



Building Capacity for Resilient Food Security in Tanzania

Climate-Smart Agriculture

Resource Book for Trainers of Agricultural Extension Workers and Students



Cover Photo: *Farmers participating in the Building Capacity for Resilient Food Security project in Tanzania (credit: IITA)*

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CLIMATE-SMART AGRICULTURE:
RESOURCE BOOK FOR TRAINERS OF AGRICULTURAL
EXTENSION WORKERS AND STUDENTS





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Farmers participating in the Building Capacity for Resilient Food Security project in Tanzania (credit: IITA)

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ACRONYMS AND ABBREVIATIONS

| | |
|---------|--|
| ACRP | Agriculture Climate Resilience Plan |
| AEZ | Agroecological Zones |
| ASDS | Agricultural Sector Development Strategy |
| ASDP | Agricultural Sector Development Program |
| BCfRSFP | Building Capacity for Resilient Food Security Program |
| CA | Conservation Agriculture |
| CDC | Collapsible Drier Case |
| CRM | Crop Residue Management |
| CSA | Climate-Smart Agriculture |
| DAICO | District Agriculture, Irrigation, and Cooperative Officer |
| DD | Dietary Diversity |
| DQA | Data Quality Assessment |
| FFD | Farmer Field Days |
| GHG | Greenhouse Gases |
| GoT | Government of Tanzania |
| HDDS | Household Dietary Diversity Score |
| ICRAF | International Centre for Research in Agroforestry |
| ICT | Information and Communication Technology |
| IDDS | Individual Dietary Diversity Score |
| IDS | Dietary Diversity Scores |
| IEC | Information, Education, and Communication |
| IEDS | Institute for Environment, Climate, and Development Sustainability |
| IITA | International Institute of Tropical Agriculture |
| IP | Implementing Partners |
| ITCZ | Inter Tropical Convergence Zone |
| IR | Intermediate Result |

| | |
|--------|--|
| KATI | Kizimbani Agricultural Training Center |
| LGA | Local Government Authority |
| MATI | Ministry of Agriculture Training Institute |
| MANRLF | Ministry of Agriculture, Natural Resources, Livestock, and Fisheries |
| MEL | Monitoring, Evaluation, and Learning |
| MELP | Monitoring, Evaluation, and Learning Plan |
| MoA | Ministry of Agriculture |
| MLF | Ministry of Livestock and Fisheries |
| NADA | National Adaptation Programme of Action |
| NAP | National Agricultural Policy |
| NCCS | National Climate Change Strategy |
| NSGRP | National Strategy for Growth and Reduction of Poverty |
| ODC | Other Direct Costs |
| PITT | Performance Indicator Tracking Table |
| PORALG | President's Office of Regional Administration and Local Government |
| RF | Results Framework |
| SDG | Strategic Development Goals |
| SAGCOT | Southern Agricultural Growth Corridor of Tanzania |
| SSA | Sub-Saharan Africa |
| TARI | Tanzania Agricultural Research Institute |
| TMA | Tanzania Meteorological Agency |
| ToC | Theory of Change |
| UNFCCC | United Nations Framework Convention on Climate Change |
| URT | United Republic of Tanzania |
| USDA | United States Department of Agriculture |
| USAID | United States Agency for International Development |





A farmers field day in Zanzibar organized by the Building Capacity for Resilient Food Security project in Tanzania (credit: IITA)

INTRODUCTION

In the Tanzanian context, the adopted definition of CSA is “agriculture that sustainably increases productivity and income, increases the ability to adapt and build resilience to climate change, and enhances food and nutrition security while achieving mitigation co-benefits in line with national development priorities” (National Task Force Planning Workshop Report, 2016). CSA aims to achieve food security and broader development goals under a changing climate and increasing food availability using different practices and technologies.

The CSA practices and technologies on crop, livestock, and fisheries aims at addressing trade-offs and synergies between and among three pillars: productivity, adaptation, and mitigation. By addressing challenges in environmental, social, and economic dimensions across productive landscapes, CSA practices and technologies also embrace priorities of multiple countries and stakeholders in order to achieve more efficient, effective, and equitable food systems. The Building Capacity for Resilient Food Security Project in Tanzania is working in partnership with the government of the United Republic of Tanzania to “Strengthen knowledge and systems to target climate action ,” as part of Tanzania’s Agriculture Climate Resilience Plan. The International Institute of Tropical Agriculture (IITA), is one of the three implementing partners alongside the World Agroforestry Center (ICRAF), and the United Nations Food and Agriculture Organization (FAO). Under this project, IITA in understanding the importance of CSA in crops, livestock, and fisheries production, IITA identified and mapped practices and technologies according to the different agro-climatic zones of Tanzania. These practices and technologies may serve as tools for deciding options within which the three pillars of CSA can be achieved. It is in recognition of the importance of CSA in Tanzania that this resource book was developed to guide stakeholders in accelerating the uptake of CSA practices and technologies within the agricultural sector.

About this resource book

This resource book is primarily intended to enhance the skills and knowledge of agriculture extension graduates on CSA practices and their application across regions and production systems. This manual was developed in collaboration with the Ministry of Agriculture - Division of Training, linking new updated curriculum for NTA Levels 4, 5, and 6, and addressing existing gaps in the general agriculture curriculum used in agriculture and livestock training institutes in relation to CSA, gender, and nutrition. In accordance with the Ministry of Agriculture and IITA policies and procedures governing training courses, the specific purpose of the course is to enable training participants to acquire and/or enhance knowledge and professional competence related to CSA. This will help them to participate more actively in CSA in crops, livestock, and fisheries production practices and technologies across the various agro-climatic zones of Tanzania and enhance their related analytical and problem-solving capacities. This manual targets local government officials, their local partners, and agriculture trainees interested in



climate change and its effects on the agricultural sector.

Training objectives

Tanzania, in both the mainland and Zanzibar, is seriously taking steps in addressing climate change impacts on the country. This is embodied in the following strategic documents:

- Tanzania's National Climate Change Strategy (2012-2020);
- The Agriculture Climate Resilience Plan (2014-2019);
- National CSA Program (2015– 2025); and
- CSA Guideline.

By addressing challenges in environmental, social, and economic dimensions across productive landscapes, CSA practices and technologies also embrace priorities of multiple countries and stakeholders in order to achieve more efficient, effective, and equitable food systems. Thus, the CSA practices and technologies may serve as tools for deciding options within which the three pillars of CSA can be achieved.

As the government serves its people, local government officials, agriculture extension officers, and related stakeholders must be able to:

- Understand the concept of climate change;
- Know the impacts of climate change on agriculture and three impacts of agriculture on climate change;
- Explain potential climate change risks and vulnerabilities in agriculture, gender relations and nutrition, food security, and quality;
- Explain potential adaptation and mitigation actions to climate change;
- Explain nutrition sensitive CSA and its effects on food security;
- Describe gender inclusion and its impacts on CSA;
- Understand and use Agromet information for CSA planning (crop calendar);
- Understand policy issues around CSA at national, district, and ward levels; and
- Come up with other possible actions to strengthen and promote CSA at the district and ward levels.

Although this training was primarily organized to target the project district councils in Tanzania, it is also designed to cover all councils across the country, including the mainland and Zanzibar, employing the experiences learned from the other councils. The training should be delivered according to the training manual three to five days in each council or a combination of assembled councils in one training.

Goal

The principal objective of this course on CSA practices and technology practitioners in the Tanzanian context is to ensure that all agriculture-related graduates, agricultural extension officers, other council level officers and stakeholders are knowledgeable in CSA practices and know-how. This would enable them to apply these practices in different regions and production

systems and accelerate the uptake of CSA practices and technologies within the agricultural sector at local levels.

Specific objectives

- Create awareness and strengthen capacities of relevant local level government personnel to understand issues around climate change, its impact on food and nutrition security, and options for effective adaptation and mitigation.
- Equip the LGA's CSA practitioners with knowledge on CSA practices and technologies that factor in gender and nutrition issues to enable them to plan well and promote appropriate CSAs in their district's development activities.
- Strengthen extension officers' capacity to understand climate change, as well as its impact in agriculture, so that they can facilitate targeted group on appropriate measures for effective adaptation and mitigation of climate change in their respective agroecological zones.
- Create a forum in which extension officers can exchange views and experiences to create network building among councils, and later to farmers.
- Equip the LGA's CSA practitioners with knowledge on CSA practices and technologies that factor in gender and nutrition issues to enable them to plan well and promote appropriate CSAs in their district's development activities.

Methodology: An output-oriented participatory approach

The course will utilize a participatory output-oriented training approach, based on a three-way dialogue between the trainers, course participants, and the environment, which ensures internalization of the training issues.

It will involve a combination of training techniques such as lectures, role play, plenary, workshops, group and panel discussions, assignment, and case study analysis. Participants will also be provided with an opportunity to exchange experiences from their localities. Results and feedback will be presented at plenary sessions wherein facilitators/resource persons are present to ensure that full understanding has been achieved. In this regard, the facilitators/resource persons will provide supplementary comments and inputs where gaps in knowledge appear.

This three-way dialogue is designed to link key points from the facilitators/resource persons with the issues, tasks, and skills identified by participants. This will be followed by feedback and supplementary input by the facilitators/resource persons. This approach ensures that training is more effective than the conventional techniques. It has the additional benefit of enhancing consensus building and the development of group approach to problem solving. In addition, participants will also be provided with an opportunity to exchange ideas and experiences from their councils.

The training teams

The team should be composed of leading experts in their respective fields from different local institutions, universities, consultants, and Respective Ministries. They should conduct



training of various modules in accordance with the participatory and output-oriented training methodology.

The team should be composed of at least three specialists on the following fields:

- Agriculture (especially crop and livestock management, and agroforestry);
- Gender and nutrition; and
- Agro-meteorology and irrigation/water management.

Description of the modules

The CSA course for extension officers is organized into eight distinct but interrelated modules:

- Introduction to CSA;
- Crop and livestock management in CSA (small stock husbandry such as poultry and rabbit, fish farming, intercropping, ridges, and perennial crops' cashew nuts and avocado);
- Agroforestry and related systems in CSA;
- Mainstreaming agro-meteorology;
- Gender issues, equity and equality in CSA;
- Nutrition issues in CSA;
- Water management, irrigation and farm management; and
- Aflatoxin and CSA.

Lectures and panel discussions constitute the modules. The principal objective of each module is to articulate and expose participants to the basic tenets of climate change, its impacts on agriculture and mitigation strategies; and to ensure emerging issues concerning CSA are adequately covered.

The modules cover: (1) concept of climate change; (2) impacts of climate change on agriculture; (3) impacts of agriculture on climate change; (4) climate change risks and vulnerabilities in agriculture; (5) adaptation and mitigation of climate change; and mainstreaming Agromet, gender, and nutrition in CSA. The contents of each of the five modules are described in the attached training guide and training manual.

Target participants

The target participants (a maximum of 30 participants, with at least 10 coming from each Council) comprise of selected Ward Extension Officers, Natural Resource/environment Officers, Community Development Officers, Health Officers, Nutrition Officers, Planning Officers, and Agriculture advisors.

Training duration

The training is designed to run from three to five days (a total of about 24 to 40 hours, at 8 hours a day from 0800H-1700H, including tea and lunch breaks). The number of modules to be

covered, as well as the details of coverage and schedule of training should be informed by the results of a training needs assessment of the specific target group.

Training expectations

After each training, the participants are expected to:

- Share knowledge gained with other LGA officers;
- Use LGA meeting platforms to advocate CSA;
- Prepare farmer-level information for sharing;
- Use acquired knowledge to help the community;
- Strategize on promoting affordable CSA practices and technologies; and
- Prioritize CSA technologies and practices.



1 INTRODUCTION TO CLIMATE CHANGE AND CLIMATE-SMART AGRICULTURE

Introduction to climate change and CSA is the basic subject for the training. If participants have no background knowledge of climate change and CSA, including their principles and scope, then trainers should be prepared to ensure that relevant background is attained prior to delivery of the additional materials.

Training objectives

After completing this module, participants will be able to:

- Explain the difference between weather and climate;
- Distinguish between climate change and climate variability;
- Describe the greenhouse effect and global warming;
- List the main causes of climate change;
- Describe the likely effects of climate change;
- Explain the effect of climate change on agroecosystem (crops); and
- Describe how different agricultural practices contribute to greenhouse emissions.

Training thematic areas

- Introduction and definition of important terms in climate change;
- Causes of climate change;
- Relationship of agriculture and climate change; and
- Climate-smart agriculture.

Possible training sub-topics (dependent on specific training needs of the group)

- Soil fertility management practices and technologies;
- Rain water, irrigation, and flood management practices and technologies;
- Crops, trees, animals, fisheries, and fodder intercropping management practices; and/or
- Farm mechanization and on-farm transport management and technologies.

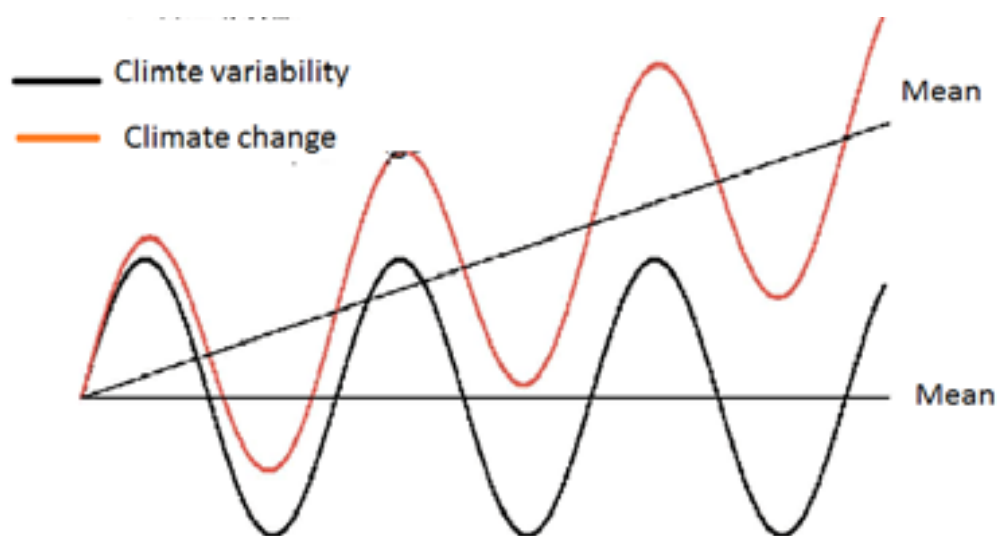
Emphasis should be given on linking them to climate change, better agriculture production, and their influence in gender relations, food security, and nutrition in light to changing agriculture practices.

1.1 What is climate change?

It is important to first establish the basic difference between weather and climate.

Weather: State of atmospheric conditions (i.e., rain, humidity, wind, sunshine, cloudiness and temperature, tornadoes, droughts, and tropical cyclones) at a particular place and time. Weather is dynamic and can change within a very short period of time, even within the same day.

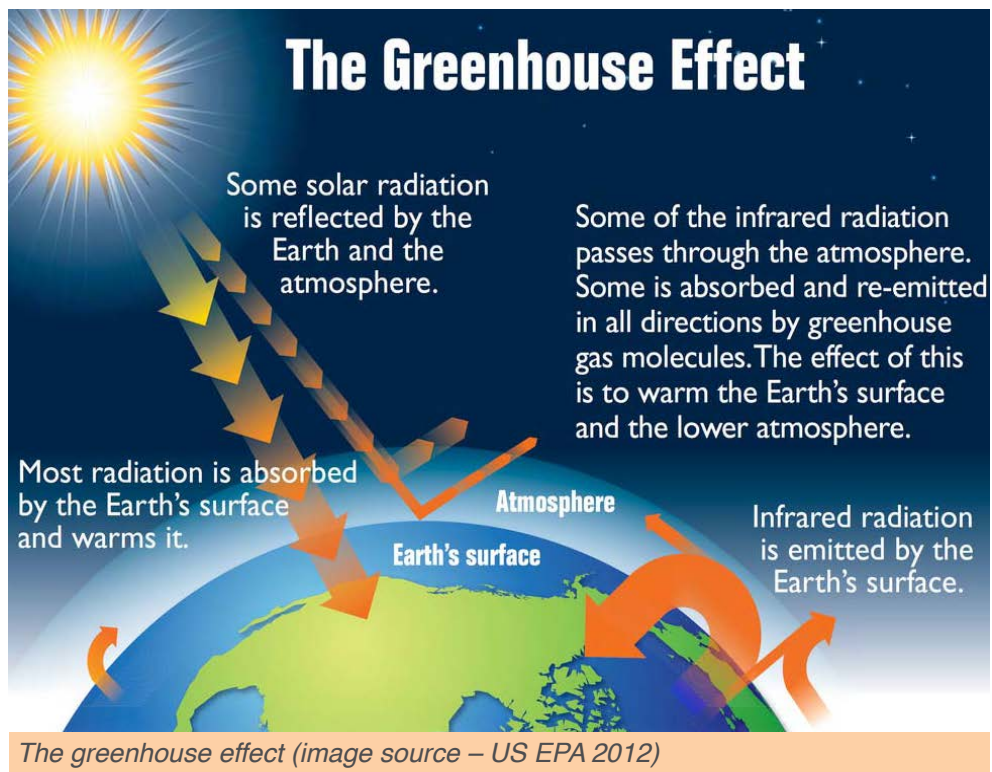
Climate: Set of weather conditions prevailing in an area over a long time, typically three consecutive decades (IPCC, 2007a). Several factors contribute to the definition of climate, including long- term averages of temperature and precipitation, frequency, duration, and intensity of weather events, such as heat waves, cold spells, storms, floods, and droughts.



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

Climate change is detected when the long-term pattern of climate variability and the mean exhibit significant measurable changes (e.g. on average, the climate gets warmer or cooler, or wetter or drier over decades).

1.2. Causes of climate change



Source: Climate-Smart Agriculture Presented by: Irina Papusoi Jimly Al Faraby, Seminar on Climate Change and Risk Management May 6, 2013

Climate change is a result of a variety of human activities that cause variations in concentration of GHGs, aerosols, land cover, and solar radiation. All these alter the energy balance of the Earth's climate and causes the following:

- Increased frequency of dry spells and drought;
- Changes in precipitations patterns;
- Increasing intensity of extreme weather events;
- Rising temperatures;
- Rising sea levels; and
- Temperature variability.

All these effects have negative impacts on the productivity of crops, livestock, fisheries, and forestry.

1.3. Impact of agriculture on climate change

- Industrial agriculture is a huge carbon-contributor. About 12% of total GHG emissions come from this sector, thus contributing significantly to global warming.
- Fertilizer and pesticide use, manufacturing, fuel and oil consumption in machinery and agricultural equipment, and production and use of electricity for utilities such as lighting and cooling significantly emit carbon dioxide, methane, nitrous oxide, and other GHGs.

- Land-use change (e.g. deforestation, soil erosion, and continuous cultivation) also contributes to GHG emissions.

1.4 Climate-Smart Agriculture

CSA is an integrated approach to managing landscapes—cropland, livestock, forests, and fisheries--that address the interlinked challenges of food security and climate change. It aims to simultaneously achieve three outcomes.

1. **Increased productivity:** Produce more food to improve food and nutrition security and boost the incomes of 75 percent of the world's poor who live in rural areas and mainly rely on agriculture for their livelihoods.
2. **Enhanced resilience:** Reduce vulnerability to drought, pests, diseases, and other shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns.
3. **Reduced emissions:** Pursue lower emissions for each calorie or kilo of food produced, avoid deforestation from agriculture, and identify ways to suck carbon out of the atmosphere.

While built on existing knowledge, technologies, and principles of sustainable agriculture, CSA is distinct in several ways. First, it has an explicit focus on addressing climate change. Second, CSA systematically considers the synergies and trade-offs that exist between productivity, adaptation, and mitigation. Finally, CSA aims to capture new funding opportunities to close the deficit in investment.

- Contrary to conventional agriculture, CSA addresses climate change-related risks.
- CSA systematically integrates climate change into planning and development of sustainable agricultural systems.

1.5 CSA policy considerations

The CSA concept reflects an ambition to further integrate agricultural development and climate responsiveness. It also aims to achieve food security and broader development goals under a changing climate and increasing food demand. CSA initiatives sustainably increase productivity, enhance resilience, and minimize GHG emissions. Better planning is vital in order to address trade-offs and synergies between the three pillars: productivity, adaptation, and mitigation. By addressing environmental, social, and economic challenges across production landscapes, CSA practices and technologies coordinate the priorities of multiple countries and stakeholders to achieve more efficient, effective, and equitable food systems.

In the Tanzanian context, CSA is agriculture that sustainably increases productivity and income, enhances the resilience and adaptive capacities of communities to climate change, and enhances food and nutrition security while achieving mitigation co-benefit in line with national economic development priorities. While the concept is new and still evolving, many CSA practices and technologies already exist worldwide and are currently used by farmers to cope with various climate change-related production risks. Mainstreaming CSA requires a critical mapping of successfully completed on-going practices and future institutional and financial enablers.



CSA needs to be mainstreamed into the core government policy, expenditure, and planning frameworks. To be effective, CSA policies must contribute to broader economic growth, poverty reduction, and sustainable development goals. They must also be integrated with disaster risk management strategies, actions, and social safety net programs.

A number of institutions are involved in promoting CSA in Tanzania. Most of their work is focused on improving productivity and enhancing adaptation and resilience of small-scale farmers, in a context where half of the population still suffers from poverty and one-third is undernourished. With the exception of the IEDS, who allocates approximately 35% of the budget to mitigation activities, most actors view mitigation as a co-benefit of adaptation interventions rather than a stand-alone objective of their work. The following graphic highlights key institutions whose mandated actions and investments promote — directly or indirectly — one, two or all CSA pillars (productivity, adaptation, and mitigation).

At the policy level, Tanzania adhere to several international and regional initiatives on climate change, including UNFCCC, Kyoto Protocol, CAADP, East Africa Community Food Programme of 2011, and the East African Community Climate Change Policy of 2009. In 2015, Tanzania submitted its Intended Nationally Determined Contributions (INDC) to the UNFCCC, specifically targeting “increasing yields through *inter alia* CSA”, as a key strategy for climate change adaptation. There were about 25 national documents that reference climate change adaptation and mitigation in Tanzania in 2015, including agriculture, forestry, and environmental policies.

The NAPA of 2007 was the first document to acknowledge climate change as an important threat to the economy, providing a first stimulus for sectoral intervention to address climate impacts. However, the implementation of NAPA was hampered by the lack of a clear funding strategy to finance the identified interventions. The roadmap for climate change action in the agricultural sector was consolidated in the NCCS of 2012 and the ACRP formulated in 2014, which mainly aimed at improving water use efficiency and promoting land, soil and water management, climate resilient crop varieties, and disaster risk management strategies, among others. Nevertheless, only 20% of the finances required to implement the plan have been coming from the government, challenging the financial sustainability of the interventions.

Complementary to these, the NAP from 2013 seeks to increase productivity and farmers’ adaptive capacity through reduced dependency on rainfall, increased private sector investment in agriculture, improvement of road infrastructure problems, and promotion of new energy sources (i.e., biofuel).

The more recent CSA Program and the CSA Guideline represent innovative policy mechanisms to advance CSA on the public agenda. It traces a variety of potential CSA technologies and practices applicable to various AEZs in the country, as a first step towards a more comprehensive, evidence-based analysis and prioritization of interventions. Below are other policy frameworks, programs, and strategies supportive of increased productivity and resilience in the agriculture sector.

1. ASDS (2001) - designed to increase farm incomes and reduce poverty through increased productivity. The major areas of intervention included institutional framework strengthening, increased private sector engagement, and streamlining of agricultural marketing to enhance commercialization.

2. ASDP I and II (2006 and 2015) - sought agricultural sector growth particularly through development of irrigation infrastructure, investments in research (science and technology), value addition, and mechanization.
3. Tanzania NSGRP I and II (2005/2006-2009/2010 and 2010/2011-2014/2015) - aimed at improving living standards, reducing poverty, increasing economic growth, and enhancing good governance.
4. Kilimo Kwanza (Agriculture First) of 2009 - an initiative to accelerate modernization and commercialization in the agricultural sector.
5. SAGCOT - initiated in 2010 to increase farmer incomes, reduce poverty, promote food security, and ensure environmental sustainability through agribusiness.
6. Livestock Sector Development Strategy of 2010 - contributed to the development of plans to settle pastoralists, the establishment of disease-free zones, and rehabilitation of livestock-holding grounds, among others.

At times, despite the robust policy framework, the lack of a clear development pathway for the agriculture sector has resulted in inconsistent growth. Furthermore, coordination of policies and interventions remain a challenge, often resulting in a fragmented and sector-specific policy development and implementation, as well as a project rather than a programmatic approach to enactment of interventions.

1.6 CSA practices and technologies

CSA Practices: these refer to management activities at the farmland landscape level (i.e., what activities are around a certain enterprise?)

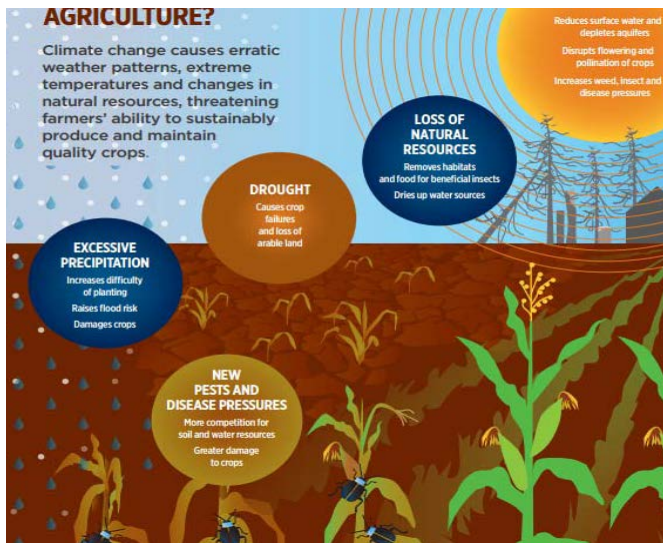
Technologies: these refer to techniques, expertise, skills, methods, and processes used for agricultural production



NOTE:

- *CSA maintains ecosystem services.*
- *CSA has multiple entry points at different levels.*
- *CSA is context-specific.*
- *CSA is gender sensitive.*
- *CSA involves multiple stakeholders.*

1.6.1 Climate change impacts on agriculture and food security



- Increased frequency of dry spells and droughts
- Changes in precipitations patterns
- Increasing intensity of extreme weather events
- Rising temperatures
- Rising sea levels
- Temperature variability

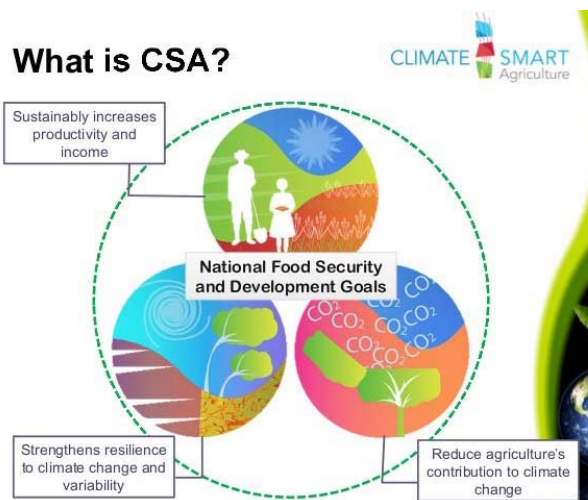
All these have negative impacts on the productivity of crops, livestock, fisheries, and forestry.

1.6.2 Defining CSA

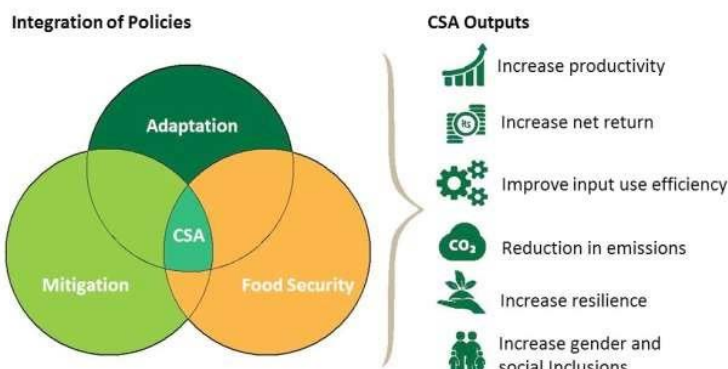
According to FAO, CSA “is agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces / removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals.”

However, the GoT defines CSA as “agriculture that sustainably increases productivity and income (profitability), increases the ability to adopt and build resilience to climate change, and enhances food and nutrition security while achieving mitigation co-benefits in line with national development priorities” (as defined at the National CSA Task Force planning workshop).

What is CSA?



1.6.3 Pillars of CSA



Source: Assessment of Climate-Smart Agriculture (CSA) Options in Nepal

1.7 Conservation Agriculture

Most agriculture systems are faced with the following challenges:

- i. Degradation of water resources
 - Increased water consumption vis-a-vis available 'blue water'
 - Decreasing groundwater tables
 - Intensified and prolonged droughts and flooding
 - Increased temperatures and more erratic rainfall patterns affecting rainfed agriculture
- ii. Degradation of land resources
 - Shrinking per capita availability of land
 - Reduced biodiversity resulting from biotechnology-developed high yielding varieties, monoculture, intensive use of agrochemicals, and tillage
 - Increased vulnerability of cropping systems
 - Reduced efficiency and profitability of farm inputs

1.7.1 Conservation Agriculture defined

CA is a combination of crop and land management practices that minimize the disruption of the soil structure, composition, and natural biodiversity. It has the potential of increasing crop yield. According to the FAO, CA strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. Furthermore, CA is based on enhancing natural biological processes above and below the ground.

1.7.2 The concept of zero tillage

Zero-tillage, or no-tillage, is a CSA practice in which seeds are deposited directly into untilled soil. It is also defined "as a system of planting (seeding) crops into untilled soil by opening a narrow slot trench or band only of sufficient width and depth to obtain proper seed coverage." Zero-tillage technology is generally used in large-scale agricultural crop cultivation systems because large machines are required for planting. For smaller-scale farms, no adequate machines are available for sowing, although farmers may do so by hand.

In zero-tillage, crops are planted with minimum disturbance to the soil by planting the seeds in an unploughed field with no other land preparation. Generally, zero-tillage encompasses four broad, intertwined management practices: (1) minimal soil disturbance (no ploughing and harrowing); (2) maintenance of a permanent vegetative soil cover; and (3) direct sowing and sound crop rotation.

Minimum tillage usually involves scratching or ripping along the row where the crop is to be planted and leaving the rest of the land untouched until weeding is required. For example, in Tanzania, farmers may simply dig holes or pits where the seed will be sown



(such as the Chololo pits in Dodoma and basins in Newala). Minimum tillage is one of the key CA practices that minimizes runoff and increases infiltration rates. The practice ensures that enough moisture is stored in the soil for plant growth.



Figure 1.1. *Zero-tillage practiced in a field.*

Exercise

Look at Figure 1.1 above and reflect on the following questions:

1. What crops can be grown using the practices shown in the picture?
2. What do you think could be the procedures to be followed in adapting this practice shown on the picture?
3. Which climatic condition is likely to support the practice shown on the picture?

The adoption of zero-tillage as a soil conservation practice is evidenced through the following features:

- a. Crop residues are distributed evenly and are left on the soil's surface;
- b. No implements are used to turn the soil, cultivate the crops or incorporate the crop residues into the soil;
- c. Weeds and cover crops are controlled by a pre-planting application of non-pollutant desiccant herbicides;
- d. A specialized planter is used to cut crop residues on the soil surface and insert the seeds and fertilizers into the soil with minimum disturbance. Generally, seed sowing is done when soil moisture content is adequate for seed germination but not so high that a large tractor or planter would compact the soil;
- e. Weed is controlled with pre- and post-emergence herbicides;
- f. Crop rotation is fundamental to zero-tillage because it helps minimize weed, insect, and disease populations when the same crop is grown year after year on the same ground; and

- g. Many experiments with zero-tillage have shown increased yields; however, in wetter areas, it took many years to see the crop yields stabilize or increase. On the other hand, in drier areas where moisture is the major limiting factor, the effects on yield were seen as early as the first year.

Zero-tillage, as a practice for conserving soil and water resources, is an important measure for adapting agricultural systems to climate change, particularly in vulnerable regions in SSA. Thus, no-tillage has great potential to help smallholder farming systems adapt to changing climatic conditions. The practice provides many benefits, including, but not limited to the following:

- The mulch layer minimizes evaporation for a certain period, and in regions of low rainfall, this can conserve water and increase the water-use efficiency of the cultivated crops. Furthermore, the change in infiltration and runoff rates can have major effects on the total water balance, which is important in sustainable production systems;
- The permanent soil cover and low disturbance resulting from no-tillage also increase soil organic matter and nutrients, at least within the top 10 cm of the soil;
- It improves soil aggregate stability where soil erosion control is seen as the clearest benefits of no-tillage;
- It retains crop residues since seeds are planted directly into the previous crop's residue and crop rotation;
- The practice also improves soil quality, structure, and biota, as well as reduces greenhouse gas emissions (nitrous oxides); and
- Generally, no-tillage saves on costs related to soil preparation because there is no need to plough or cultivate the soil before sowing. However, for the first few years, this technology requires extensive use of herbicides that may offset savings from preparing the soil.

Activity

Observe the ecological zone where your training institute is found and form a manageable group to prepare a demonstration plot using zero-tillage practice. Then, write a summary of the procedures and requirements that you will consider.

1.7.3 Crop residue management

CRM is another CSA practice whereby vegetative crop materials are left in the field/farms after the crops have been harvested, pruned or processed. The residues include sticks and stubble/stems, leaves, and seed pods. Crop residues can also be used as animal feed outside the crop field. CRM usually involves a reduction in the number of passes over the field with tillage implements and/or in the intensity of tillage operations, including the elimination of plowing (inversion of the surface layer of soil). This practice is designed to leave sufficient residues on the soil surface to reduce wind and/or water erosion.



Generally, the crop residues left on the surface shields the soil from rain and wind until emerging plants provide a protective canopy. Crop residue also improves soil tilth, adds organic matter to the soil, and may even leave some grain for wildlife. Less tillage reduces soil compaction and saves the farmer time and fuel cost (if a tractor is used). CRM involves baling and removing the straw, retaining the surface, mulching, and incorporating residues.

CRM is an ideal CA practice because the cover of leaves, stems, and stalks from the previous crop protects the soil surface from heat, wind, and rain. Also, it keeps the soil cool and reduces moisture losses by evaporation. In dry conditions, it reduces crop water requirements, makes better use of soil water, and facilitates deeper rooting of crops. Under extremely wet conditions, CRM facilitates rainwater infiltration, reducing soil erosion and the risk of downstream flooding. Sometimes, farmers leave the residues in the field or collect them for stall feeding, fuel, fences, and doormats. When left in the field, animals usually eat them, and the resulting animal manure serve as a source of soil organic matter.

Activity

Visit a nearby farm where CRM is practiced and note how it is done, what crops are involved, and what challenges farmers usually encounter. Then, upon your return to your training institute and with your colleagues, prepare a demonstration plot that employ CRM practices. Write a brief summary of the procedures and requirements that you will consider.

1.7.4 Crop rotation

Crop rotation is a CSA practice wherein a series of different crops are planted on the same piece of land in a repeating order over a given period (seasonal or annual). New crops planted during succeeding seasons will be from a different family. This rotation of crops allows soil nutrients to be cycled and replenished (as different crops have different nutrient requirements). Same goes for the pests that the crops attract – no one type of pest will be able to build a population in a single field because the crops that they specifically feed on are constantly altered.

Crop rotation is also effective in suppressing weeds because of regular changes in the root zone composition and patterns of nutrients absorption. Rotation and the inclusion of nitrogen-fixing crops such as legumes could contribute to optimum plant growth without increased greenhouse gas emissions usually associated with the use of chemical fertilizers. Crop rotation over several seasons also minimizes the outbreak of pests and diseases.

Effective as it may seem, crop rotation has not been formally adopted by many small-scale farmers mainly because of the shortage of land and the traditional practice that a farm can never be left to fallow for a season without planting maize, the staple food in many African countries. The only option is to intercrop maize with other crops to maximize the use of the field and yield more than one crop.

In adopting crop rotation as a CA practice, it is important that equal gender participation is taken into consideration in land tenure system wherein both male and female are involved

in selecting what crops should be rotated. Women should also be given access to land to practice crop rotation.

Additionally, crop rotation has many environmental benefits: (1) minimizes disease and insect incidences that rely on one plant host (Cropping sequence takes away the common host organism and causes a disruption in the annual life cycle of insects, diseases, and weeds); (2) results in better soil fertility; (3) enhances the soil's carbon storage capacity through longer crop cover period and help reduce greenhouse gas emissions; (4) for crops having either tap or fibrous roots, the diversity in the root structure enhances the chemical, physical, and biological structure of the soil; (5) enhances water infiltration and minimize surface runoff; and (6) facilitates better farm productivity by replacing fallow periods with growing different crops that replenish soil nutrients. However, crop rotation may result in less profitability because of the decrease in acreage of a highly valuable crop.

1.7.5 Other CA practices

Other types of CA practices include:

- Cover cropping
- Mulching
- Crop rotation
- Intercropping
- Minimum / Zero Tillage
- Crop residue management
- Contour farming
- Mulching/compositing
- Intercropping with leguminous cover crops
- Direct seeding

1.7.6 CA and soil health

- Soil carbon impacts production and other resources such as water and nutrients.
- Cultivation makes soils lose considerable amounts carbon.
- Soil organic matter (SOM) levels below 2% are common in CA.
- Effects are more pronounced in the tropics.
- Tillage is a major soil-degrading factor.

1.8 Liming acid soil

- Improves nutrient uptake
- Increases root growth
- Improves soil biology



- Application of Gypsum on saline soils?

Overall, increasing fertilizer-use efficiency reduces nutrient loss into the environment; hence, decreases pollution and emissions of GHG.

1.9 Optional Addition 1: Soil fertility management practices and technologies

An additional coverage can be done on soil and soil water management for CSA. If details are needed, a facilitator can expound a complete coverage of the topic as attached herein.

Modular focus:

At the end of this training session, the trainees will be able to describe soil management practices, which are relevant to addressing the impacts of CC. Specifically, they should be able to:

- Explain the meaning and importance of soil fertility management practices;
- Define the efficient use of fertilizers;
- Identify soil fertility management in line with CSA pillars; and
- Explain soil fertility in line with CSA pillars.

1.10 Soil and water conservation practices

- Ridging and tie-ridging
- Water retaining/harvesting pits (e.g. *Matengo* pits or *Ngoro*)
- Pit and trench farming (e.g. *Chololo* pit)
- Terraces and contour farming (*Fanya Juu*; *Fanya Chini*, Bench and Stone terraces)
- Crop residue management
- Mulching
- Rainwater harvesting
- Ripping and sub-soiling

THE PRINCIPAL OF WATER HARVESTING

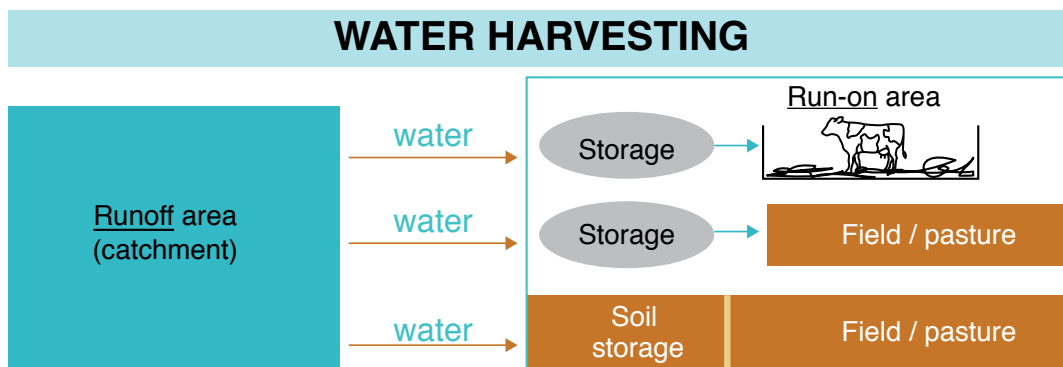
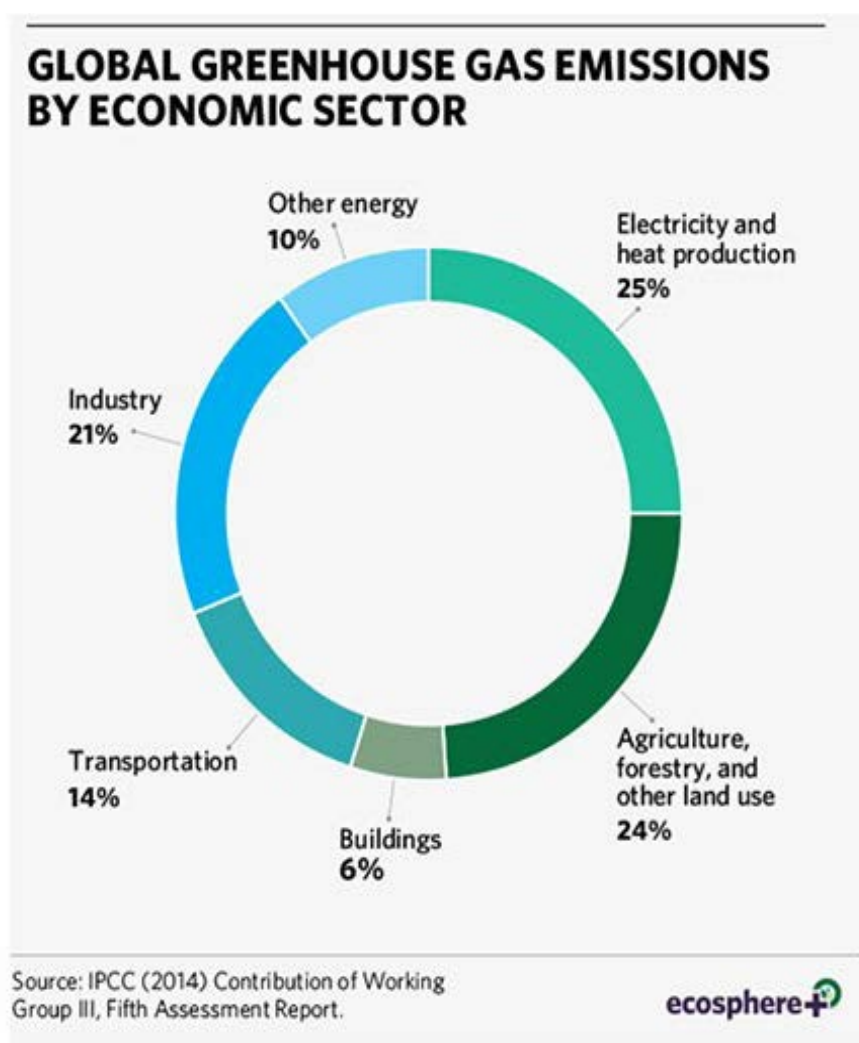


Table 1. CSA practices and techniques.

| Sub-category | CSA practice/technology |
|-----------------------------|--|
| Rainwater harvest | Rainwater harvesting and storage structures, Chololo pits. |
| Irrigation | Drip/trickle irrigation, system of rice intensification, Irrigational canal lining. |
| Soil and water conservation | Ridging, tie-riding, water retention/harvesting pits. |
| Terracing | <i>Fanya Juu Fanya Chini</i> terraces, bench terraces, stone terraces. |
| Conservation Agriculture | Cover cropping, mulching, minimum/ zero-tillage, crop rotation, intercropping, CRM. |
| Soil fertility management | Manuring (compost and Farm yard Manure FYM), efficient use of fertilizer (micro-dosing), ISFM. |
| Agroforestry | Trees in crop land, improve fallow, fodder banks, afforestation. |
| Crop management | Use of most adapted crops (drought-tolerant, flood-tolerant, disease-tolerant, IPM, etc.). |





Climate-Smart animal husbandry practices

a. Improved livestock breeds

Improved livestock breeds are obtained through crossbreeding of indigenous breeds with improved or exotic ones to combine the high yield and early maturity of the exotic breeds with the tolerance of indigenous breeds to local biotic and abiotic stresses. The aim of cross-breeding is to improve local breeds with regards to meat, milk, and egg production while reducing time to maturity. This way, livestock keepers benefit through increased incomes. With regards to CSA practice, the adoption of improved livestock breeds takes into consideration the adaptability of a certain livestock breed to a particular environment.

b. Adapted livestock

Different livestock types and breeds require specific environmental conditions. Climate determines the types of breed, quality of pasture, availability of water, and livestock pests, thereby also influencing overall livestock quality and productivity. Adapted livestock types and breeds often survive and do well under specific environmental conditions. Under a changing climate, care should be taken in deciding on livestock enterprise for any particular geographical location.

c. Improved feeding

Livestock production can be enhanced by adopting improved feeding strategies such as cut-and-carry, rotational grazing by paddocks, fodder crops, and grassland restoration and conservation. This also involves livestock keepers to manage paddocks and/or pastures for ensuring enough fodder for livestock. It can also involve cutting and carrying fodder for feeding livestock at home, especially under zero grazing.

d. Traditional *in-situ* fodder conservation system

Like farmers, livestock keepers (pastoralists) have a rich indigenous knowledge on natural resources management, and human and animal diseases relative to their environment. The communities control resource-use pattern and conservation using the traditional knowledge of the ecosystem and the biological diversity of the areas. Among such age-old livestock management systems are fodder conservation and grazing land management. Generally, the practice promotes soil conservation, restores land from degradation, regulates local climate of an area, and conserves biodiversity.

This method needs plenty of land to practice. *In-situ* fodder conservation system means that grasses, shrubs, and several species of trees, which can provide fodder for livestock, is strictly forbidden from being utilized through grazing unless the community elders deem that the situation is very alarming or that the rainfall season is approaching. Wherever this system is used, their livestock do not die from inadequate pasture during bad years.

- **Ngitili:** This is a traditional fodder conservation system that was developed by Sukuma of Shinyanga agro-pastoralists as a means of alleviating acute dry season fodder shortage. *Ngitili* involves retaining an area of standing hay until the rain season ends.
- **Olelii:** This is a traditional fodder conservation system developed by the Maasai pastoralists (Arusha) as means of conserving fodder for the dry season for the

calves, sick animals and/or milking heard. In this system, the vegetation is left to grow and regenerate during the wet season and livestock are allowed to graze during the dry season.

e. Alternative sources of water for livestock

In semi-arid areas, water content of forages is very low during the dry season. And due to high evaporation rates, water sources may contain high concentration of salt. To overcome this problem, succulent plants can offer an alternative source of water, as well as feed to grazing animals. Some of these plants are sufficiently palatable, even when drinking water is available. Examples include the juicy herb wondering dew (*Commelina benghalensis* and *Commelina africana*) and the swollen stems of *Pyrennecantha malvifolia*. Water melons (*Citrullus vulgaris*) are available in appreciable quantities in some villages of semi-arid Central Tanzania and are also used by livestock as a source of water during dry season.

f. Zero-grazing

Zero-grazing is a system of pasture utilization wherein grass is mechanically mown and brought to cattle. Zero-grazing allows cattle to consume fresh grass from fields that are too far away or are separated by busy road, thereby allowing its inclusion in the cattle's grazing rotation. Zero-grazing can also play a vital role when utilizing fields too wet for grazing, provided the machines employed have sufficiently wide wheels to safely distribute their load. This system is mainly practiced in pre-urban areas where land is scarce.

g. Animal feed production and storage technologies

Crops, preferably cereals (*Poaceae* family) like maize and sorghum, are planted normally at closer spacing while managed by weeding and fertilizer application. The crop is harvested by cutting at the boom stage of development (milk stage) aimed at livestock feed. This is done to ensure that the livestock keepers have enough feeds throughout the year.

Conclusion

The effects of climate change can be felt daily, especially by farmers, but very few solutions have been discussed to address this catastrophic threat (Acciona, 2029)¹. However, there is one widely unknown solution to reducing the amount of GHGs trapped in the atmosphere: CAS, which focuses on adaptation, mitigation, and improving food security. Reducing tillage, agroforestry, proper utilization of water resources, recycling of farm wastes, expanding crop rotations, planting cover crops and reintegrating livestock into crop production systems, and employment of proven technologies in harvesting, postharvest management, processing and use of farm products have been proven to reduce agriculture's own footprint, as well as capture the excess carbon generated by other industries. This captured carbon is then converted into plant material and/or soil organic matter, improving soil health and increasing the ability to produce food on the land in the future. CSA practices have been proven to reduce input costs as well. Adopting these practices seems like the obvious choice; however, a majority of farmers globally have continued using traditional agriculture practices.

¹<https://www.acciona.com/climate-change/>



2 AGROMETEOROLOGICAL SERVICES AND ADVISORIES IN CSA

Introduction

Climate and weather both play important roles and has profound influence on agricultural production. The TMA play a central role in providing weather, climate services, and warnings for the safety of life and property to the general public and to various users, including agriculture to ensure food security, water resources, disaster management, and health. This topic will discuss the definition of agrometeorological terms, role of agrometeorological information in the agricultural production, application of weather and climate information in agriculture, use of agrometeorological information, and advisories for improved decision, communicating weather information to stakeholders and selection of CSA practices or technologies based on agrometeorological advisories provided by TMA.

2.1 Definition of agrometeorological terms

In this section the following terms will be defined:

- **Above normal rainfall:** This refers to rainfall performance above 125% of the long-term average rainfall in a given area.
- **Agro-meteorological information:** This refers to weather and climate information tailored for application in agriculture.
- **Agro-meteorological products:** This refers to weather and climate products that contain agro-meteorological information (e.g. information of the onset of the season, expected rainfall performance, and agro-meteorological advisories).
- **Below normal rainfall:** This refers to the rainfall performance less than 75% of the long-term average rainfall in a given area.
- **Bimodal areas:** This is a term used to describe areas in Tanzania, which receives two rainfall seasons: Masika (March and May) season and Vuli (October and December) or short rain season.
- **Climate:** Climate is an average weather condition of a place recorded for a long period of time, normally 30 years and above.
- **Climate Services:** The provision of one or more climate products or advice in such a way as to assist decision-making by individuals or organizations.
- **Dekadal:** This is a term used to describe ten days interval in meteorology.
- **ITCZ:** Also called equatorial convergence zone, is a belt of converging trade winds and rising air that encircles the Earth near the Equator. The rising air produces high cloudiness, frequent thunderstorms, and rainfall. The area covered by the ITCZ is the doldrums, which is characterized by warm air. The ITCZ shifts north and south seasonally with the sun.
- **Normal rainfall:** This refers to rainfall performance between 75% and 125% of the long-term average rainfall in a given area.

- **Synoptics:** This is a term used in climatology to describe the science of describing an entire weather situation at a specific location.
- **Unimodal areas:** This is a term used to describe areas in Tanzania, which have only one rainfall season (between October to May).
- **Weather:** Is the state of atmospheric condition recorded for a short period of time (e.g. hour, day, month etc.). Weather parameters include rainfall, cloud cover, temperature, humidity, and wind.
- **Weather forecast:** Is a term used to describe application of science and technology to predict the conditions of the atmosphere for a given location and time. Weather forecasts are essentially short-term, as the reliability of forecasts falls off rapidly after five days.

2.2 The role of agrometeorology information in agriculture production

Agrometeorology describes the behavior of the weather elements that have direct relevance to agriculture and their effects on production and productivity. Basically, agrometeorology involves weather and climate and these have direct impacts, both positive and negative, on agriculture. Therefore, timely availability of agrometeorology information before, during, and after rain seasons is of paramount importance in improving decision-making in agriculture.

2.3 Agrometeorological advisories in agricultural production calendar

Agrometeorological advisories are given to farmers based on local area climatic conditions or weather forecasts before, during, and after the rainy season. These are important to assist farmers in making informed decisions on the selection of appropriate crop varieties and animal breeds, CSA practices and technologies, and management of dry spell periods in agricultural production for improved productivity. Advisory services need to be accurate and provided in a timely manner for integration in agricultural production calendar.

An agricultural production calendar is a planning tool that provides information on the life history of agricultural production¹ and appropriate agronomic practices in crop farming, livestock keeping, and fisheries. In crop farming, the agricultural calendar contains information on windows for land preparation, sowing, weeding, fertilizer application, bird scaring, harvesting, drying, rain water harvesting, and threshing times, among others. Each stage of the calendar is influenced by weather conditions. Hence, farmers need to know how to integrate agrometeorological information and advisories in the production calendar in relation to agroecological dimensions of an area. Agrometeorological information and advisories provide a solid base on making plans on reducing weather related risks.

Plan to ensure availability of appropriate agricultural inputs, including fertilizer, seed varieties, other planting materials, and preparation of charcoal dams, can be done more effectively and ahead of time if agrometeorological information is available and accessible to farmers and extension officers in time. Agro-dealers and other relevant stakeholders can make the necessary arrangements to allow farmers to be able to make land preparation, planting, and control of pests and diseases at the right moments.



2.4 Understanding rainfall regimes in Tanzania

Tanzania has two rainfall regimes known as **unimodal** and **bimodal**. The unimodal regime includes all areas within the country that receives only one rainfall season commonly known as *Msimu*. Regions falling under unimodal rainfall regime in the country includes Kigoma, Katavi, and Tabora regions in the west; Rukwa, Iringa, Songwe, and Mbeya regions in south-western highlands; Dodoma and Singida regions in central; Lindi and Mtwara regions in the southern coast; and Morogoro south, Ruvuma and Njombe regions in the southern part of the country.

Bimodal rainfall regime, on the other hand, includes areas, which receive two rainfall seasons per year known as *Masika* for the rains starting from March to May and *Vuli* for the rains from October to December in the same year. The seasons are more prominent in Kagera, Geita, northern Kigoma, Mwanza, Mara, Simiyu and Shinyanga regions in Lake Victoria Basin(s); Kilimanjaro, Arusha, and Manyara regions in northeastern highlands; Dar es Salaam, Morogoro north, Pwani, Tanga regions, and the Island of Unguja and Pemba in the northern coast.

2.5 Preparation of agricultural production calendar

Agricultural production calendar usually starts with the beginning of the agricultural season. To most people and in many places, the start of the season is marked by the onset of the rains. Scientifically the start of the season is confirmed if an area received rains for at least 20mm in four consecutive days with at least two days wet and not followed by dry spell of more than ten days in the next 21 days. Key features of the production calendar include identification of times for land preparation, selection of crop or seeds for planting, sowing, vegetative plant growth phase, weeding, fertilizing, flowering period, maturity, and harvesting.

2.6 Application of weather and climate information in agriculture

Appropriate understanding and utilization of the agrometeorology information should help farmers in making informed decision during the planning of agricultural activities. This will help them to improve quantity and quality of agricultural produce, as well as minimize production risks associated with weather and climate challenges².

2.6.1 Weather and climate information provided by TMA

Services provided by TMA, which relates to agriculture, include seasonal weather outlook, a dekadal weather bulletin, daily weather forecast, short-term weather forecast, and warnings.

2.6.2 Daily weather forecasts

The daily weather forecast is a 24-hour forecast that contains detailed information on expected weather conditions for the next 24 hours or less. The forecast usually includes information related to rainfall or precipitation, maximum and minimum temperature, wind

speed and direction of major water bodies, thunderstorms, sunrise and sunset hours and advice on precautionary measures. At the moment, the forecast is provided daily through TV, radio, magazine, TMA website, and social media.

2.6.3 Severe weather warnings and advisories

TMA provides severe weather warning alert once they monitor signs of severe weather condition at a given locality and warn the public to take necessary precautions to avoid or minimize associated risks. The warnings are usually communicated using all possible channels including TV, radio, social media and farm SMS.

2.6.4 Agrometeorological bulletins

These bulletins provide long-term (monthly, seasonal) and medium-term (ten days/ dekadal) agrometeorological products released at the beginning of the month, season, and after every 10 days. Seasonal agrometeorological bulletins are provided for *Masika* and *Vuli* seasons in bimodal areas and *Msimu* season for unimodal areas. The seasonal bulletin is complimented by the monthly and dekadal agrometeorological bulletins.

2.7 The use of Agromet information and advisories in CSA

The three key areas of the agricultural production phases where agrometeorological information and advisories are required are: (1) before rainfall onset; (2) during the rains; and (3) after the rains.

a. Before the rain season

Farmers make decisions and preparations for the upcoming agricultural season before the start of the season. Forecasted rains are classified as normal, below normal or above normal. Advisory provided in most cases relate to forecasting with the highest probability. However, this does not mean that those with lower probability are not likely to happen.

b. During the rainy season

Within the season, dekadal and monthly bulletins are produced to inform operational decisions like time for weeding, applying fertilizer, mulching, rainwater harvesting, and drip irrigation, as well as to determine when to trigger disaster and risk reduction actions.

c. After rain season

At the end of the rainy seasons, crops and pasture are usually mature and ready for harvesting, storage, and transportation to the markets. At this stage, agricultural products no longer face challenges associated with nutrient deficiency. However, there might be challenges with postharvest handling and management that may affect food safety and quality.



2.8 Communicating weather information to stakeholders

The diversity of audience gives rise to differences in the information required, communication channels (including appropriateness, timeliness, access, and credibility), and language used to ensure equal access and operationalization by all users. Channels for communicating climate and weather information include:

- Face-to-face communication;
- Traditional communication;
- Platforms/sectorial events and structures;
- Meetings; and
- ICT.

2.9 Agromet-induced selection of CSA

Some of CSA practices and technologies, which can be considered before, during, and after the rain season, include crop variety selection, harvesting of rainwater, and control of soil erosion (Table 4).

Table 2. CSA practices and technology options for different agricultural phases

| S/N | Agricultural Phase | Activities |
|-----|----------------------------|---|
| 1. | Before the onset of rains | Selection of appropriate crop variety, identify sowing dates with minimal risk of wilt, decide on appropriate agricultural practices and control of soil erosion; de-stocking, vaccination, shifting of livestock from vulnerable areas; and strengthen fish pond and irrigation infrastructures. |
| 2. | During rains | Control of soil erosion, harvesting of rainwater, planting/transplanting, conserve soil moisture, control of pest and diseases, apply fertilizer/manure, irrigate, storage of animal feeds, pasture management and weeding. |
| 3. | After rain /rain cessation | Bird scaring, harvesting, drying, storage, transportation, value addition, and marketing and fish harvesting. |

Conclusion

Meeting the needs for agrometeorological services, including agroclimatological services, in the livelihood of farmers is the focus of this topic. This ideally leads to agrometeorological services for response, CSA, farming with irrigation scheduling, early warnings, microclimate manipulation, and application of weather and climate forecasts in a changing and increasingly variable climate.

3 AGROFORESTRY TECHNOLOGIES AND PRACTICES IN CSA

Introduction

Demand for agricultural land and forest products is increasing in most developing countries such as Tanzania. This leads to shortage of arable land and accelerated land degradation and, consequently, decreased agricultural productivity. In the tropics, agroforestry technologies have been proposed as solution to climate change and land shortage and productivity as they imbue resilience, adaptation, and high productivity to even small areas for forestry or agriculture. Despite the fact that agroforestry interventions have been in Tanzania for many years, the pace at which agroforestry technologies are adopted by rural people is not yet encouraging. Less adoption of agroforestry technologies may be attributed to inadequate knowledge and information on its importance to poverty reduction and socio-economic services.

3.1 Goal

To explain the concept of agroforestry in relation to CSA and describe the role of CSA practices/ agroforestry practices/technologies (trees/shrubs) in mitigation and adaptation of climate change effects on agriculture/livestock

3.1.1 Specific objectives

Learning outcomes of this training:

- Distinguish agroforestry from agriculture and forest disciplines based on its components and attributes;
- Classify and describe the structure and functions of major CSA/agroforestry practices/technologies in temperate and tropical region; and
- Clarify the roles/benefits of CSA/agroforestry practices on climate change mitigation and adaptation.

3.1.2 Training outlines

- Introduction: Concept of agroforestry vs CSA.
- Agroforestry/CSA practices/technologies.
- The role of trees/shrubs in relation to CSA.

3.1.3 Learning outcome of this training

- Distinguish agroforestry from agriculture and forest disciplines based on its components and attributes;
- Classify and describe the structure and functions of major CSA/agroforestry practices/technologies in temperate and tropical region; and
- Clarify the roles/benefits of CSA/agroforestry practices on climate change mitigation and adaptation.



3.2 Agroforestry versus CSA

Agroforestry is composed of three actors: forestry, agriculture, and/or animals that interact (negatively or positively) within the same area or unit of land. Trees/shrubs are the main components of an agroforestry system.

Generally, agroforestry is defined as “a dynamic, ecologically based natural resource management system that, through the integration of trees on farms and in agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels” (WAC, www.icraf.cgiar.org).

CSA refers to land management practices that increase food security, resilience/adaptive capacity of farmer households to climate variability and mitigate climate change by sequestering carbon in biomass and soils and/or reducing emissions when possible (FAO, 2013).

3.2.1 Three main features of agroforestry and CSA

- Increases productivity and income;
- Makes farms more resilient to the effects of climate change; and
- Environment friendly.

3.2.2 CSA/Agroforestry practices/technologies

- **Fodder ban:** Growing of high-quality, fast-growing, and high-yielding trees, shrubs, grass, and herbaceous legumes in small homestead.
- **Rotational woodlot:** Agroforestry practice that involves alternating arable crops with improved tree fallow on the same piece of land over time (e.g. *Leucaena spp*, *Acacia polyacantha*, *Gliricidia sepium*, and *Albizia lebbeck*).
- **Alley cropping:** Planting of rows of trees and/or shrubs to create alleys wherein agricultural or horticultural crops are produced.
- **Home gardens:** Intimate multi-storey combinations of large number of various trees, crops and/or animals around homesteads.
- **Contour farming with trees/ shrubs, (Fanya Juu/Fanya Chini)**
- **Shelterbelts:** Use of trees/shrubs to protect the fields from the wind, sea (salt water) encroachment, and floods.
- **Improved fallow:** Fast growing, preferably leguminous, woody tree species planted and left to grow during the fallow phases between cropping years for site improvement.

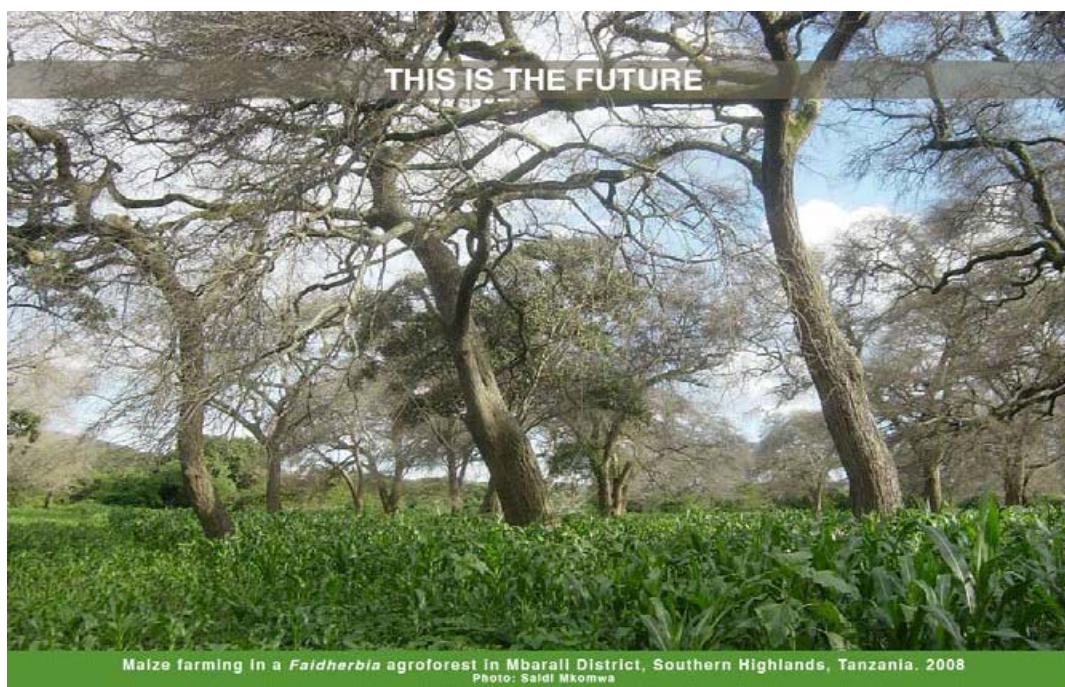
Group assignment: Question for Group discussion and presentation

1. **Mention and describe the roles agroforestry/csa practices/ technologies in mitigate and adaptation to climate change effect on agriculture / livestock**
 - ✓ 15 minutes for group discussion
 - ✓ 20 minutes for group presentation (1 and 2)
 - ✓ 15 overall discussion and posing them to the next slides of the CSA/ Agroforestry practices benefits related to assignment given and their presentation

- **Intercropping:** Trees/shrubs planted in rows at specified spacing and alternate with crops.
- **Taunya:** Growing herbaceous crops at early stage of timber tree establishment.
- **Improved cooking stoves:** Mature energy technology for the efficient conversion of energy from biomass to heat.

Resilience effect :Maize grain yield (kg ha⁻¹) in a maize-*Gliricidia* intercropping system during ten consecutive cropping seasons (1992/93 to 2000/01)

| | | N fertilizer | | | | | | | | | |
|---------------------------|----------|--------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Production system | rate (%) | 1992/93 | 1993/94 | 1994/95 | 1995/96 | 1996/97 | 1997/98 | 1998/99 | 1999/00 | 2000/01 | 2001/02 |
| Sole maize (no trees) | 0 | 1994 | 1501 | 1490 | 1200 | 529 | 1073 | 1015 | 804 | 857 | 1000 |
| <i>Gliricidia</i> + maize | 0 | 1657 | 3922 | 2984 | 5302 | 3356 | 4322 | 4487 | 2309 | 5059 | 4150 |
| | Mean | 1825 | 2712 | 2237 | 3251 | 1943 | 2698 | 2751 | 1557 | 2958 | 2575 |
| Sole maize (no trees) | 25 | 3418 | 2111 | 3108 | 3917 | 1987 | 2953 | 2646 | 1708 | 2640 | 2890 |
| <i>Gliricidia</i> + maize | 25 | 2982 | 4446 | 4092 | 7117 | 4160 | 5997 | 5926 | 2947 | 5830 | 5290 |
| | Mean | 3200 | 3279 | 3600 | 5517 | 3074 | 4475 | 4286 | 2328 | 4235 | 4090 |
| Sole maize (no trees) | 50 | 4147 | 3155 | 3320 | 4750 | 1931 | 4000 | 3844 | 2076 | 3018 | 3620 |
| <i>Gliricidia</i> + maize | 50 | 4013 | 4545 | 3730 | 7523 | 4469 | 5815 | 6455 | 3519 | 6344 | 5120 |
| | Mean | 4080 | 3850 | 3525 | 6137 | 3200 | 4908 | 5150 | 2798 | 4681 | 4370 |
| LSD(0.05): | | | | | | | | | | | |
| Prod. syst. | | 198 | 169 | 132 | 172 | 232 | 123 | 212 | 166 | 321 | 530 |
| N fert. rate | | 242 | 207 | 161 | 211 | 285 | 151 | 248 | 204 | 393 | 649 |
| Prod. syst. × N | | ns | 293 | 228 | 232 | ns | 214 | 350 | ns | ns | ns |
| fert. rate C.V. (%) | | 11.7 | 11.8 | 11.9 | 5.98 | 15.3 | 12.5 | 6.58 | 15.8 | 18.9 | 13.7 |





Shelterbelts in Dodoma, Tanzania



Tropical Homegardens

Chagga home gardens in Northern Tanzania



3 – 4 strata (layers)

15

Alley cropping in Temperate Regions

Definition: Planting single or multiple rows of trees at a wide spacing, creating alleys in which herbaceous (agricultural or horticultural) crops are produced (Garret, 2009)



Alley cropping (temperate), Guelph Ontario

Inter-row spacing can be selected to accommodate mechanization

16

Integrated farming practice: chololo pits and Gliricidia tree in Dodoma

Maize_Chololo pit_gliricidia Maize_gliricidia



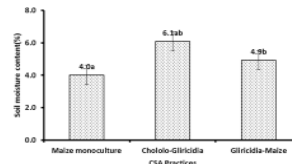
Agroforestry bring Resilience of soil moisture and soil fertility through mulching

- Pruning (*G. Sepium*) first 2.3 and second 5.3t/ha
- Weeding

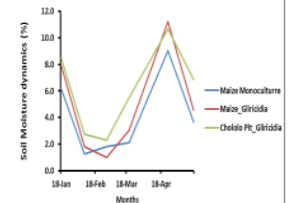


Agroforestry bring Resilience of soil moisture and soil fertility

Moisture changes



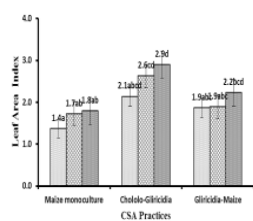
Moisture changes



Agroforestry bring Resilience on maize plant health and growth

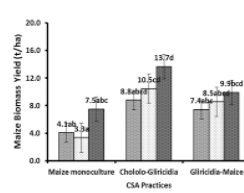
plant growth (LAI)

- Leaf area index was significantly ($p > 0.05$) highest (2.9) for late maize planted in *G. sepium* -Chololo pits treatments than early and TMA planting maize alone treatments.

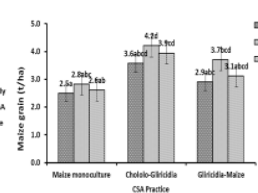


Agroforestry bring Resilience on maize production in Dodoma

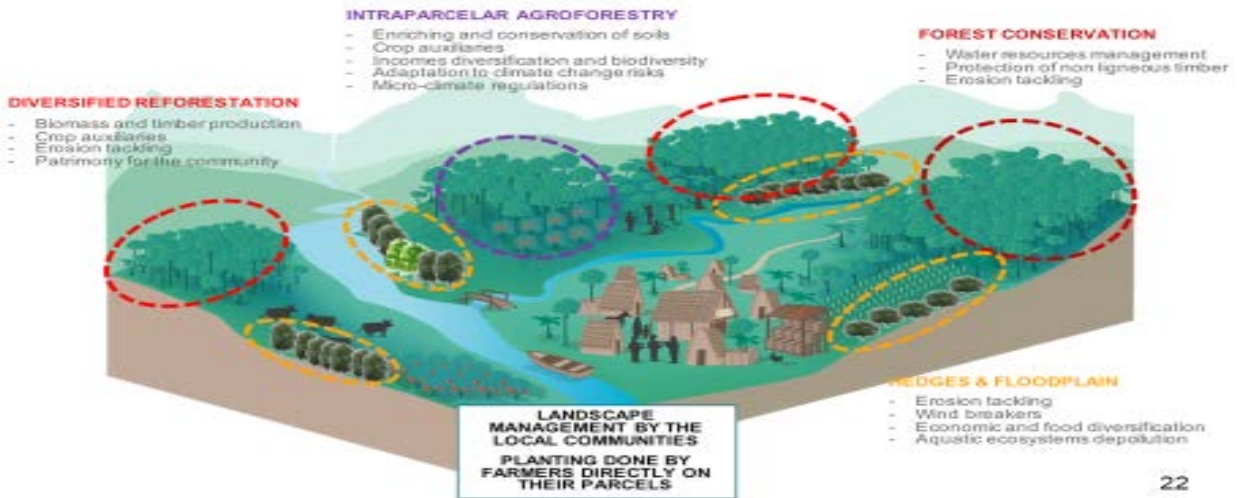
Maize Biomass Yield



Maize Grain Yield



Benefits of CSA /Agroforestry Practices



Conclusion

The integration of agroforestry in farming operations helps build resilience and sustain crop production. Based on available evidence, agroforestry has the potential capacity to contribute to climate change mitigation and adaptation by: (1) reducing threats and enhancing agricultural landscape resiliency; (2) facilitating species movement to more favorable conditions; (3) sequestering carbon; and (4) reducing GHG emissions.



4 POSTHARVEST MANAGEMENT AND AFLATOXINS

4A: POSTHARVEST MANAGEMENT

INTRODUCTION

In agriculture, postharvest handling is the stage of crop production immediately following harvest. It involves cooling, cleaning, sorting, and packing. The instant a crop is removed from the ground or separated from its parent plant, it begins to deteriorate. The postharvest system ensures the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency, and maximum return for all involved.

The term “system” denotes a dynamic, complex aggregate of logically interconnected functions or operations within a particular sphere of activity. The term “chain” or “pipeline” highlights the functional succession of various operations but tends to ignore their complex interaction.

In considering the system or the agro-food chain as a whole, harvesting can be seen as the hinge or as a ridge between the pre-harvest slope, corresponding to production activity and the postharvest slope, extending from harvesting to consumption.

4.1 Goal and objectives

Goal

This topic is geared towards helping the trainees realize the roles of postharvest management and its importance to food security and sufficiency, especially within the context of climate change.

Specific objectives:

- i. For participants to understand the role, importance, and magnitude of the challenges of postharvest management of food crops in food sufficiency and security.
- ii. To understand available technologies and practices in improving food security, nutrition. and sufficiency in the face of climate change.

4.2 Important components of a postharvest system

The postharvest system involves a sequence of activities and operations that is divided into two groups:

1. Technical activities: harvesting, field drying, threshing, cleaning, additional drying, storage, and processing; and
2. Economic activities: transporting, marketing, quality control, nutrition, extension, information and communication, and administration and management.

Main elements of the postharvest system:

- i. **Harvesting.** The time of harvesting is determined by the degree of maturity. With cereals and pulses, a distinction should be made between maturity of stalks (straw), ears or seedpods and seeds, for all that affects successive operations, particularly storage and preservation.
- ii. **Pre-harvest drying.** This is mainly for cereals and pulses. Extended pre-harvest field drying ensures good preservation but also heightens the risk of loss due to pest attacks (birds, rodents, and insects), molds encouraged by weather conditions, as well as theft. On the other hand, harvesting before maturity entails the risk of loss through molds and decay of some of the seeds.
- iii. **Transport.** Much care is needed in transporting a really mature harvest to prevent detached grain from falling on the road before reaching the storage or threshing place. Collection and initial transport of the harvest depends on the place and conditions where it is to be stored, especially with regards to threshing.
- iv. **Postharvest drying.** The length of time needed for the full drying of ears and grains depends considerably on weather and atmospheric conditions. In structures for lengthy drying such as cribs or even unroofed threshing floors or terraces, the harvest is exposed to wandering livestock and attacks of birds, rodents or small ruminants. Apart from actual wastage, the droppings they left often result in higher losses than what they actually eat. Also, if the grain is not dry enough, it is vulnerable to mold and can rot during storage.

Moreover, if grain is too dry, it becomes brittle and can crack after threshing, during hulling or milling. This applies specially to rice if milling takes place a long time (two to three months) after the grain has matured, when it can cause heavy losses. During winnowing, broken grain can be removed with the husks and is also more susceptible to certain insects (e.g. flour beetles and weevils). Also, grain that is too dry is also lighter and thereby sells for less.

- v. **Threshing.** If a harvest is threshed before it is fully dried, this operation will most probably be incomplete. Furthermore, if grain is threshed when it is still damp and then immediately heaped up or stored (in a granary or bags), it will be more susceptible to attack by microorganisms; thus, limiting its preservation.
- vi. **Storage.** Facilities, hygiene, and monitoring must all be adequate for effective, long-term storage. Control of cleanliness, temperature, and humidity is particularly important in closed structures (i.e., granaries, warehouses, hermetic bins). Damage caused by pests (i.e., insects and rodents) and molds can lead to deterioration of facilities (e.g. mites in wooden posts) and result in losses in quality and food value, as well as quantity.
- vii. **Processing.** Excessive hulling or threshing can also result in grain losses, particularly in the case of rice (hulling), which can suffer from cracks and lesions. The grain is then not only worthless, but also becomes vulnerable to insects such as the rice moth (*Corcyra cephalonica*).
- viii. **Marketing.** Marketing is the final and decisive element in the postharvest system although it can occur at various points in the agro-food chain, particularly at some stage in processing. Moreover, it cannot be separated from transport, which is an essential link in the system.



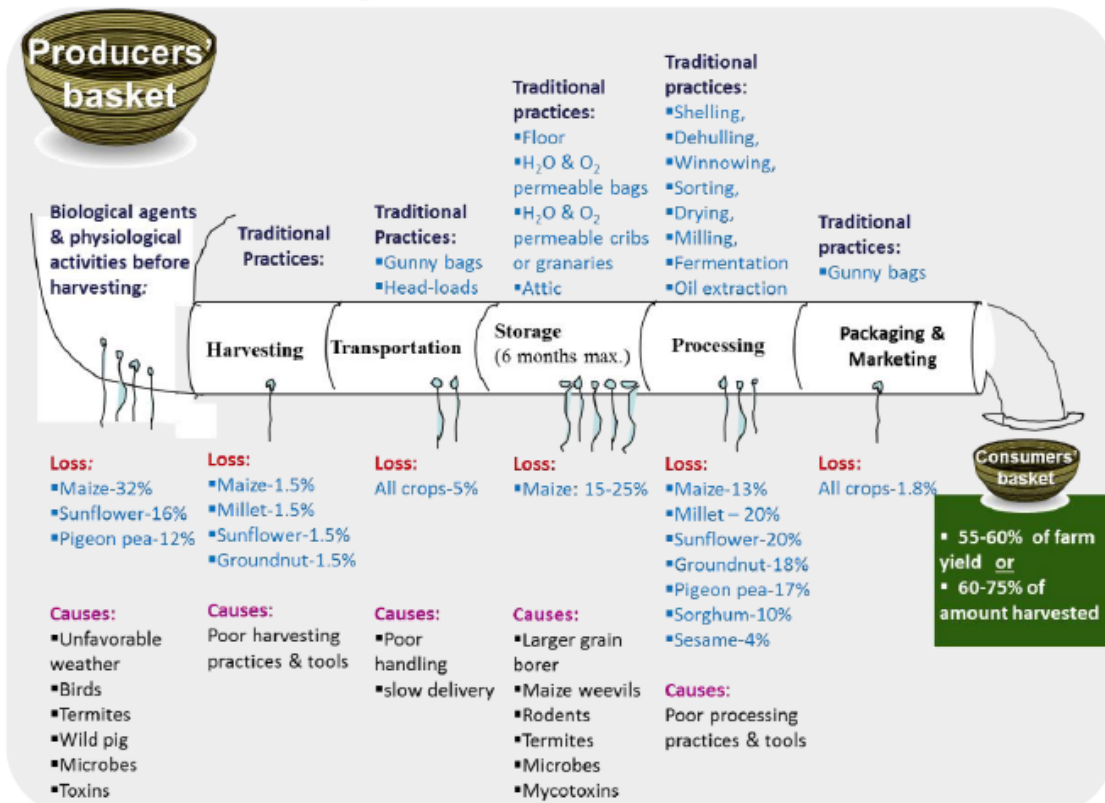
A smart postharvest management system combines these elements to optimize quality, minimize losses, and reduce costs and exposure of harvests to infections and use of industrial chemicals. Furthermore, participation of men and women, the youth, and other groups while benefiting all in the process, should be enhanced to reduce unnecessary emissions and use of unsustainable energy in storage and transport through all the steps identified above.

4.3 Types of postharvest losses

- Quantitative losses (measurable loss in physical quantity).
- Weight losses (loss of sellable weight).
- Qualitative losses (nutritive value and safety of food).
- Damage (deterioration of the product, quantified in terms of weight and cost) (e.g. broken and pitted grains).
- Economic loss (quantity and quality loss translated into economic and monetary terms).

4.3.1 Causes of losses

- Direct causes:
 - Pilferage or theft
 - Spillage
 - Feeding of pests
- Indirect causes
 - Reduction in quality (e.g. consumer's refusal)



Source IITA

4.3.2 Losses caused by insect pests

These are losses to crops before germination, at-growth, and during harvest and storage caused by various insects eating, laying eggs in or on them, and or resulting to contamination to food and reduction of their volume or quality and usefulness.

Insect pests



Larger grain borer (Scania)



Maize Weevil



Lesser grain borer



Angoumois grain moth



Indian meal moth



Saw-toothed grain beetle



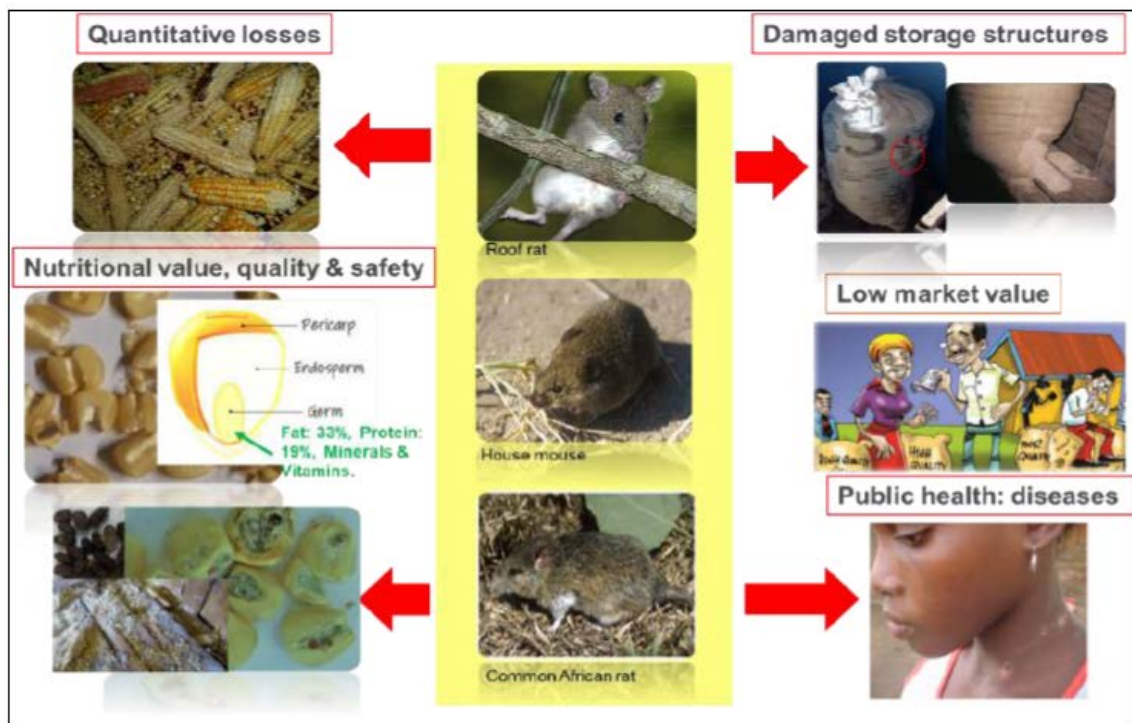
Flour beetle

4.3.3 Control measures for insect pest losses

- Carry out proper and timely harvesting.
- Ensure proper drying before storage.
- Use clean storage containers, disinfest the store, and maintain storage hygiene.
- Prevent and protect against infestation during storage.
- Inspect the produce store regularly.

4.3.4 Losses caused by rats and mice

- Feed on the stored produce (Rats=25g, mice=3-4g/day).
- Contaminate the produce with urine, faces, hairs, and pathogens.
- Damage storage materials and equipment (e.g. tarpaulins, bags, and the store itself).
- Transmit diseases to human beings (e.g. typhoid, paratyphoid, and scabies).



4.4 Control measures for losses caused by rats and mice

- Granaries should be raised and fitted with rat guards.
- Ensure that doors, ventilation openings, and the junctions between the roof and the wall of granaries are well sealed.
- Keep the store clean.
- Store bags in tidy stacks set up on the pallet, ensuring that there is a space round the stacks.
- Store any empty or old bags on pallets.
- Keep store free of rubbish.
- Clear area surrounding the store of tall weeds, rubbish, and stagnant water.
- Use appropriate rodent control methods such as mechanical traps or biological methods (e.g. use of a cat).

4.4.1 Losses caused by fungi

- Weight loss, poor nutritive value, poor milling quality, and deterioration in flavor and color.
- Toxins are produced (i.e., aflatoxin) that harm humans, poultry and livestock, and causes death as well.
- Contaminated grains cannot be consumed by humans / livestock and has **no market value**.
- The extent of fungal contamination is influenced by grain moisture, temperature, physical damage, and insect activity during storage.
- Storage fungi can grow on maize stored at moisture content above 14%.

4.4.2 Controlling damages by fungi

- Dry to safe moisture content (14% or below) on tarpaulins (not directly on the soil),
- Clean maize before storage to remove foreign matter, broken kernels, dust, and other debris.
- Clean storage structure thoroughly to remove dirt, chaff, grain debris, etc.
- Protect grain from insect damage.
- Check stored grains and aerate the store regularly.
- Avoid damp conditions.



₹ 0.2



₹ 1



₹ 2

4.4.3 Why the need to raise awareness of the magnitude of losses?

- To take appropriate measures to ensure the quantity, quality, and safety of the harvested food that reaches consumers.
- To safeguard trade, especially international trade.
- To emphasize/facilitate the use of pre- and postharvest management technologies, including storage infrastructure, improved processing methods and machinery.

4.5 Possible impacts of food losses

- Insufficient food for households.
- Poor quality of nutrients in household diets.
- Unsafe foods.
- Malnutrition in children, lactating women, and the elderly.
- Frail or sickly population.



4.6 Technologies for interventions



Drying: CDC

Benefit of using CDCs:

- Improved drying.
- Better grain quality.
- Reduced losses.
- Discolored grains eliminated.
- Reduced impurities, visible mold grains, and insect damaged grains by 30%, 42%, and 44%, respectively.
- Significantly less damaged grains.

Postharvest mechanization

Mechanization is a driver of CSA, which includes, among others, the use of mechanized shellers.

4.7 Opportunities for application

- Farmers can significantly reduce losses and improve quality of their produce for the market.
- Improvement in quality leads to better market access and crop price.

Opportunities for generating income



Youth employ themselves in service provision ; generate incomes.



Skilled youth empowered to back-stop mechanization with technical aspects: repairs, fabrication, and spare-parts



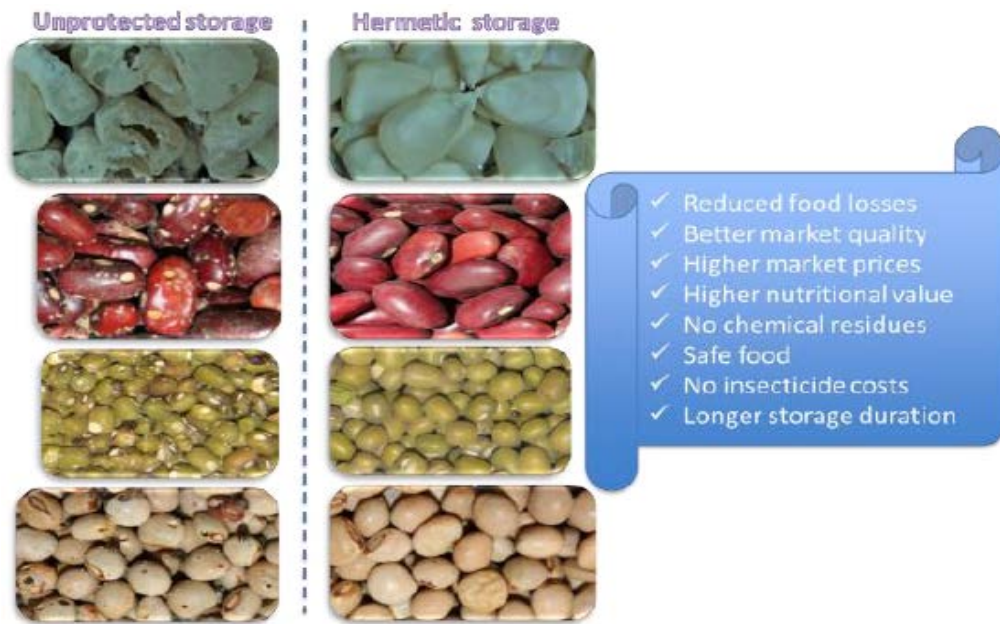
Demand is created and service providers are linked to local fabricators and engineering partners



Hermetic storage

Benefits of using hermetic technologies:

- Build-up of insect pests and insect damage is significantly reduced.
- In maize, grain damage and losses are reduced by more than 85%.
- There is enough food to feed an average household of five people for about 4-5 months, based on annual per capita maize consumption of household.



Different types of hermetic containers are profitable depending on quantities produced by farmers.

Conclusion

Many postharvest processes significantly contribute to GHG emissions, which further strengthens the case for more resource-efficient processing, packaging, waste/by-product management, marketing and transport, together with heightened consumer awareness. Climate change, adaptation, and postharvest systems are all complex and broad themes, requiring a multi-sectoral understanding and approach to work with them.

The use of an innovation systems approach can support a more holistic appreciation of the dynamic, complex, and multi-dimensional nature of the relevant issues and interconnections. It also highlights the involvement of stakeholders who may hold diverse views and experiences but whose interactions are necessary in order to bring about the changes required for postharvest adaptation to climate change. Co-learning approaches can bring together these diverse players to contribute to developing and testing practical solutions and skills for coping with and adapting to the change enveloping them.

Transforming postharvest systems to be more resilient, and the communities and consumers who rely on them less vulnerable to climate change, will require leverage of public and private investments. Postharvest agriculture is gradually returning to the development agenda. It is vital that this attention is increased and that the initiatives arising from it incorporate a dynamic understanding of postharvest climate sensitive agriculture.

Climate change interacting with other drivers of change will have serious impacts on postharvest agriculture and livelihoods in east and southern Africa – from household, local to national, and even international levels. However, uncertainty exists regarding future climate projections. There are difficulties in downscaling the projections, understanding their probability, likely magnitude, and the diverse impacts and feedback implications. This uncertainty serves to highlight just how vital it is to strengthen postharvest actors' and systems' ability to adapt to climate and other change.

4B: AFLATOXIN IN CSA

4B.1 Goal

At the end of this training session, participants are able to build a comprehensive understanding of the concepts of aflatoxin contamination and its management sufficient enough to enable them to train other people in their areas.

4B.1.1 Specific objectives

Participants are able explain and/or describe:

- Meaning and effects of aflatoxin;
- Relationship between climate change and aflatoxin contamination;
- Effects of aflatoxin exposure on the nutrition and health of babies and young children;
- Measures to mitigate aflatoxin contamination; and
- Use of Aflasafe™ as an effective mitigation measure for aflatoxin contamination.

4B.2 Aflatoxins

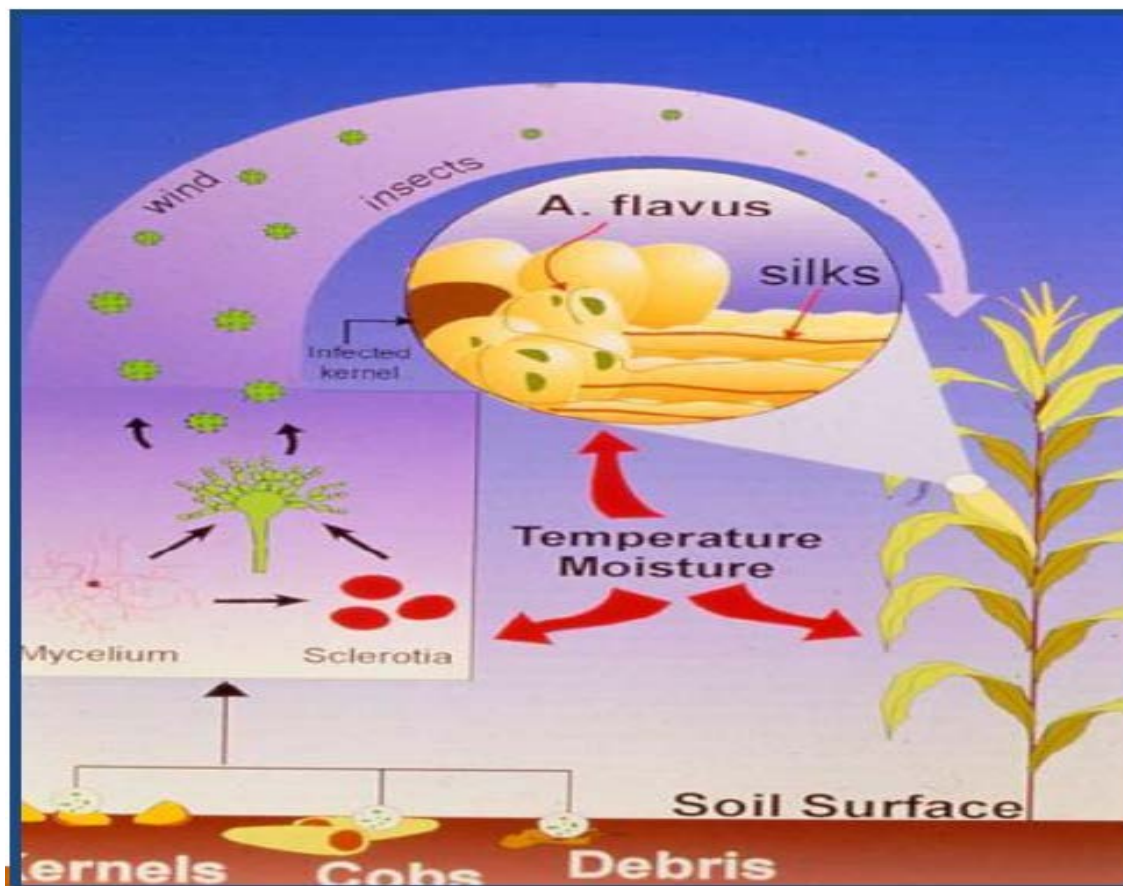
Aflatoxin is a poison produced by fungal growth (mainly *Aspergillus flavus*) on cereals (i.e., maize), oil seeds (i.e., groundnuts), tubers (i.e., cassava), spices (i.e., ginger), animal feeds, and milk and its by-products. Worryingly, it may be transferred from a lactating mother to her baby through her milk. Aflatoxin's other characteristics include:

- It does not have color, smell, and taste.
- It can tolerate high temperatures.
- It contaminates many crops, especially groundnuts and maize.



4B.2.1 Contamination by aflatoxin

- Aflatoxin contamination starts in the field.
- *Aspergillus flavus* is a soil-borne fungus that can survive freely in soil as spores.
- It can survive on crop debris.
- Contamination by *A. flavus* and aflatoxin production can occur anywhere along the maize value chain. However, contamination at the pre-harvest stage is the most critical.



Aflatoxin contamination commonly occurs at the farm (pre-harvest stage) and increases during transportation and storage (postharvest stage), especially when exposed to stresses such as droughts, flood, high temperatures, and diseases. Climate change-related stresses also influences aflatoxin contamination in farms.

4B.2.2 Effects of aflatoxin contamination

Aflatoxin contamination affects both humans and animals through either acute aflatoxicosis or chronic aflatoxicosis. In recent years, a number of casualties and deaths related to aflatoxin contamination have been reported. Some of the more notable ones include:

- In 2006, more than **250 people** died due to acute *aflatoxicosis* in Kenya.
- In 2017, more than **64 people** were affected by acute *aflatoxicosis*, with **19** dead, in Chemba, Kondo, and Kiteto Districts.
- In 2019, more than **23 people** were hospitalized and **5** died due to acute *aflatoxicosis* in Chemba District.

Aflatoxin contamination has also been linked to carcinogenicity, particularly causing liver cancer, that lead to:

- Teratogenicity;
- Reduced production for livestock;
- Weakened nervous system;

- Stunted growth especially for children; and
- Compromised immunity.

4B.2.3 Aflatoxin and children nutrition

Children are exposed to aflatoxin commonly through:

- Maternal food intake;
- During breast feeding;
- Through weaning; and
- Post-weaning through foods like maize, peanuts, and milk.

What happens when children are exposed to aflatoxin?

- Intestinal tract (enterocytes) is damaged, which impairs intestinal barrier and permeability resulting to malabsorption of vitamins and minerals like zinc. It also leads to bacterial infection caused by poor sanitation and hygiene.
- Inhibits synthesis of proteins, enzymes and fatty acids, and impairs glucose metabolism.
- Leads to loss of appetite and reduced food intake.
- Decreased food conversion rate.
- Poor weight gain, stunting, wasting, and growth restriction.
- Delayed physical and behavioral development.
- Poor coordination.
- Poor immunity to diseases such as diarrhea, pneumonia, malaria, etc.

Effects of aflatoxin contamination on regional and international trade:

- Aflatoxin contamination can lead to rejections of specific export shipments.
- Prohibitive costs of treatment, destruction, or re-shipment of rejected products pose significant economic loss to exporting country or entity.
- If contamination is chronic, regulators can curtail the right of countries to further export aflatoxin-susceptible products.
- Loss of revenue can affect individual livelihoods as well as the agricultural sector as a whole.



4B.3 Using Aflasafe™ to control Aflatoxin

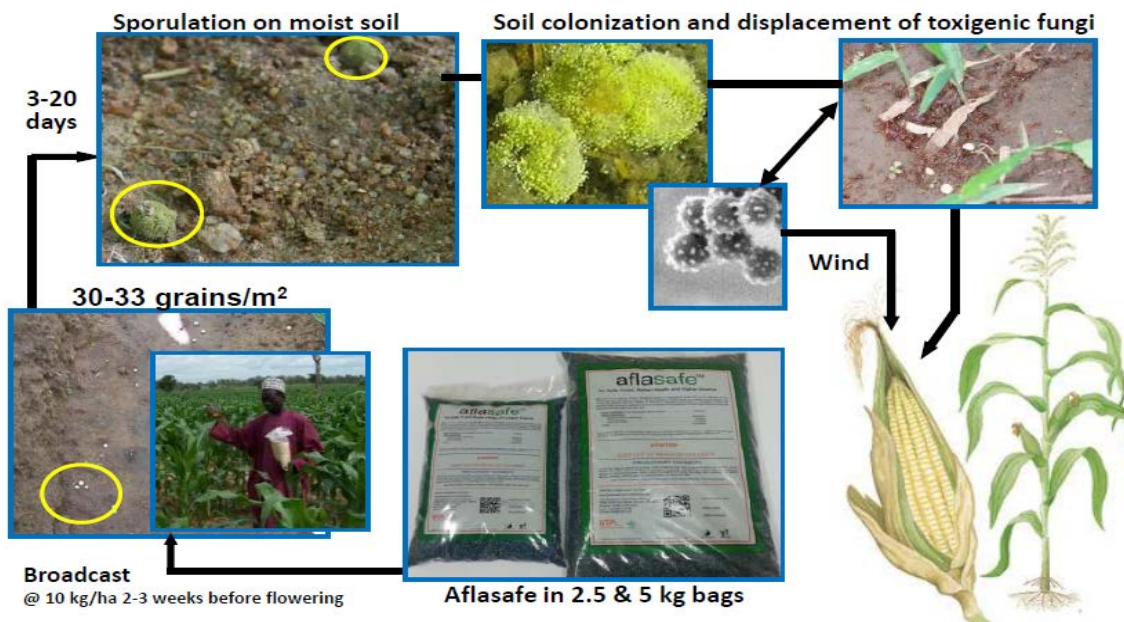
Aflasafe™ is an aflatoxin biocontrol product derived from the atoxigenic strain of the *A. flavus* fungi, which is coated on white sterile sorghum as its medium. Other composites include polymer, blue dye, and water.

Atoxigenic fungi compete and outweigh its toxigenic counterpart in the farm through a process called "**competitive exclusion**".

Aflasafe™ is a biocontrol technology that has been proven to be highly effective, simple to use, and is user- and environment-friendly.

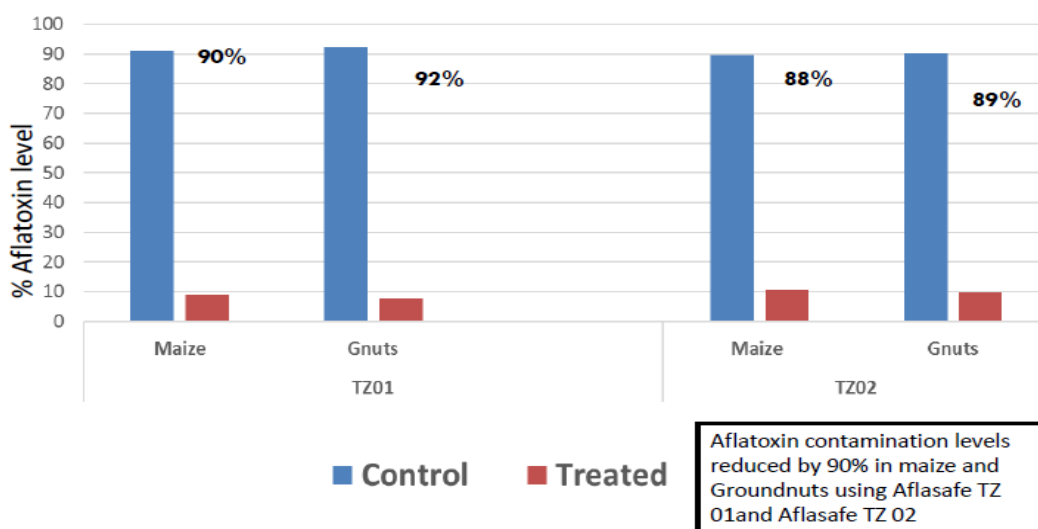
Aflasafe™ is applied on the farm by manual broadcasting. The following should be noted:

- It has to be broadcasted 2-3 weeks before flowering of maize and peanuts on a weeded field.
- Broadcast at ratio of 10 kg Aflasafe™ per hectare, or 10 kg per 2.5 acre, or 4 kg per acre.



Aflasafe™ effectively reduces to very minimum levels the toxic fungi in farms, crops, and harvests, especially for maize and groundnuts.

Reduction in Aflatoxin levels in maize and groundnuts efficacy trials



Conclusion

Assuring food safety and security entails the active involvement of a number of stakeholders performing agreed and clearly defined roles. Climate change has both direct and indirect impacts on the occurrence of food safety hazards at various stages of the food chain, aflatoxin being one.

Recommendations:

- i. Raise public awareness on how to avoid or prevent aflatoxin contamination. This would help in both short-term and long-term planning of mycotoxin control during harvesting and grain handling, and storage and marketing strategies that ensure economic viability and food security.
- ii. The government has a mandate to catalyze the process of technology transfer to assist farmers tackle aflatoxin in maize. Crop yields can be predicted using climate model output and crop models.
- iii. To avoid aflatoxin contamination, maize should be stored in conditions that prevent exposure to and growth of *Aspergillus* fungi, such as maintaining cool air temperatures and low humidity.

Develop maize varieties and hybrids with tolerance to the *A. flavus* fungi.



5 GENDER-SENSITIVE CSA

Introduction

Gender-responsive service delivery is a critical component of inclusive governance and key to achieving SDGs, food security, and agriculture transformation. Despite their presence in agriculture value chains at more than 60% in Tanzania, efforts to achieve commitments on gender equality are impeded when women do not have access to discussion tables and planning events. Women are often constrained by geographic distances or their socio-economic status and, in too many sectors, fail to be considered as part of the beneficiary category, as in the case of farmers.

5.1 Goal

At the end of this training session, participants will be able to understand and conceptualize concepts of gender and its applications in CSA.

5.1.1 Specific objectives

Participants should be able to learn and understand:

- Meaning of gender, gender equity and gender equality, sex and gender, and gender effects in agriculture;
- Gender relations in production and service delivery and its effects/ application in CSA;
- Concepts of women empowerment as a mechanism in gender balance;
- Application of gender-based rights in CSA; and
- Streamlining gender in CSA.

5.1.2 *The need to increase the number of women in decision-making positions*

Increasing the number of women at the frontlines of extension services and farm input delivery (i.e., as extension officers, farm/market managers, trainers, or agricultural agents), access to services for and by women beneficiaries improves significantly.

Putting women in key decision-making positions also builds the capacity of civil societies to demand gender-responsive climate-sensitive agriculture, as well as offer a venue for women to communicate their sentiments, priorities, and needs to the government. Such an initiative also enhances accountability and catalyzes governance reforms to specifically address women's needs in CSA.

5.2 Key concepts

Gender equity – is a process of being fair to women and men by creating necessary measures to compensate for the imbalances in power relations (status, choices and decision making) and access to resources and opportunities. Equity leads to equality.

Gender equality – means that men and women have equal opportunities and conditions to realize their full potential to contribute to national political, economic, social, and cultural development; and benefit from the results thereof. The concept of gender equality goes beyond equal treatment to results; whereby, equity is considered as the means to achieve the expected results.

Women’s empowerment – is a process to transform gender power relations through individuals or groups by developing their awareness of the women’s subordination and build their capacity to challenge it.

Empowerment is about people – both men and women taking control of their lives – setting their own agenda, gaining skills, increasing self-confidence, solving problems, and developing self-reliance. It is both a process and an outcome.

All the above aspects are related to promoting and protecting women’s rights.

5.3 Sex, gender, and gender relations

Gender

Gender is simply taken to imply the social roles played by both men and women and the power relation that the two use in management and distribution of natural resources (Huisinga *et al.*, 2001). This term strongly came into use after the Second World War following feminist works. Gender does not refer to sexes but to the cultural, social, and behavioral differences between the two sexes. It is these differences either being biological or physical that affects absenteeism and women are trapped in more than men (UN, 2010; End Poverty, 2015). In conducting research in the social sciences and in socio-economic development, these differences presents barriers.

Sex

Biological characteristics generally define humans as female or male. It is universal and does not naturally change over time (Ichino and Moretti, 2009).

Figure 1. Shows the differences between sex and gender

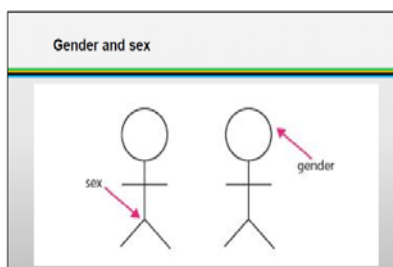
What is ‘Sex’?

Biological characteristics generally define humans as female or male.

Universal

Not changed over time

Gender can be learned.



What is ‘Gender’?



5.3.1 Gender relations

Gender relations refer to ways in which society defines rights, responsibilities, and identities of men and women in relation to one another, in all spheres of life. This includes private (family, marriage) and public domains (schools, labor markets, political life). Other intersecting factors to consider are ethnicity, age, class, religion, and geographic location. Understanding gender relations in a given society are important since they are the ones that determine the following:

- Gender entitlement systems such as assets and opportunities;
- Capabilities and choices;
- Gender divisions of labor and employment opportunities (such as unpaid and temporary work);
- Gender patterns of production; and
- Power-sharing at all levels, decision making, and control of resources.

5.3.2 Gender issues in agriculture

Women may have ownership rights and access to land (as a natural capital), but they may not have decision-making power with regards to production on that land. Identifying the complexity of the relationships to assets within the household is an important element of gender analysis.

Gender issues in climate smart agriculture, practices & technologies

Agricultural productivity is negatively affected by consequences of CC & variability.

The impact of CC & variability on agriculture extends to both men & women differently

Understanding gender differences can enable better design and targeting of interventions that reduce vulnerability to CC and contribute to gender equality

Gender is pertinent to adoption of CSA technologies

In the agriculture sector of Tanzania, female farmers contribute more than their male counterparts particularly in crop production and management. However, despite their significant role in agriculture, the triple roles of female farmers are not well recognized or valued in the society; hence, aggravate the gender inequality. Gender has been recognized as an essential variable for analyzing the roles, responsibilities, constraints, opportunities, incentives, costs, and benefits in agriculture. Ironically, women and the youth are known to be more involved in agricultural activities than men in SSA countries.

Moreover, women engage in a range of farm activities some of which were exclusive to men before. The increased feminization of agriculture is a result of men's rural-urban migration in search of paid employment leaving agriculture in the hands of women. In order to understand the role of female farmers in agriculture, it is important to describe roles and responsibilities of each party in an agriculture value chain. Table 1 assists in identification of roles played by each party in a classical farm set up (*note to facilitator: ask participants to tick/check appropriate option. Afterwards, with the help of participants, analyze scores and arrive at consensus through discussions*).

Table 1. Farming operations in relation to agricultural production in Mvomero District

| S/N | Farming activities/ Operations | Gender | | Both | Remarks |
|-----|-----------------------------------|--------|---|------|--|
| | | M | F | | |
| 1. | Land preparation | * | | | Manual land preparation operations are conducted by women while mechanized operations are men's responsibilities. |
| 2. | Planting | * | | | |
| 3. | Weeding | * | | | |
| 4. | Weeding and gap filling | * | * | * | These operations are done by both men and women, but in most cases are carried out by women and children except when it is becoming late on the season and there is a threat to production |
| 5. | Fertilizer application | * | * | * | |
| 6. | Second weeding | * | * | * | |
| 7. | Planting late crops | | * | | This becomes a concern of men as early planting failed |
| 8. | Harvesting begins | * | | | |
| 9. | Major harvesting | | * | | |
| 10. | Harvesting late crops | * | * | * | |
| 11. | Transportation | | * | | |
| 12. | Shelling/Winnowing | * | * | * | Depends on type of crops and mechanization level. Mechanized winnowing, shelling, pesticide application and storage are done by men. |
| 13. | Pesticide application | | * | | |
| 14. | Storage | | * | | |
| 15. | Marketing | | * | | Men don't involve women in marketing and financial management, especially for cash crops. |



Control and decision-making related to land is usually under male authority. This may involve decisions to manage and modify the natural environment such as developing settlements and semi-natural habitats like arable fields and pastures (***note to facilitator: probe on this topic with participants for further appreciation***).

5.3.3 Gender issues and sex roles related to climate change

Below are a number of issues that point to the crucial role of gender when understanding the causes of climate change, aiming to mitigate it, and working towards successful adaptation to inevitable climate change:

- Women and men, in their respective social roles, are differently affected by the effects of climate change. Reasons are inter alia to be found in different responsibilities for care work and income-generating work, dependency on natural resources due to lack of access to environmental services, or in knowledge and capacities to cope with the effects because of differences in their access to education and information systems.
- Women and men, in their respective social roles, are differently affected by climate protection and adaptation instruments and measures. If these mechanisms and measures are developed in a non-gender-sensitive way – which most often is the case – they again do not take into account different responsibilities and financial options.
- Women and men differ with regard to their respective perceptions of, and reactions to, climate change. It is well known, especially in industrialised countries, that women have a higher risk perception than men, and thus also recognize climate change as a more serious problem than men do. Gender differences are crucial when it comes to assessing adequate measures, too. While men trust in technical solutions, women tend more towards making lifestyle changes and reducing energy consumption.
- Women's and men's contributions to climate change differ, especially with regard to their respective CO₂ emissions. This is especially proven in regard to transport systems. For example, in Sweden, men consume up to double the amounts of energy compared to women. Difference results mostly from car use and mobility patterns.

5.3.4 What are women's rights and why are they important?

There are clear connections (both positive and negative) between gender and the environment. One famous quote says, "No climate justice without gender justice". Although women are responsible for 80% of agriculture-related activities in Africa, they remain vulnerable and poor. They have limited access to, and control over, resources. Poverty is both a cause and a consequence of vulnerability, especially among women. In addressing climate change in agriculture, it is good to also include issues related to gender to reduce the chances of further marginalizing already-vulnerable groups, such as women and youths.

- Women's rights ARE human rights.

- In theory, women have never been overtly excluded from the concept of human rights.
- In 1945, the UN Charter afforded to women and men equal economic, social, cultural, political and civil rights.

Nevertheless, because women have traditionally been relegated to the private sphere and to subordinate status in society, they have generally been excluded from recognized definitions and interpretations of human rights. As such, women and girls' experiences with human rights abuse have been virtually ignored, especially in agriculture.

Quiz

Table 3. Marital resource management in a family

Think of a local family and determine, between the husband and the wife, the resources they bring, control, benefit, and/or take back at marriage, separation, divorce, death, and/or inheritance within a traditional system, a legal arrangement, and/or a religion-related understanding.

Fill in the table and analyze the common marital situation in your area according to the different status during marriage, separation, and/or death of the husband or the wife.

| Sharing resources during | Traditional | Legal | Religious | Is it fair? |
|--------------------------|--|-------|-----------|-------------|
| Separation | Bring Control Benefit Take home | | | |
| Divorce | Bring Control Benefit Take home | | | |
| Death | Bring Control Benefit Take home | | | |
| Inheritance | Bring Control Benefit Take home | | | |
| Marriage | | | | |





5.4 Women in agriculture

The ways in which farming women experience human rights — and human rights violations — are unique. More often, farming women face abuse from non-state actors (i.e., employers, partners, husbands, families and community members), even from vendors and transporters who are supposed to be more partners. When the state dismisses the majority of violence against women as private or domestic matters, it sends a clear message that violence against women is condoned.

5.5 International policy frameworks for gender equity and women's rights

Many countries have signed and ratified /adopted the international instruments on gender equity and women equality GE+WE

and include:

- United Nations 1948 Declaration on the Universal Human Rights - stipulates that human rights apply to all people equally, “without distinction of any kind such as race, color, sex, language or any other status”.
- UN Convention on the Elimination of all forms of Discrimination Against Women - was the first document to comprehensively address women's rights within political, cultural, economic, social, and family spheres.

Story telling

- Kaja Khidr was accused of adultery by her husband's family and held hostage by six family members in Iraqi Kurdistan. Kaja Khidr was tortured and mutilated; family members cut off part of her nose and told her she would be killed after the birth of her child. After fleeing to Syria, two of her abusers were arrested. However, they were both released within twenty-four hours because authorities determined they had acted to safeguard the honor of the family. No charges were ever brought against them.

- i. The 1993 Declaration on the Elimination of Violence Against Women set forth ways in which governments should act to prevent violence and to protect and defend women's rights. It holds states responsible to “exercise due diligence to prevent, investigate and, in accordance with national legislation, punish acts of violence against women, whether those acts are perpetrated by the state or by private persons” (UN Beijing Declaration, 1995; Platform for Action, The UN Millennium Development Goals, specifically MDGs 3,4, and 5).

5.6 Country setup and governance



Despite the good legal and policy framework, gender inequality persists in all sectors including agriculture and governance. Governance is the manner in which the State acquires and exercises its authority to provide public goods and services. It also affects the other sectors, including agriculture.

Good governance is responsive to the present and future needs of the organization, exercises prudence in policy-setting and decision-making, and that the best interests of all stakeholders are taken into account. It should be noted that:

- Poor management of resources affect agriculture, production relations, and rights; and
- Good governance includes participation, decision-making, inclusiveness, consensus, transparency, rule of law, equity, and efficiency.

In agriculture, all these pose explicit and implicit differences between men, women, children, and PWDs. Good governance is one big solution approach to gender challenges.

5.6.1 Gender mainstreaming in agriculture

CSA objectives are explicit to both men and women.

Sex disaggregated data

- Activities to reflect needs of men and women



5.6.2 Gender division of labor

- Consulting men and women needs in relation to their roles in CSA.
- How does CSA affect roles of women and men?
- How do activity schedules affect tasks done by women and men?
- What factors will encourage women and men to participate in CSA?

5.6.3 Access and control of CSA resources

- Enable women to have authority over resources.
- Previous experiences.
- Measures done to ensure ownership of resources.
- Training to be conducted in language women understand.
- Consider outcomes and aftermath of interventions.

5.6.4 Access and control of CSA benefits

- What will be the CSA benefits to men and women?
- How will CSA affect what's already there?
- How will CSA enhance opportunities for men and women?

5.6.5 Consider influencing factors

Social roles and responsibilities of women and men lead to different degrees of dependency on the natural environment. Women are usually the ones engaged in household subsistence activities. Degradation of forests, watersheds, foreshores, and agricultural land in developing countries can have a severe effect on their ability to perform their daily household maintenance tasks. Factors to consider include:

- Social factors;
- Cultural factors;
- Religious factors;
- Economic trends; and
- Marital relations.

5.6.6 Understanding the differences between consultation and participation

The participation of women in decision-making regarding climate policy – mitigation and

adaptation – and its implementation in instruments and measures is very low. Generally, it is the men's perspectives that are taken into account during planning processes. Things to consider include:

- Constraints to participation by men and women;

- Separation or integration of activities for men and women; and
- Clear communication channels on equity between men and women.

5.6.7 Women's social status and roles

- Improvement of the condition and status of farming women.
- Involvement of farming women in the decision-making process.
- Community's perceptions and sentiments of the role of women.

5.7 CSA program monitoring and evaluation

- Targets set for participation of men and women.
- Gender-sensitive indicators.
- Disaggregated data.
- Ongoing consultation with community groups.
- Follow-up to assess impact.

5.7.1 CSA resource needs and availability

- Adequate for implementation.
- Availability of CSA resources to both men and women.
- Utilization of gender expertise.

5.7.2 Gender needs and undertakings in CSA

- Well-governed and high quality CSA should be judged in part by the degree to which they address gender practical or strategic needs.
- A gender-responsive CSA initiative identifies that males and females (and specific groups of women and persons with different gender identities and sexual orientation) often have different practical and strategic needs.
- Prioritizes what and how CSA services are provided.

Practical gender needs

Practical gender needs refer to needs that:

- Women identify based on their socially accepted roles in society;
- Do not challenge, although they arise out of gender division of labor and women's subordinate position in society;
- Are a response to immediate and perceived necessity, identified within a specific context (e.g. in cash vs food crops production or animal husbandry); and
- Are practical in nature and often concern inadequacies in living conditions (i.e., water provision, health care, and employment).



Strategic gender needs

Strategic gender needs refer to needs that:

- Women identify based on their subordinate position in society;
- Vary according to particular contexts, related to gender divisions of labor, power and control, and may include several issues (i.e., legal rights, domestic violence, equal wages, and women's control over their bodies);
- Helps women achieve greater equality and change existing roles, thereby challenging their subordinate position; and
- Are more long-term and less immediately visible compared to practical gender needs.

5.8 Intergration of gender issues in CSA

Pillar 1. Sustainably increase agricultural productivity and incomes

It is common for men and women within the same agricultural household to pursue separate but interrelated livelihoods and to incorporate different technology and production management options. Thus, it is important to look at how these differences shaped by social norms and intra-household decision-making may affect men's and women's participation in more sustainable agricultural practices and the consequent benefits.

Pillar 2. Adapt to and build resilience to climate change

The impacts of climate change and related adaptive strategies are not gender-neutral because vulnerability is often determined by socio-economic factors, livelihoods, people's capacity, and access to knowledge, information, services and support – all of which may differ along lines of gender. In addition, men, women, and other social groups may have different coping strategies.

CSA to address Gender Needs

- Gender-responsive CSA may address practical or strategic needs.
- CSA should reflect on whether we focus enough on gender-responsive agric initiatives that contribute to fulfilling strategic needs, and;
- Whether this focus will be further refined in the coming strategy and period.

Pillar 3. Reduce and/or remove GHG emissions

The ability to adopt CSA practices that also reduce GHG emissions appears to be affected by gender inequalities. For example, insecure land tenure, workload, heavy tools, lack of capital, and limited farm inputs pose major barriers to the adoption of CSA and agroforestry (often regarded as climate-smart) by women and youth farmers.

Key questions for discussions:

- How much and to what extent of the practices are labor intensive?
- The labor-saving benefits are mainly related to minimum tillage (involving mulching, cover crops, and the use of herbicides for weeding).
- Does the practice increase or reduce work load within and outside the household?
- For example, in areas farmed with plough and where men are typically responsible for preparing land, minimum tillage reduces the time men spend on land preparation but can actually increase women's labor requirements for weeding because more weeds grow with minimum tillage compared to ploughing.
- Who is mostly affected?
- These consultations must involve male and female stakeholders for an accurate assessment of how specific changes in practices are likely to affect men and women and how they are likely to unfold over time.
- Who has power in making decisions on adoption?

Conservation agriculture interventions have implications for investment decisions concerning mechanization and herbicide use, crop choice, and residue management.

Other practices such as the diversification of crop rotations or intercropping can highlight men's and women's contrasting crop preferences and threaten women's control over crops that are key to household food and nutrition security.

- Who benefits from the practices?

Leaving crop residues in the fields reduces the availability of livestock feed. And if women are responsible for feeding livestock or grazing small stock, they may be forced to travel farther for livestock feed or to purchase a resource that was previously freely provided in the form of open grazing of crop residues left in the field.

5.9 Gender mainstreaming in CSA projects

All new project/intervention needs to be appraised and approved before implementation of the planned activities begins. Below are possible gender questions to be considered in the appraisal phase:

- Have the needs, priorities, constraints, and challenges of women and men in relation to the project been mapped?
- Have their specific roles and responsibilities within the household, community, and sector(s) been analyzed?



- Have both women and men (of different ages and socio-economic groups) been engaged in project planning and implementation?
- Does the monitoring and evaluation framework include gender sensitive indicators?

Work out the following questions:

- What is the situation in your area?
- How can the identified situation be addressed?
- Have you ever thought of this in your experiences?
- What's the council/local officials' strategy in dealing with this situation?

Conclusion

Women and men are not homogenous groups but include people of various age, ethnicity, education, and income. These social categories also relate to differences in influence, attitude and in contribution to climate change, to how people are affected by it and which possibilities they possess to adapt to climate change. Agriculture is under-performing because of gender imbalance and unequal sharing of resources and achievement of rights among rightful parties (disabled youths and women's unequal access to land, fertilizer, technology, extension, and credit). The same holds true for the adaptation to climate change. Women in developing countries suffer most and have the least capacities (economic, information, education etc.) to adapt to climate change and to prepare for the effects.

Whereas, both women and men need to adapt their production and consumption behavior and daily life routines in order to mitigate climate change, they are differently affected by natural disasters and changing weather conditions. In agriculture, the main production line for developing countries just like Tanzania also faces formidable challenges (i.e., increased food demand, climate change impacts). Thus, closing these gender gaps would be good for both men and women, and for climate sensitive agriculture.

6 MAINSTREAMING NUTRITION IN CSA

Introduction

This topic presents the aspects of mainstreaming nutrition into CSA. Production and processing of foods are aspects of nutrition-sensitive agriculture and sustainable diets. Changes in climate patterns are expected to negatively impact nutrition by reducing production, influencing disease prevalence, and increasing postharvest losses and mycotoxin contamination. CSA approaches will lead to increased food and nutrition security.

Nutrition-sensitive agriculture needs to consider and understand the role of biodiversity in improving dietary quality and diversity, as well as seasonality in food supply. Apart from improving agricultural systems to close the nutrition gap, efficient storage and food processing technologies to prolong shelf-life are required. In addition, gender-based constraints must be addressed to increase agricultural productivity, improve food and nutrition security, reduce poverty, and build the resilience of rural populations.

- Introduction should cover the much-needed understanding of the role of biodiversity in improving dietary quality, diversity, and seasonality in food supply;
- Gender-based constraints must be addressed to increase agriculture productivity, improve food and nutrition security, reduce poverty, and build food security resilience;
- Nutrition-sensitive agriculture: production and processing of foods for sustainable diets leading to increased nutrient intake;
- Change in climate with its negative impact on food availability and nutrition (reducing production, disease prevalence, and increasing postharvest losses); and
- CSA approaches to increase food and nutrition.

6.1 Learning objectives

- Define basic nutrition terminologies.
- Classify foods into groups according to their nutrients and differentiate between macronutrients and micronutrients.
- Relate climate change, nutrition-sensitive, and agriculture from production stage to processing stage.
- Describe plant health strategies for food and nutrition security in relation to climate change.
- Describe how culture affect gender and nutrition.
- Describe how gender affects nutrition.

6.2 Content and coverage

This training covers:

- Food groups and their functions;
- Balanced diet and dietary diversification;



- Development of food recipes using locally available foods;
- Consequences of micronutrient malnutrition;
- Nutrition-sensitive agriculture from production to processing;
- Approaches to nutrition-sensitive agriculture;
- Food-based approach to overcome malnutrition and micronutrient deficiency;
- Seasonal variations and agroecology;
- Agrobiodiversity and nutrition education and knowledge; and
- Culture, gender, and nutrition.

6.3 Basic terminologies

Food is a material, usually of plant or animal origin, which contains essential nutrients that the human body needs to produce energy, stimulate growth, and maintain life.

In this section, the following basic nutrition terms are defined:

- **Nutrition** is the outcome of various processes from when food is eaten, digested, assimilated, and nutrients are absorbed by the body for better health.
- **Nutrients** are substances in food that the body can utilize for energy, growth, maintenance, and repair or build body tissues. Categories of nutrients include carbohydrate, protein, fat, vitamins, and minerals.
- **Micronutrients** are nutrients, which are essential but are required by our bodies in relatively small amounts. These include vitamins (A, D, E, K, B, and C) and minerals (iron, zinc, iodine, copper, magnesium, and selenium).
- **Macronutrients** are nutrients that the human body requires in reasonably large amounts for normal growth and development. These include carbohydrates, proteins, and fats.
- **Food** is a material, usually of plant or animal origin that contains essential nutrients that the human body needs.
- **Healthy eating** means eating balanced meals that contain a variety of foods and nutrients from different food groups.
- **Malnutrition** is a poor health status resulting from insufficient, excessive or imbalanced consumption and utilization of nutrients. Malnutrition related to insufficient nutrients is called under-nutrition, whereas the one due to excessive nutrients is over-nutrition.
- **Food security**; “Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

6.4 Food groups and their functions

Food has five main groups:

1. Cereals, green bananas, and roots and tubers

This food group consists of cereals (i.e., maize, rice, millet, wheat, and sorghum), green bananas, and roots and tubers (i.e., yams, cassava, and potatoes). The main nutrient found in this food group is carbohydrates, which provide energy.

2. Food of animal origin and legumes

This food group typically consists of meat, milk and milk products, fish, eggs, edible insects, beans, peas, and nuts. The main nutrient found in this food group is protein.

3. Fruits

This food group consists of fruits (i.e., pawpaw, mangoes, oranges, tangerines and pineapples), wild fruits (i.e., baobab fruits, *mabungo*), and tamarind, which is locally called *ukwaju*). The common main nutrients found in this food group are vitamins and minerals.

4. Vegetables

This food group consists of vegetables (sweetpotato leaves, cassava leaves, pumpkin leaves, amaranth, chinese cabbage, okra, carrots, pumpkin, and tomatoes) and indigenous vegetables (*mlenda*, *mchungu*, *figiri*, and *mnavu*, also known as nightshade). The main nutrients found in this food group are vitamins and minerals.

5. Sugar, honey, fats, and oils

This food group typically consists of fatty and oily foods (ghee, butter, coconut oil, margarine, sunflower oil, palm oil, groundnuts, and cashew nuts) and sugars (i.e., honey and table sugar).

6.5 The role of water in maintaining body functions

- The human body is made up of over 75% water of its weight. It is very important to drink water daily, considering its importance.
- **People select the foods they eat for various reasons** such as taste, level of hunger, food availability, convenience, affordability, and socioeconomic status.
- **Malnutrition** is a poor health status resulting from insufficient, excessive or imbalanced consumption and utilization of nutrients.
- **Undernutrition** refers to insufficient nutrient intake.
- **Overnutrition**, the reverse of undernutrition, refers to excessive intake of nutrients.

Note: Water is an essential nutrient required in large amounts (at least eight glasses per day) as:

- All biochemical reactions occur in water, which acts as solvent;
- It is involved in almost every bodily function; and



- It is not stored in the body.


A balanced diet:

- Naturally helps prevent diseases and illnesses.
- Promotes physical and mental health.
- Helps control weight and enables an individual to meet daily nutritional needs.


Not eating a balanced diet leads to malnutrition.

FOOD GROUPS


1. Cereals, green bananas, roots and tubers:CHO




3. Vegetables: Vitamin and minerals




**2. Foods of animal origin and plant origin (legumes)
Protein**



4. Fruits: Vitamin and minerals



5. Sugar, honey, fats and oils: Energy



6.6 Dietary diversity in CSA

A balanced diet provides an adequate amount and variety of foods from the five food groups to cover energy and nutrient needs. To achieve a balanced diet and stay healthy, people must eat a variety of foods from each of these five food groups daily. CSA should consider cultivating crops, which meets the five foods groups.

DD is a qualitative measure of food consumption that reflects household access to a variety of foods and is also a proxy for nutrient-adequacy of the diet of individuals. It has been affected by climate change due to food insecurity. The HDDS reflect the economic ability of a household to access a variety of foods. IDDS reflect nutrient adequacy for an individual. An increase in IDDS is related to increased nutrient adequacy of the diet. DD represents the food groups that a household or an individual has consumed over the preceding 24 hours.

DD is important in improving the quality of the diet and achieving a balanced diet. The consequence of not eating a balanced diet is malnutrition, resulting from inadequate or excess intake of nutrients.

| DD score | | |
|--------------------|------------------------|--------------------|
| High | Medium | Low |
| DD ≥ 6 food groups | DD 4 and 5 food groups | DD ≤ 3 food groups |

6.7 Dietary Diversity Scores (DDS)

DDS are calculated by adding the number of food groups consumed in the household or by the individual respondent over a 24-hour recall period. There are 16 food groups in the questionnaire. To calculate the DDS, some food groups in the DD questionnaire are combined into a single food group to create the HDDS and IDDS. The potential score range is 0-12 for HDDS and 0-9 for IDDS (not 0-16, which is the number of questions in the questionnaire before aggregation into groups to create each score). The food groups are aggregated according to nutrient content (e.g. Vitamin A-rich foods should be in one group).

6.8 Individual Dietary Diversity and Food Frequency

Table 4. DDS (Example of DDS for a household in Nyamagana District, Mwanza)

| | IDD | Score 1=Yes 0=No | Frequency of consumption (indicate number) | | |
|--------------------------------------|--|------------------------|--|-----------|----------|
| | | | Per week | Per month | Per year |
| | From the list of foods consumed in the 24-hour dietary recall, score 1 if any of the food items within a food group was consumed and 0 if the food item was not consumed in the past 24 hours, and then ask for the frequency of consumption. | | | | |
| Cereals, green bananas | Any bread, rice, or other foods made from grains, oats, maize, barley, wheat, sorghum, millet, or other grains? Banana (other locally available grain such as ugali, porridge)? | 1 | - | - | - |
| Vitamin A-rich vegetables and tubers | Pumpkin, carrots, squash, or sweet potatoes that are orange inside + other locally available vitamin-A rich vegetables (e.g. sweet pepper) | 1 | - | - | - |
| White tubers and roots | White potatoes, white yams, cassava or foods made from roots | 0 | 2 | - | - |
| Dark green leafy vegetables | Dark green/leafy vegetables, including wild ones + locally available vitamin-A rich leaves (i.e., cassava leaves) | 1 | - | - | - |



| | IDD | Score | Frequency of consumption (indicate number) | | |
|-------------------------------|--|-------------|--|---|---|
| Other vegetables | Other vegetables (e.g. tomato, onion, eggplant), including wild vegetables | 1 | - | - | - |
| Vitamin A-rich fruits | Ripe mangoes, cantaloupe, dried apricots, dried peaches + other locally available vitamin A-rich fruits | 1 | - | - | - |
| Other fruits | Other fruits, including wild fruits | 0 | 0 | 4 | 0 |
| Organ meat (iron-rich) | Liver, kidney, heart or other organ meats or blood-based foods | 1 | - | - | - |
| Flesh meats | Beef, pork, lamb, goat, rabbit, wild game, chicken, duck or other birds | 0 | 1 | - | - |
| Eggs | | - | 2 | - | - |
| Fish | Fresh or dried fish or shellfish | 0 | 2 | - | - |
| Legumes, nuts and seeds | Beans, peas, lentils, nuts, seeds or foods made from these | 1 | - | - | - |
| Milk and milk products | Milk, cheese, yogurt or other milk products | 0 | 3 | - | - |
| Oils and fats | Oil, fats or butter added to food or used for cooking | 1 | - | - | - |
| Sweets | Sugar, honey, sweetened soda, or sugary foods (i.e., chocolates, sweets, or candies) | 1 | - | - | - |
| Spices, condiments, beverages | Spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages or local examples | 1 | - | - | - |
| YES=1 | | NO=0 | | | |
| Individual level only | Did you eat anything (a meal or snack) OUTSIDE of the home yesterday? | | | | 0 |
| Household level only | Did you or anyone in your household eat anything (meal or snack) OUTSIDE the home yesterday? | | | | 1 |

6.8.1 Creating HDDS and IDDS

Create new food group variables for food groups that need to be aggregated. For example, in the IDDS, the food group “Starchy staples” is a combination of “cereals” and “white roots and tubers”. A new variable termed “Starchy staples” should be created by combining the answers to “cereals” and “white roots and tubers”. This can be done using the following type of logical syntax: Starchy staples = 1 if q1 (Cereals) = 1 or q2 (White roots and tubers) = 1 Starchy staples = 0 if q1 (Cereals) = 0 and q2 (White roots and tubers) = 0. As a check, run a “frequency” test on all newly created variables and make sure that all values are either 0 or 1.

6.8.2 Creating a new variable

Compute values for the DD variable by summing all food groups included in the DDS score (either 12 food groups for household or nine for women - see above for food group definitions). As a check on the creation of the variables, all scores should be within the following range: HDDS (0-12), IDDS (0-9)

1. Cereals, green bananas; White tubers and roots MAKE Starchy staples=1
2. Vitamin A-rich vegetables and tubers; Dark green leafy vegetables; Vitamin A-rich fruits, MAKE Vitamin A-rich foods=1
3. Other vegetables; MAKE source of other minerals =1
4. Organ meat MAKE source of iron-rich=1
5. Legumes, nuts, and seeds MAKE protein source=1
6. Oils and fats and sweets MAKE energy =1

Spices, condiments, and beverages are not important in nutrient sources.

Result makes a total of 6 DDS. The same questionnaire can be used to calculate food frequency.

6.8.3 Agrobiodiversity

Agricultural biodiversity – or agrobiodiversity – is defined as the diverse traits exhibited among animals, crops, and other organisms used for food and agriculture, as well as the web of relationships that exist among them at the ecosystem, species, and genetic levels. It is the basis of the food and nutrient value chain and its use is important for food and nutritional security.

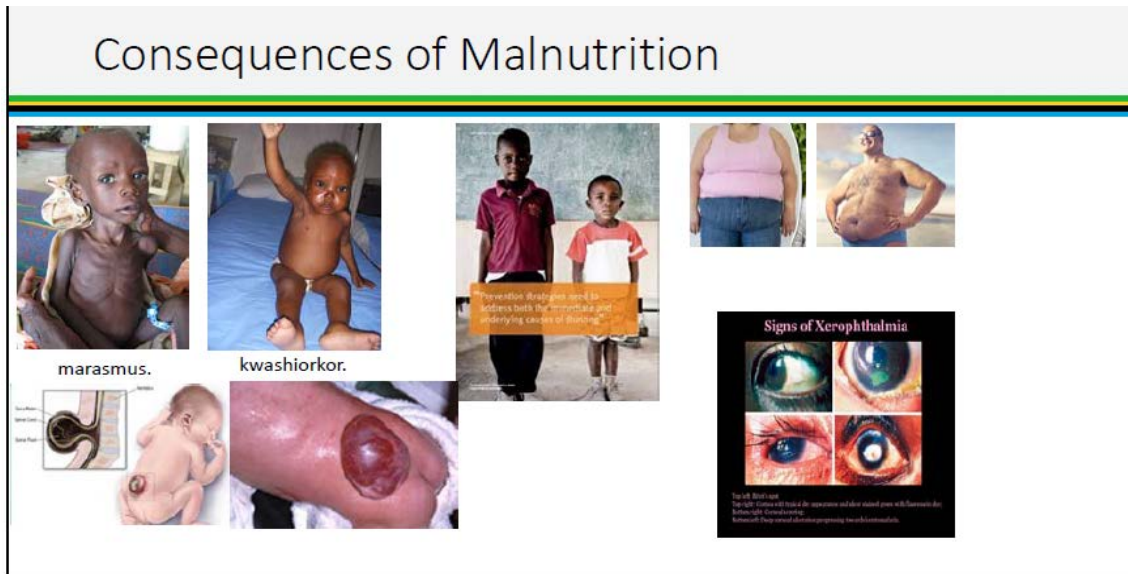
Nutrition-sensitive agriculture requires consideration and understanding of the **role of agrobiodiversity** in improving dietary quality and diversity (i.e., the consumption of a wide variety of foods across nutritionally distinct food groups). A lack of diversity is a crucial issue, particularly in the developing world where diets mostly consist of starchy staples and where nutrient-rich foods such as those from animal sources and fruits and vegetables are less available or accessible. CSA should emphasize on the production of nutritionally distinct foods to address nutrition security issues.



6.8.4 Developing food recipes using locally available foods

Farmers should be assisted to develop nutritionally improved complementary food recipes using locally available and affordable foods in different seasons, local processing, and cooking equipment/utensils. Recipe development should be based on the five food groups.

6.9 Micronutrient malnutrition and climate change



Rising carbon dioxide levels due to climate change decreases zinc, iron, and protein in food crops by 3% to 17% and this leads to dietary deficiencies in millions of humans (Matthew et al., 2018). This decrease in nutrients could lead to nutrient deficiency by an individual. Micronutrient malnutrition is the lack of essential vitamins and minerals. It is a result of several factors such as poor dietary intake and high burden of infectious diseases. Likewise, it occurs because diets in many Tanzanian families lack essential vitamins and minerals, which are vital for good physical and mental health, development, and productivity (THD-MIS 2016).

The major micronutrient deficiencies in Tanzania are Iron Deficiency Anaemia, Iodine Deficiency Disorders, and Vitamin A Deficiency. Other micronutrient deficiencies of concern include Zinc, Folic Acid, and other B vitamins (B12 and Niacin).

6.9.1 Integrating nutrition and food safety in CSA

Nutrition-sensitive agriculture interventions are needed throughout the entire food system – from production, processing, transport, postharvest loss management and consumption.

As climate change impacts agricultural production, it also affects the nutritional quality of some foods. Climate change also increases the likelihood food insecurity for vulnerable groups (i.e., the poor, children, and pregnant and lactating mothers), affects key factors for good health (i.e., clean air, water, food, shelter, and incidence and severity of diseases), and contributes to premature death.

Climate change holistically and directly affects agricultural production and food systems, which leads to increased prevalence of malnutrition, nutrition insecurity, and lack of food availability and access. Nutrition-sensitive agriculture could help mitigate these latter impacts of climate change. In this regard, the production of nutritionally rich foods, diversifying diets, food safety, and food fortification need to be promoted and practiced at the household level.

6.9.2 Food safety and nutrition security in CSA

Climate change has been indicated as a driver for food safety issues worldwide, mainly due to the impact on the occurrence of food safety hazards at various stages of food chain. Apart from improving agricultural systems in order to close the nutrition gap, efficient storage and food processing technologies to prolong shelf-life are required. If processing is poor, high food losses can cause food insecurity or increase the risk of producing unsafe and unhealthy food. Food security has been affected by climate change on yields and quality of food. The moldy contamination of foods such as cereals and legumes has received attention because of their acute and chronic effects in humans and animals. Contamination by aflatoxin is one of the food losses with negative health effect.

Aflatoxins are secondary fungal metabolites that contaminate agricultural commodities and can cause sickness or death in humans and animals.

6.9.3 Approach to nutrition-sensitive agriculture

Nutrition-sensitive agriculture stress the multiple benefits derived from enjoying a variety of foods, recognizing the nutritional value of food for good nutrition, and the importance and social significance of the food in agricultural sector for supporting rural livelihoods. The overall objective of nutrition-sensitive agriculture is to make the global food system better equipped to produce good nutritional outcomes.

6.9.4 Proper field management practices

Observing proper field management can increase yields and significantly reduce the risk of aflatoxin development. Such practices include the use of resistant varieties, crop rotation, well-timed planting, weed control, pest control especially control of insect pests and avoiding drought and nutritional stress through fertilization and irrigation. On the other hand, measures to manage aflatoxin contamination **in the field** includes the use of pesticides, timely harvest, and the deployment of the biocontrol product Aflasafe™.

6.9.5 Postharvest interventions

Postharvest interventions to reduce aflatoxin contamination include rapid and proper drying, proper transportation and packaging, sorting, cleaning, drying, smoking, post-harvest insect control, and the use of botanicals or synthetic pesticides as storage protectants.



Another approach is to reduce the frequent consumption of **'high risk' foods** (especially maize and groundnut) by consuming a more varied diet and diversifying the diet into less risky staples like sorghum and millet.

6.9.6 Seasonal variation of food availability

Understanding the seasonal variation in food intake is critical in accurately assessing the adequacy of nutrient intakes of populations to inform the selection and design of strategies to reduce micronutrient deficiency. Seasonal variation in food availability should be considered to have more food options. To have vegetables, fruits, and other food – which are cheap and good sources of micronutrients and protein – available throughout the year, community members could be encouraged to establish home gardens.

6.9.7 Plant health strategies for food and nutrition security

Plants account for over 80% of the human diet. As such, they are essential for food security or the ongoing access to sufficient, affordable, safe, and nutritious food for us all to live active and healthy lives.

6.9.8 Pesticides and herbicides and their effects on human health

Agriculture supports rural livelihood by providing varieties of food and recognizing their nutritional value for good health and productivity. However, can we really have food that is safe for human consumption? This question prompts plant health strategies for food and nutrition security. Possible interactions among elements of the food chain – human health, the environment, and knowledge and education – should be seen from a systemic perspective. In this respect, farmers should know the proper use of chemical pesticides and herbicides, and the effects on their health.

6.10 Gender in nutrition

Women's heavy workload may negatively affect their own food intake, as well as their children's and other members of their families. The combination of low food availability and less time for food preparation may result in lower meal frequency and smaller meals that are less varied and ill-prepared. Shortage of time could also influence a mother's child-caring capacity and quality, with the common alternative option of other family members or other adults standing in for the mother. Without other people to look after their children, mothers, usually working as field laborers, are often forced to take their young with them to the field where it is difficult to provide the desired quantity and quality of complementary food to their children.

Studies on women's seasonal work and pregnancy outcomes have suggested that low birth weights are related to women's seasonal workload. Improved birth weight is as an essential first step in reducing stunting by the age of two. Other potential consequences of increased seasonal workload to women include lack of time for other tasks such as food gathering, house-cleaning, and fuel and water collection. We simply cannot end malnutrition if we don't invest in women.

Conclusion

A child's **first 1000 days** (the period between a woman's pregnancy and her child's second birthday) is the most crucial as it is a unique period of opportunity when the foundations for optimum health and development across the lifespan of a child are established. During this period, the mother and child require the right nutrition and care for survival, proper growth, ability to learn, and rise out of poverty. Although all nutrients are necessary for brain development of a child, key nutrients that support neuro-development include protein, zinc, iron, choline, folate, iodine, vitamins A, D, B6, B12, and long-chain polyunsaturated fatty acids. The lack of these nutrients in the first 1000 days of growth are critical for brain development and may result in irreversible damage to a child's development and lowers the capacity to learn in school. Studies demonstrate that it is far more effective to support brain development in the first 1000 days by preventing nutritional deficits than treating nutritional ailments. Nutrition interventions at school age cannot correct the damage done to the brain in early life. In view of this, the right nutrition for adolescent girls and young women before, during, and after pregnancy is of paramount importance.



7 EFFECTIVE COMMUNICATION AND LEARNING ALLIANCES IN CSA

7.1 Goal

At the end of the training session, participants will be able to have insights on communicating CSA to different stakeholders and of forming alliances as a way of learning together about CSA.

7.2 Specific objectives

At the end of the course, participants will be able to:

- Learn key elements of good communication such as
 - » Understanding your purpose;
 - » Understanding your audience;
 - » Crafting your message; and
 - » Selecting the proper channel.
- Understand what CSA learning alliances are and how they function:
 - » What are learning alliances and who are the members of learning alliances?
 - » Lessons from existing learning alliances.

7.3 The essence of communication



7.3.1 Understand our audience

Understanding our **audience** will enable us to tailor-fit our **message** more accurately. This could be achieved by asking the following:

- What are their needs?
- What are their values?
- What matters most to them?
- What media is the best to reach them?

7.3.2 Message – Give a complete message!

For the audience to understand the purpose of your message, consider the question “What do you want your audience to do and why?”

- Inform – to increase their knowledge.
- Persuade – to take action (e.g. change behavior).
- Motivate – to take action (e.g. change policy).
- Instruct – how to do something (e.g. how to implement a technology)

It is imperative that your message is **clear, simple, and easy to understand and follow**.

7.3.3 Channels of communication

Depending on your communication objective and message, you may consider the following channels:

- Social media (Facebook, WhatsApp, Twitter, Instagram, chats);
- Broadcast media such as radio (traditional and online) and television;
- Social gatherings (ceremonies, funerals, public meetings);
- Face-to-face; and
- Print media (i.e., leaflets, newspapers, pamphlets, booklets)

7.3.4 Factors to consider in choosing a channel

- Message – How complex is your message?
- Cost – How much money do you have?
- Audience preference/accessibility
- Education levels/access
- Age (e.g. young people prefer social media)
- Gender (e.g. women prefer radio while men generally prefer mobile phones)



A mixture of channels works best!

Timing: Examples of factors

- Different messages based on cropping season.
- Timing on media programs (when do the audience listen/watch selected media).
- What time do you hold meeting to get most participants (e.g. when are men or women usually available to attend)?



7.4 Opportunities for CSA learning

CSA Learning Alliances (Lushoto, Kilolo, & Kilosa):

- What are they? – History of learning alliances
- How are they formed?
- CSA learning alliances in Tanzania – Lessons and challenges
- Discussion on opportunities for formation of CSA alliances

7.4.1 TCSAA: Tanzania Climate-Smart Alliance

- Launched in March 2018.
- Its main objective is to serve as a multi-stakeholder platform for the consolidated coordination of actors involved in CSA in order to ensure coherence in the implementation of CSA initiatives, learning, and experience sharing.

7.4.2 Principles of TCSAA

- Voluntary, open and inclusive membership.
- Democratic, transparent, and participatory approach in all undertakings.
- Work through Thematic Working Groups.
- Openly share CSA information, knowledge, experiences, expertise, and support collective learning.
- Free public access and use of TCSAA information.
- Independent and technical CSA platform without any political leanings and undertakings
- Concern for smallholder farming, the environment and rural livelihoods.

Exercise: Planning for CSA communication

Proposed Locations

| Audience | Communication Objectives (What do you want them to do?) | Message | Channel Which channel will be most effective | Timing (Any consideration for timing of message?) |
|----------|---|---------|--|---|
| | | | | |
| | | | | |

Conclusion

Leveraging behavioral change is not easy. Research into climate change communication and adaptation reveals a worrying disconnect between understanding and action. Conveying the urgency, uncertainty, multiple-causes of the problem and the multi-stakeholder nature of adaptation and mitigation can result in paralysis, confusion and feelings of helplessness. In other terms, climate action faces both a “proximity limit” and an “in the future/intergenerational time frame”. The public are more likely to address visible and direct concerns (sanitation infrastructure, water quality, and local habitat protection) than transboundary long-term issues such as biodiversity loss, overfishing, or climate change. Climate change communication needs to become less informational and more audience-centric, with the audience being made to feel an active agent in both the causes and solutions.



8 CSA SELECTION AND ESTABLISHMENT OF A DEMONSTRATION SITE

8.1 Preliminary works

EXERCISE 1: Why do you want to demonstrate CSA in agriculture?



- Most farming technologies are new.
- Farming systems might be new to the place and/or community.
- Farming system is a combination of its components.
- Showcase a special combination of different plants, crops, and animals.
- Demonstrate differences resulting from treatments.

EXERCISE 2

Demonstrate, on paper, examples of your demonstration sites that you are presently conducting, have conducted in the past, or may be planning to in the future. These demo sites do not necessarily have to be on CSA practices and techniques.

8.2 Steps in conducting a CSA demonstration



1. Know your target audience or stakeholders

Possible audience/stakeholders could include:

- Small-scale farmers;
- Extension Officers;
- Policymakers; and/or
- Agricultural Extension Trainees.

Issues to consider:

- Audience
- Demonstration site activities

2. Know the agro-climatic conditions/zone where your site is located:

- Understand the important physical features and weather characteristics of the zone where the demonstration plot is going to be situated.
- Obtain, in a participatory manner, an understanding of the farming systems (e.g. crops grown, cropping calendar, etc.).
- Gather farmers' perceptions of weather patterns, weather variability or history of the weather fluctuations (i.e., wet, dry, and normal seasons).

3. Select and prioritize the CSA intervention:

Engage your audience to organize the workshop. How? By asking in advance, through a rapid appraisal, with some key stakeholders:

- What are the important crops in the area?
- What is the cropping calendar?



- What is the historical weather conditions for normal and extreme weather conditions?



NOTE: This are very important information because it will help you establish an appropriate demo.

8.3 CSA practices

CSA questions to ask in advance:

- What CSA practices do they know about or are familiar with?
- What CSA practice(s) do they practice?



NOTE: Sometimes it might not be easy for them to identify among their practices that can be considered as CSA.

Other questions to ask:

- How do they cope with extreme weather conditions?
- What strategies do they adopt to deal with floods, droughts, soil erosion, hunger, etc.?



NOTE: The strategies they use can now be called their CSA practices. Develop a list of these CSA practices with them.

8.4 Selection of a demonstration site



Criteria for CSA demonstration site selection:

- Ongoing work
- Presence of potential stakeholders
- Accessibility
- Availability of suitable land

8.5 Packaging of CSA practices



CSA has a number of techniques:

- CSAs should be packaged in order to maximize their benefit to the planted crops.
- Consider how many practices and techniques can be conducted at this demonstration site.
- Crops to be planted.
- Planting schedule based on cropping calendar.

8.6 Determining plot size

Plot size will depend on the number of CSA technologies and combinations thereof to be demonstrated. Demonstration field orientation depends on the site features.

8.7 Setting up a field demonstration



After selecting/identifying a suitable location:

- Prepare the land;
- Lay out the field;
- Set up CSA where appropriate; and
- Plant the selected crops.



Table 5: Proposed training schedule

| Day | Time | Event | Facilitators | |
|--|--|--|--------------|--|
| Day 1 | 8:00-8:30 | Arrival and Registration | All | |
| | 8:30-8:45 | Introduction | All | |
| | 8:45-9:00 | Welcome remarks | | |
| | 9:00-9:10 | Project Overview and Training Objectives | | |
| | 9:10-10:00 | Pre-Training Evaluation | All | |
| | 10.00 – 10.30 | Break –Tea | | |
| | Theme 1: CSA terminologies, Practices ,and Technologies | | | |
| | 10:30-13:00 | General Overview Conservation Agriculture practices Soil ffertility management practices and technologies Water harvesting practices and technologies | | |
| | 13.00-14.00 | Break –Lunch | | |
| | 14:00-15:20 | Discussions (clarifications and Q&A) | | |
| | | Group exercise and presentations (four groups, each presenting two topics) | | |
| | Theme 2: Agroforestry and Livestock Management | | | |
| | 15:20-17:20 | General Overview Agroforestry practices and technologies in relation to CSA Livestock management practices and technologies | | |
| Discussions (clarifications and Q&A) | | | | |
| Group exercise and presentations (four groups, each presenting two topics) | | | | |
| 17:20-17:30 | Day 1 evaluation | | | |

| | | |
|---|---|---|
| Day 2 | Theme 3: Crop management and Irrigation | |
| | 08:00 – 10:00 | General overview Crop management practices and technologies CSA irrigation practices |
| | | Discussions (clarifications and Q&A) |
| | | Group exercise and presentations (four groups, each presenting two topics) |
| | 10:00-10:30 | Break -Tea |
| | Theme 4: Agrometeorological and Demo plots Establishments | |
| | 10:30 – 13:00 | Generation and dissemination of agrometeorological information Application of agrometeorological information and advisories CSA selection and establishment of a demonstration site Group exercise and presentations (four groups, each presenting two topics) |
| | 13.00-14.00 | Break -Lunch |
| | Theme 5: Nutrition-sensitive issues | |
| | 14:00 – 15:00 | Nutrition-sensitive CSA Discussions (clarifications and Q&A) |
| Theme 6: Gender Issues and Practices | | |
| 15:00 -16:30 | General overview Gender issues in CSA practices and technologies Mainstreaming gender in CSA practices and technologies Discussions (clarifications and Q&A) | |
| 16:30-17:00 | Day 2: Evaluation, final evaluation, and closing | IITA |
| | | |
| Day 3 | Field Visit | |
| | 08:00 – 5:00 | Site visit report and discussion |





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