutrition-rich leaves during the rainy season. The leaves improved soil fertility, while the open canopy allows sufficient light to reach crops cultivated under the tree, resulting in good growth and increased crop yield. In times of famine, people eat the seeds after repeated boiling. Pods and leaves of Msangu are excellent fodder for livestock. Msangu can be grown in intercrops with crops, as boundary trees around homesteads and farms. It can be used in fallows and also be planted along banks of streams.

(iv) Gliricidia sepium (Mexican lilac):

A species that grows well in a wide range of altitudes in Malawi. G. sepium enriches soils by fixing nitrogen in its root nodules. It can be cultivated as fodder and green manure banks, in alley cropping systems, as contour vegetation strips, and in fallows.

(v) Leuceana diversifolia (Luceana):

A very fast growing, drought resistant agroforestry species that is well adapted to most parts of Malawi. It improves soil fertility by fixing nitrogen in its root nodules. In Malawi, Leuceana is used extensively as green manure, livestock feed and for soil conservation. It can be grown in alley cropping practices, fodder/green manure banks or planted along banks of streams.

(vi) Moringa oleifera (Horse-raddish tree) (Chamwamba or Kangaluni in Chichewa):

A fast growing agroforestry tree that originated from India and Arabia, but is naturalised in many tropical areas including Malawi. M. oleifera grows well in low to medium altitudes, such as along the rift valley. It is a multipurpose tree whose leaves and flowers can be cooked after pounding and used as relish. Moringa leaves are good fodder for livestock, while powder from ground seeds can be used to purify water. Moringa also has many medicinal properties that can benefit farmers.

(vii) Sesibaia sesban (River bean) (Jelejele in Chichewa):

A very fast growing agroforestry species that grows well on a wide range of soils in Malawi. It is a good fodder and green manure species and also improves soil fertility through nitrogen fixing. S. sesban can be used in fallows, fodder and green manure banks in under-sowing systems, as contour vegetation strips; or for planting along banks of streams.

(viii) Tephrosia vogelii (Fish bean) (Mthuthu in Chichewa or Mtetezga in Chitumbuka):

A fast growing shrub that grows well at medium to high altitudes, in a wide range of soils in Malawi. It improves soil fertility through heavy leaf fall and nitrogen fixation in its root nodules. T. vogelii can be used in alley cropping, planted in boundaries around homesteads and/or farms, used in fallows, and as contour vegetation strips and also in under-sowing planting systems. T. vogelii is particularly important to agriculture because of its insecticidal properties against a wide range of pests including maize stem borers.

Source: Bunderson et al., 2002

Why the use of agroforestry technologies is a climate smart practice:

A farmer who integrates agroforestry species of trees and shrubs into a crop farm will benefits through:

- Improved soil fertility;
- Reduced the need for application of mineral fertilisers;
- The trees and shrubs offering permanent cover over the soil;
- Increased soil carbon stocks – from soil carbon absorption (sequestration) (mitigation);
- Increased water infiltration into the soil;
- Reduced soil moisture loss;
- Improved soil structure and organic carbon content;
- Diminished effects of extreme weather events, such as heavy rains, drought and storms on the agro-ecosystem;
- Greater quantities of absorbed (sequestered) carbon than in agricultural systems that have no trees or shrubs (mitigation);
- Increased diversification (resilience/adaptation and food security);
- Improved human nutrition (food security);
- Tree products that include fruits, which improve nutrition and incomes of farming families;
- A wide range of co-benefits that are important for improved livelihoods of farming families;
- Increased productivity of the land: higher yields & more products (resilience/ adaptation and food security);
- Less variability in yields;
- Favourable microclimatic conditions for beneficial species such as pollinators and natural enemies of crop pests;
- Alternative source of firewood and construction timber; medicines; livestock fodder/feeds and thus new source of income;
- Increased animal feed (resilience/adaptation, mitigation and food security); and
- A relatively efficient and cost-effective method for mitigating climate change compared to other mitigation strategies.

Rangeland and fodder management

Climate smart grazing of livestock:

Overgrazing is one of the major sources of vulnerability to climate change in semi-arid rangelands of Malawi.

To make grazing of livestock climate smart a farmer must:

1. Restore degraded or overgrazed land to produce more biomass by selectively planting grasses;
2. Add phosphate fertilisers to grazing lands; and
3. Alternate grazing with rest periods for the land.
4. Integrate livestock with crop production

Figure 10: Cattle feeding on maize crop residues after harvesting

Photo by DCM. Releasing cattle and other livestock into the field to feed on crop residues after harvesting maize is a common practice in many parts of Malawi. Photo taken in Hewe, Rumphi District

Beekeeping

Beekeeping is a profitable enterprise that is undertaken by subsistence farmers as well as commercial farmers in Malawi. While a majority of farmers harvest honey from the wild, integration of beekeeping in farming systems will ensure: improved nutritional status of farmers; sustainable crop productivity and diversification of sources of income.

Farmers in all agro-ecological areas where flowering plants occur in Malawi can practice beekeeping. To integrate beekeeping into a farming system a farmer must:

1. Use traditional hives; transitional hives or the more advanced modern hive (depending on available resources);
2. Hang the beehives within the farm and/or surrounding vegetation;
3. Conserve and or plant bee forage plants for nectar, pollen and resin within and/or surrounding vegetation;
4. Provide clean drinking water near the beehives, for bees to drink;
5. Regularly monitor performance of the bee colonies; and
6. Leave two or three combs in the hive when harvesting, for the bee colony to survive on.

Figure 11: Apiary (hives under shade trees)

Figure 12: Tanzanian Top Bar (TTB) hive (a transitional hive)

Figure 13: Langstroth hive (a modern hive)

Why beekeeping is a climate smart practice

Farmers who integrate beekeeping in their crop farming systems benefit from:

- Production of honey which is consumed by the farmers resulting in improved nutritional and health status of the population; or sold to generate income for the beekeepers;
- Production of other commercially valuable products such as bees wax, royal jelly, propolis, and bee venom;
- Provision of a viable means of diversifying agricultural activities;
- Enhancing agricultural productivity of crops through pollination services by the bees on cultivated flowering plants;
- Enhancing pollination services to other valuable cultivated tree species, agroforestry species, ornamental plants as well as wild forest trees, shrubs, medicinal plants, and other flowering plants (thus ensuring preservation of environmental health);
- A gender friendly technology to men, women and youth;
- A technology that can be integrated comfortably into a busy schedule, especially of women who tend to be overburdened with numerous household tasks;
- A technology that is consistent with commitment to actions on gender sensitivity; sustainable crop productivity and sound ecological land use;
- A technology that has minimum labour input requirements (it is estimated that only 25 hours are required to attend to a beehive in a year)

Figure 14: Honey comb with sealed & unsealed honey (L) Enhancing pollination of cultivated and wild flowering plants (R)

Photos by DCM.

Climate Smart post-harvest practices

Management of post-harvest losses

In addition to implementation of CSA practices in the field, during crop development, it is important to use appropriate climate-smart post-harvest practices, which ensure that the stored harvest is of good quality and in good condition; and the community's resilience to impacts of climate change is increased by ensuring food and nutritional security. Large quantities of crop yield are destroyed by storage pests and diseases, resulting in food insecurity among farming families.

Post-harvest challenges faced by farmers in Malawi tend to be given limited attention by farmers and the agricultural sector as a whole, compared to pre-harvest operations; and yet post-harvest losses and food waste are a major bottleneck in Agriculture. There is limited emphasis on post-harvest handling compared to field production operations. There are limited technologies developed and limited extension services provided for post-harvest than for field operations. And yet post-harvest is almost as important as filed development of the crop.

Post-harvest handling is about preparing the harvest into a most suitable form for consumers and industry. It includes primary and secondary processing of the crop. It is estimated that post-harvest losses of cereals globally are 30% (Tefera et al., 2011, Tefera, 2012); fruits and vegetables are 45%; oilseeds and pulses are 20%; root and tuber crops are 45%; dairy are 20%; fish and seafood are 30%; and meat are 20% (National Academy of Sciences, 1978, Kader, 2005).

For a long time, post-harvest losses were mostly regarded as only those occurring in storage. In fact post-harvest crop losses in Malawi start from the field and only reach the peak in storage. Improved post-harvest handling practices involve: preparing for the new harvest; harvesting on time (when the crop has reached the harvest maturity stage); and transporting the crop from the field to the homestead (ensure that the farmer has transporting equipment such as wheelbarrows, baskets etc that minimise losses in transit). Once the harvest is at the homestead, the farmer must:

- Dry the harvest;
- Thresh the harvest;
- Winnow and clean the grain; and
- Ensuring good storage of the grain and.
- Have linkages to markets to sell the stored grain when market prices are high.

Drying

Most grain crops contain extra moisture during harvest in some seasons, crops become ripe and ready for harvest while the rains are still falling. The challenge is to ensure that the grain moisture is kept very low. When drying the harvest the farmer ensures that:

- The harvest is dried on canvas or on mats
- The drying grains are not allowed to get wet
- The grains are covered with canvas if it rains
- The drying grains are turned over every 2 hours
- The drying grains are covered or take it in-doors at night
- The harvest is guarded from animals and birds.

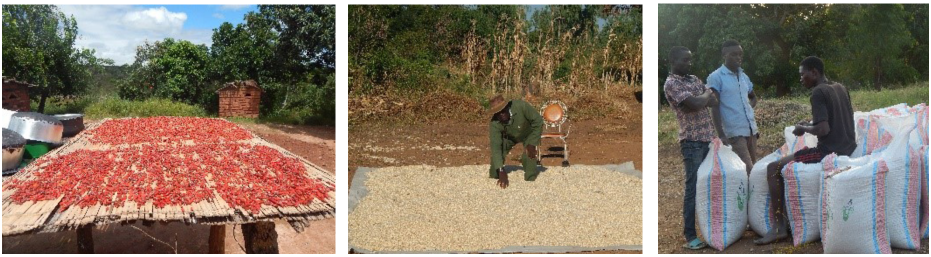

Figure 15: Drying paprika on mats (L); Drying maize grains on canvas (M); Storing maize grains in clean new sacks (R)

Photos by DCM.

Preparation for threshing of the harvest

When preparing to thresh the farmer must ensure that:

- Threshing mats, canvas, a flat threshing ground and threshing tools are ready;
- The stores and sacks for storing the harvest are thoroughly clean so that residues of the old harvest will not be mixed with the new harvest.
- If the farmer is using the traditional threshing ground, it should be flat enough and plastered with mud.
- The threshing ground should be covered with a plastic, a mat or a canvas when threshing the harvest.

Manual threshing

With beans or oil seed crops like soya beans:

- Pile the harvest on the canvas and beat the bundles with a stick (or other suitable tool) until the grain in released from the shell.
- Use a nut sheller to release other pulses (such as ground nuts).

Figure 16: Pile of harvested beans beat with stick to release the bean seeds

Photo by DCM. Farmers sell beans and other products at designated markets on specific market day in rural areas. The beans fetch MWK 9,000 per tin at harvesting time and MWK 15,000 later in the dry off-season months.

Storage facilities

The ideal storage facilities are those that provide maximum possible protection and suitable conditions to the harvest. To be climate smart, the farmer must use improved storage facilities. The storage facility should:

- Be dry, cool and well ventilated.
- Protect the harvest from extremes of temperature and, moisture;
- Protect the yield from insects, microorganisms, rodents and birds;
- Enable the farmer to easily inspect; disinfect; load and unload; clean and recondition the grains; and
- Be affordable to the farmer


Figure 17: Traditional storage facility for storing maize cobs with husks (L); Improved mud-smeared and thatched storage facility for storing maize cobs with husks (R) in Mpitankhwakwa village, Rumphi district

Photos by DCM.


Figure 18: Traditional storage facility for storing maize cobs with husks (L) and Improved storage facility for storing shelled maize grain (R) in Mpitankhwakwa village, Rumphi district

Photos by DCM.

Preparing the storage facility

To prepare the store for storage of the harvest, the farmer must ensure that:

- Remove any remnants and spillage of the previous harvest from the grain store;
- Clean and fumigate the grain store before storage of the new harvest;
- The grain store is well ventilated and made rodent-proof;
- New sacks (if possible) are used to store the new harvest;
- Old sacks are thoroughly washed, in hot water, and then dried before putting in new grain; and
- Torn sacks are not used to store grain.

Storing of harvest

To store the harvest:

- The sacks containing new harvest must be sewn shut.
- The filled sacks must be stacked on pallets of sticks or stones with some distance left from any sides of the wall
- The grain store must be checked regularly.

Management of storage pests

The destructive pests of stored products are: moulds, insect pests and rodents.

Moulds

Mould is the most common problem in grain stores world-wide. It is a fungal disease that spoils the grains, discolouring them and giving them a nasty smell. The fungus produces mycotoxins which are dangerous to human and animal health. It is a result of:

- High grain moisture content;
- High relative humidity; and
- High temperatures in the store.

Control of moulds

To control moulds the farmer must:

- Harvest the crop at the right time of maturity of the grains
- Not allow rain to damage the crop in the field
- Dry the grain to the required moisture level before storage;
- Clean the store before putting grain into it;
- Soak/wash the sack in boiling water and dry it well before putting grain inside it;
- Create aeration in the store to reduce temperature.

Insect pests

Several types (Orders) of insects including grain moths (Lepidoptera) and beetles - weevils (Coleoptera) damage grains in storage. Infestation often starts in the field and is intensified in storage.

- The storage insect pests damage grains by making holes and tunneling inside the seeds.
- They also reduce the quality of the grains through their presence and their droppings inside the seeds.
- The holes made by the insects act as entry points for mould.
- Insect pests can cause 100% grain loss in storage.

Control of insect pests

To control insect pests of stored products the farmer must:

- Harvest the crop at the right time of maturity
- Protect harvest from rain damage while in the field
- Dry the grain to the right moisture level before storage;
- Clean the store well before taking in the new harvest;
- Soak the sack that will be used to store the grain in hot water and then dry it well before putting grain in it;
- Create aeration in the store to reduce the temperature;
- Use airtight containers (if affordable);
- Never mix old and fresh harvest in the same store;
- Fumigate the store using 5% phostoxin if there is an insect outbreak;
- If long-term storage is anticipated, apply seed-dressing to the grains using a relatively safe insecticide (eg. a 5% malathion formulation).

Rodents

Rodents consume almost everything that a farm house homestead can have (apart from metal objects)

- They damage stored products through direct feeding.
- Rodents consume large quantities of stored products
- They contaminate the stored produce by urinating on the produce and through their droppings (faecal material) which get mixed with the stored grain, rendering the produce unusable
- They transmit important human diseases.

Control of rodents

To control rodents, a farmer must:

- Build impregnable storage structures to prevent rodent damage
- Use cats (a biological control method)
- Fumigate the store with phostoxin
- Use rodenticides available in the market.

Market based approaches

Diversifying into production of high value crops

Strengthening market linkages and unlocking value and higher income from agriculture can create incentives for smallholder farmers and capacity to adopt CSA practices and inputs. A key limiting factor to increased production of the high value crops by smallholder farmers is access to produce markets in the remote, rural communities. Fortunately, many companies engaged in agribusiness in Malawi (including Afri-Nut Limited, ExAgri Africa Limited, National Smallholder Farmers Association of Malawi, RAB Processors, Tropha Estates Limited and Farmers World) are promoting production and marketing of oil seed crops, including groundnuts, soya beans and sunflower; legumes like kidney beans, energy crops such as jatropha and spices such as bird's eye and paprika for processing and/or export (Malawi Country Cooperation Framework, 2015). These are high value crops that support the manufacturing sector in the country and are in high demand in the local as well as the export market.

Many of these crops (including soya beans, kidney beans, paprika, sunflower and groundnuts) are grown by resource-poor smallholder farmers in rural communities for sale to markets. A majority of farmers in Malawi are experienced in production of kidney beans, soya beans and groundnuts. Relatively few are familiar with production of the other crops (jatropha, sunflower and paprika). However, farmers in Malawi are always willing to try new crops, provided training on their production and processing methods is provided and easy access to reliable markets is assured. Promotion of increased production of high value crops as components of CSA practices will increase resilience of the smallholder farming systems; enhance adaptation to climate change effects and also increase incomes of the resource-poor farming families. Increased production of the high value crops requires training of farmers on best production as well as marketing practices. For example, in order to increase volumes/tonnage of their products and secure better markets, farmers must form farmers groups and adopt a strategy of marketing their high value cops collectively.

To improve marketing of farmers' products requires that produce markets are established within or near communities involved in production of the high value crops. This could entail that:

- Companies/agribusinesses, in collaboration with other stakeholders (such as NGOs, government extension officers and local authorities) should set up buying points in strategic locations in the production areas during the harvesting period.
- Establishing "market days" when farmers would bring their products to the buying points.
- Providing farmers with better access to market information or
- Using of markets to manage risk (through buying and selling of livestock or grains by farmers) to avoid post-harvest losses.

Potential for marketing high value crops to companies

Companies that are willing to buy high value crops produced by smallholder farmers exist in Malawi. A few examples include: Grain Security LTD, Farmers World Group (for Kidney beans, soya beans and ground nuts); Mzuzu Coffee Union (for coffee and honey) and Tropha Estates Limited (will buy paprika, chillies, and macadamia nuts). These organisations are also willing to:

- Establish product-buying points within easy reach of farming communities and
- Establish demonstration plots and
- Provide farmers with training in order to enhance production of their crops of interest.

Prices and potential profitability of high value crops

Profitability of production of high value crops grown by smallholder farmers will depend on the prices the crops fetch in the market. The prices which buyers offered to growers vary depending on quality (grades) of the products as well as supply and demand factors.

A majority of farmers sell their crops to vendors at very low prices while vendors sell the products at much higher prices in local markets and in markets in towns and cities. In general, the prices offered by companies tend to be higher than those by vendors. To address the problem of prices offered to farmers:

- Companies must establish markets within easy reach of farming communities to make production of the high value crops more profitable to the farmers than selling to vendors. Some companies are willing to establish such markets in rural locations.
- Government must revive the Agricultural Development and Marketing Board (ADMARC) buying points in rural areas.
- Government must intervene on commodity prices and ensure that such a policy is policed and enforced.

Role of front-line extension services in promoting adoption of CSA practices

Increased adoption of CSA practices requires effective extension services that promote active interaction with and support to farming communities. To enhance uptake of suitable CSA technologies, front-line extension workers must:

1. Facilitate formation of farmer groups;
2. Identify and use champion farmers who are effective in obtaining and disseminating information and knowledge on available CSA technologies and practices;
3. Organise and facilitate educational visits and/or farmer field days/shows;
4. Facilitate and enhance sharing of farmers' knowledge and experiences on CSA practices among themselves and with extension staff, policy makers and the private sector; and
5. Provide information to farmers on new developments on climate, climate change and CSA

When promoting CSA practices and technologies, agricultural extension staff must adopt a gender equity approach (Sexsmith et al, 2017). Promotion of gender equity must be considered as one of the functions associated with the duties of frontline extension staff to the communities they serve in the EPA or Section.

To ensure successful adoption of CSA practices:

- Implementation strategies should be developed with "local women and local researchers" that are familiar with the cultural contexts regarding gender norms.
- The frontline agricultural extension staff must engage women as partners in the development and implementation of suitable CSA practices for the specific areas.
- From the on-set, the front-line agricultural extension staff must work with women as key stakeholders in the implementation of the available CSA technologies.
- The extension staff must include women in the monitoring of the impact of the CSA at every stage.
- The selected CSA practices must be conceptualized as being implemented by women as much as by men.
- An explicit gender strategy of empowering women along the whole agricultural value chain of a commodity must be developed and adopted.

- Gender considerations must be imbed in project contracts with government, consumers and suppliers

- Equal participation of female and male farmers must be the practice as far as possible, at community level and any other stakeholder groups that are engaged in the implementation of CSA practices.

- Additional "women-only" consultations must be conducted, and the special needs of women identified during such consultations must be considered during planning, implementation, monitoring and evaluation of adopted CSA practices.

- Equal participation female and male farmers or employee trainings on CSA practices and technologies must be ensured. It must not be assumed that the knowledge gained by men will be passed from men to non-participant women.

A Gender-Sensitive approach to implementation of CSA practices

Women form the largest workforce in the agricultural sector in developing countries (Ogunlela and Mukhtar, 2009). They dominate the agricultural sector in Malawi and other African countries. Women play a crucial role in:

- Increasing agricultural productivity;
- Improving food security;
- Alleviating poverty in rural households, and
- Distribution of incomes in rural communities.

However, despite the crucial roles they play in agriculture, their contributions are rarely recognized and acknowledged. Although government and other stakeholders (including development partners) are committed to actively promote consultations with and participation of women as part of the development agenda, there is little evidence to show that much progress has been made to address gender issues in practice.

As is the case with many developing countries of the world, gender inequalities in agriculture exist in Malawi. The inequalities occur in 5 areas: (i) discrimination in land rights; (ii) discrimination in access to productive resources; (iii) through unpaid work done by women; (iv) discrimination in employment opportunities and (v) discrimination in decision making roles and structures (Sexsmith, et al., 2017).

Gender discrimination in land rights

Women are less likely to hold statutory land rights. When they own the land rights, the plots tend to be relatively smaller than those of men. To address this:

- Cultural and legal barriers to womens' rights to land must be identified and removed.

Gender discrimination in access to productive resources

It is more difficult for women farmers to acquire labour-saving innovative production inputs than men. Women face more barriers in accessing extension services than men. This creates a knowledge gap in women farmers. To address this:

- Cultural barriers to women's access to productive resources – including training and information on production techniques must be identified and removed.

Gender discrimination through unpaid work

Women have greater household labour burdens beyond farm work such as preparing food for the household members, ensuring balanced diets, fetching fuel-wood and water etc. Women have limited access to labour saving technologies that can reduce these labour burdens of women. To address this:

- The time women spend on such "care work" and "food provisioning" must be reduced - through access to labour-saving technologies (ie through supporting new income generating activities; promoting intercropping to contribute to food and nutritional security; creating womens' groups that develop strategies for alleviating their heavy household burdens)

Gender discrimination in employment opportunities

In the agricultural sector, women tend to be employed in insecure, temporary employment. To address this:

- Women actively be involved in processing and marketing processes to lift them from low-skilled positions and also be provided with the necessary training.

Gender discrimination in decision making processes

Women are under-represented in producer cooperatives or workers groups; in internal decision making groups or in dispute-resolution bodies. There is a poor track-record of womens' voices in negotiations. Women have relied mostly on opinions of male elites. To address this:

- Women must be included in all decision making structures at all levels of society.

The adverse impacts of climate change affect men, women and youth differently. This is partly because socio-economic vulnerabilities differ between the three groups. Women are particularly crucial in the implementation of adaptation and mitigation solutions and building resilience in farming communities in Malawi. Therefore, it is important that there is equal uptake of suitable CSA technologies to ensure equal benefits from CSA practices. To achieve this:

1. An analysis of how climate change affects youth, women and men differently must be conducted to identify gender specific responses to climate change; to ensure adoption of CSA activities that are gender sensitive.
2. Gender specific concerns and subsequent solutions must be considered when planning and implementing adaptation and mitigation measures in response to climate change.
3. Each of the gender groups (women, youth and men) must participate in the implementation of adaptation measures that lead to increased resilience of food production systems in farming communities.

Adaptation to Climate Change

Adaptation to climate change requires a farmer to adopt changes in farming systems and practices in order to increase their ability to produce under anticipated or experienced climatic risks. It increases resilience of farming systems and livelihoods of farmers. Proper adaptation should significantly reduce negative impacts of climate change and promote positive benefits. Sometimes adaptation might mean taking advantage of new opportunities that might arise due to climate change.

Adaptation practices that minimize impacts of climate change

To adapt to climate change impacts and ensure food security a farmer must:

1. Shift from crops and livestock types that are highly susceptible to drought and heat to crops and livestock types that are drought and heat tolerant;
2. Shift from crops and livestock types that are highly susceptible to pests and diseases to crops and livestock types that are pest and disease resistant/tolerant;
3. Shift from crop varieties and livestock breeds that are highly susceptible to drought and heat to crop and livestock varieties/breeds that have greater drought and heat tolerance;
4. Diversify enterprises towards: planting higher value crops, keeping higher value livestock, engaging in value addition (processing), engaging in off farm employment and marketing infrastructure;
5. Use improved grain storage practices at household level to ensure security of carry-over stocks from one harvest to the next, and access to surpluses all year round;
6. Use climate forecast advice from extension services when implementing farm activities;
7. Buy weather-related crop and livestock insurance (where available and affordable) to mitigate against risks of total crop or livestock losses/failures due to climate change;
8. Intensify food production through use of suitable improved seed, soil fertility inputs (e.g. fertilisers and manure), pest management inputs (e.g. insecticides, fungicides and weed killers) and reliable water supply;
9. Change from reliance on rain-fed agriculture to use of improved on-farm water-use efficiency technologies, affordable irrigation systems, water harvesting technologies, sustainable extraction of groundwater and other underground water resources;
10. Change from use of conventional agriculture practices to use of CSA practices such as conservation agriculture (CA) and agroforestry.

Adaptation strategies in agriculture

Adaptation strategies that minimise farmers' vulnerability to climate change

To minimise vulnerability to climate change farmers must:

1. Diversify their sources of income (i.e. engage in: beekeeping; integrated crop-livestock-fish farming; value addition/processing; and in off farm employment and marketing infrastructure);
2. Participate in initiatives that transfer income or assets to the poor (i.e. participate in cash for work or food for work programmes);
3. Participate in community based risk management measures aimed at addressing crop failures and high food prices (e.g. participate in establishment of grain banks; belong to self-help groups etc.);
4. Participate in innovative financial risk management instruments and insurance schemes to reduce climate-related risks (e.g. the weather/climate indexed crop insurance).

Figure 19: A dam constructed by a farmers' group for irrigating horticultural crops, winter maize and other crops at Palango Mhango village in Doroba (15 km outside Mzuzu city)

Photos by DCM, 2018.

Figure 20: A consultative/planning meeting of farmers willing to participate in farmers groups

Photo by DCM, 2018. Most farmers are willing to participate in farmers groups for marketing high value crops such as kidney beans, soya beans and paprika to markets that are near their villages and offer better prices.

Adaptation strategies that build farmers' capacity to respond to climate change

Farmers' capacity to respond effectively to climate change can be built by service providers (including relevant government extension agencies and/or development partners).

To build farmers' capacity to respond to climate change the relevant government agencies and/or development partners must:

1. Develop efficient communication systems;
2. Develop effective planning processes;
3. Improve mapping and weather monitoring;
4. Improve Natural Resource Management (NRM) practices.

Adaptation activities crop production farmers must undertake to build response capacity to climate change

To adapt to climate change and ensure food security a farmer engaged in crop production must:

1. Use varieties that can withstand adverse conditions caused by climate change. In parts of Malawi where prolonged rains are being experienced as a result of climate change, local maize varieties , which are long maturing and late maturing hybrid varieties such as Njovu are being planted instead of short maturing varieties.
2. Conserve and use genetic resources (such as local crop varieties) that are more resistant to pests and diseases;
3. Use mulch stubble and straw;
4. Use crop rotation;
5. Use low planting densities;
6. Avoid mono-cropping;
7. Change timing of farm operations; and
8. Adjust sowing dates to offset (avoid) moisture stress during warm periods.

Mitigation strategies in agriculture

Mitigation practices a farmer can undertake

To mitigate against climate change, farmers must:

1. Reduce tillage (or practice zero tillage) in crop fields;
2. Restore organic soils and degraded lands;
3. Enhance soil carbon absorption;
4. Enhance adsorption of carbon from the atmosphere - through afforestation and reforestation;
5. Improve grazing of livestock;
6. Improve efficiency in the food chains; such as through reduction of post-harvest losses.

Practices that reduce GHG emissions

To reduce volatilisation of soil carbon and reduce leaching and volatilisation of applied nutrients from crop fields, a farmer must:

1. Minimise soil disturbance by adopting Conservation Agriculture and practicing minimum or zero tillage;
2. Improve nutrient use efficiency by adopting precision farming by incorporating fertilizers and manure in the soil around the plants and improved timing of fertiliser and manure application;

To maintain organic soils in the farm, a crop farmer must reduce drainage of organic soils from the field by:

1. Avoiding deep ploughing (i.e. adopting CA practices);
2. Practicing row-cropping;
3. Growing tuber crops.

To reduce emissions of GHGs from intestines of livestock, a livestock farmer must:

1. Increase efficiency of the digestive processes in the animals;
2. Improve forage quality and quantity;
3. Plant fodder grasses or legumes with higher productivity and deep roots;
4. Reduce fuel load during vegetation management;
5. Improve pasture management (by adopting recommended stocking rates; practicing rotational grazing and enclosing of grassland from livestock grazing).

To reduce emissions of GHGs from forests farmers must:

1. Reduce deforestation and forest degradation (REDD);
2. Practice sustainable management of existing forests.

To reduce emissions of GHGs from fishponds the farmer must:

1. Increase input/output rations. Thus, increasing GHG efficiency rates.

Practices that avoid GHG emissions

To avoid GHG emissions per unit of food produced, the farmer must:

1. Use biofuels as energy sources for agricultural production and processing activities instead of fossil fuels. Use fire wood for cooking instead of charcoal; biodiesel instead of diesel in engines to operate machinery for example
2. Adopt greater use of wood products leading to displacement of CO_2 emissions;
3. Reduce post-harvest losses, through adoption of climate-smart technologies and practices recommended in this handbook;
4. Use improved storage and post-harvest handling practices.

Practices that remove emitted GHGs from the atmosphere

Emitted GHGs can be absorbed (sequestered) from the atmosphere through "sinks". A sink is any process, activity or mechanism, which removes GHGs from the atmosphere. Improved agricultural production practices that increase soil carbon create sinks that absorb emitted CO_2 since carbon is the precursor to soil organic matter.

To create carbon sinks through improved agronomic practices a farmer must:

1. Plant cover crops in the field (a CA practice);
2. Avoid use of bare fallows (a CA practice);
3. Incorporate crop residues to generate higher inputs of carbon residue, thus increasing soil carbon storage (a CA practice).

To create carbon sinks by adopting improved soil and water management practices, a farmer must:

1. Increase availability of water in the crop root zone, through construction of soil or stone bunds to increase biomass production by the crop;
2. Use drains or irrigation to enhance root as well as above ground biomass production, which in turn creates carbon, sinks when the biomass is incorporated into the soil.

To create carbon sinks by increasing carbon storage in trees a farmer must:

1. Combine crops with trees for food, timber and fodder (practice agroforestry);
2. Establish shelter belts and riparian zones/buffer strips with woody species (practice agroforestry);
3. Convert land from non-forest to forest land use (afforestation);
4. Carry out reforestation of degraded forests.

To create carbon sinks in aquaculture areas a fish farmer must:

1. Replant suitable aquatic plants in the aquaculture areas.

GLOSSARY

Adaptation: Responses by individuals, groups and governments to actual or expected changes in climatic conditions or their effects.

Adaptive capacity: The ability or potential of a system to respond successfully to climate variability and change, including adjustments in both behavior and in resources and technologies.

Adoption: A farmer has adopted a technology or practice when she or he has established it for long term use on a scale that produces significant or visible benefits.

Adverse effects of climate change: Changes in the non-living environment or in living things resulting from climate change which have significant negative effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.

Agroforestry: A practice of deliberately growing or retaining trees or shrubs within an agricultural or pastoral land-use system either under the same form of spatial arrangement or in temporal sequence. Agroforestry can also be defined more simply as any deliberate planting or use of a tree by a farmer.

Alley cropping: Cultivating crops between hedgerows of woody legumes that are pruned periodically to prevent shading the crop, and to improve soil fertility from prunings and also supply fodder and fuel-wood.

Biodiversity: Diversity of living things.

Climate: The situation of a climate system, including the statistical description, taking into account averages and variations in temperature, rainfall, wind and other relevant meteorological factors in a given period.

Climate change: A large-scale, long-term shift in global weather patterns or average temperatures.

Climate-Smart Agriculture: Agriculture that sustainably increases productivity and resilience (adaptation), reduces/removes greenhouse gases (GHGs) (mitigation) and enhances achievement of national food security.

Compost: Organic residues from plants and animals, sometimes mixed with soil, that are piled, moistened and allowed to decompose. Compost is used to improve soil fertility when incorporated into the soil.

Contour: Linking points in a field at the same altitude so that it forms a contour like.

Deciduous tree: A tree that losses (sheds) all leaves periodically (ie is not evergreen).

Dry spell: A period of dryness that has little or no effect on soil moisture or water levels. It is caused by deficiency of precipitation over a short period of time. Dry spells turn into droughts when they last 3 to 4 months.

Drought A reduction in moisture availability to levels that are significantly below the normal during the cropping season as a result of a prolonged deficiency of precipitation over an extended period of time usually over a season or more. Drought occurs in Malawi when rainfall is less than 75% of normal.

Erosion: The wearing away of the land surface by running water or wind.

Exotic: Introduced from outside; not indigenous.

Fallow crop: A food or tree crop that is planted or allowed to grow in a farmland during fallow period after the main crop is harvested, to help improve or recover soil fertility.

Fertilizer: Materials such as animal manure or inorganic chemicals that contain the nutrients necessary for healthy plant growth. When applied to the soil, they help improve soil fertility and crop yield.

Food security: Food security exists when all the people have physical and economic access to sufficient, safe and nutritious food, that meets their dietary needs and food preferences for an active and healthy life, at all times.

Fodder species: Fast growing, high yielding tree/shrub or grass, of high nutritional value, usually grown for cutting and carrying to feed livestock.

Green manure: Green leafy material applied to the soil to improve its fertility.

GLOSSARY

Irrigation: An artificial application of water to crops in order to overcome soil moisture deficit. This may be through utilisation of available surface water from rivers or may require development of water sources such as dams and boreholes.

Intercropping: Growing two or more crops in the same field at the same time in a mixture.

Leaching: Nutrients moving with water below and away from the rooting zone of the plants.

Mitigation measures: Actions taken to reduce and avoid GHG emissions and enhance sinks.

Mulch: Leaves, crop residues, grass, or other material left in the field to reduce evaporation and retain moisture within the soil.

Multipurpose tree: A woody perennial that is grown or used to provide more than one product or service.

Nitrogen fixing plant: A plant that has the ability to convert nitrogen in the air into a form that can be used by plants. This process is performed by another organism that lives within the roots of the plant. In leguminous plants the micro-organism is a bacterium.

Perennial plant: A plant that grows for more than one year, in contrast with an annual, which grows for only one year (or one season) before it dies.

Runoff: Rainfall or other water that does not infiltrate into the soil but flows across the surface.

Semi-arid: Climate with a substantial dry season and an average annual rainfall of 150 to 900 mm. In semi-arid areas, rainfall in some years is insufficient to maintain crop cultivation.

Shrub: A woody plant that branches at or near the base, with no defined trunk and is usually smaller than a tree.

Slope: The inclination or angle of the land surface, which can be measured as a per cent, ratio or in degrees or grades.

Soil fertility: The relative ability of a particular soil to support crop growth. It is a function of the physical, chemical and biological properties of the soil.

Soil and water conservation: Measures undertaken by farmers and other resource users to conserve soil and water resources for a specific purpose or range of uses.

Soil moisture: Water in the soil, a portion of which is available to plants.

Species: A classification level of organisms below genus. Individuals within a species can interbreed, but breeding between species does not normally occur or results in sterile offspring.

Sp., spp: Abbreviations for a single species (sp.) or for more than one species (spp.).

Tree: A woody plant with one main trunk and a fairly distinct and elevated canopy or head.

Volatilization: Changing of nutrients into the gas phase and being lost from the rooting zone or soil surface.

Weather: Weather describes environmental/atmospheric conditions prevailing outdoors in a given place at a given time. It is what happens from minute to minute. The weather can change a lot within a very short time. For example, it may rain for an hour and then become sunny and clear. Weather includes daily changes in precipitation, barometric pressure, temperature and wind conditions in a given location.

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