Curriculum for Farmer Field Schools on Climate Smart Agriculture in Belize

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ACRONYMS AND ABBREVIATIONS

CSA	Climate Smart Agriculture
EPM	Ecological Pest Management
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmer Field School
GHGs	Greenhouse Gases
IPM	Integrated Pest Management
MAFFESDI	Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development and Immigration
GFCS	Global Framework for Climate Services
ToT	Train of Trainers

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1. PROMOTING CLIMATE SMART AGRICULTURE THROUGH FARMER FIELD SCHOOLS IN BELIZE

Climate change and climate variability are impacting agriculture production in Belize; therefore, it is imperative for the government of Belize to implement actions aiming to reduce the vulnerability of the agricultural sector. Institutional strengthening and improved technical capacities in the agriculture sector of Belize can improve the country's ability to respond to climate risks and take advantage of opportunities that could emerge in the long-run.

The Climate Smart Agriculture (CSA) approach can be seen as a strategy to respond to climate risks. This approach seeks to answer the question "What steps can be taken now to move towards a more sustainable future in agriculture considering climate risks?" (FAO 2016). Building and implementing CSA adapted to local conditions can improve the existing agro-ecological, and socio-economic situation of local communities in Belize.

The government of Belize is interested in using Farmer Field School (FFS) to promote the CSA approach since this methodology has been identified as the most suitable method to work with farmers. Opposed to traditional training approaches that primarily focus on unidirectional teaching/learning processes where the participants (farmers) are passive recipients of information, FFS builds on adult education principles and provides opportunities to put together concepts, methods, and practical experiences. It reinforces the understanding of different topics through field learning exercises, experiments and multiple interactions among the farmers who are organized in a group or a FFS.

In order to facilitate the implementation of FFS to promote CSA in Belize, two documents have been produced: (i) a Training Manual on CSA, and (ii) this curriculum.

The purpose of this FFS curriculum for CSA is to support and guide technicians from the extension service of the Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development and Immigration (MAFFESDI), and other institutions in fostering the Climate Smart Agriculture (CSA) approach. It provides information on how to establish and run FFS, as well as the general requirements needed to implement capacity building and adoption of Climate Smart Agriculture (CSA) innovations. The specific innovations are 25 top agriculture practices that were prioritized by farmers, technicians, and experts in Belize and that are contained in the training manual mentioned above.

These 25 practices represent practical tools that contribute to: (i) increasing agricultural productivity and income in a sustainable way, while ensuring food and nutrition security, (ii) adapting to climate change through improvements in water and soil management, the creation of favorable micro-climatic conditions, better use of agrobiodiversity, the rational management of crop, and animal production, (iii) contributing to reduce or capturing GHG emissions, when possible, in order to reduce the carbon footprint of the agriculture sector in Belize.

1.1 The structure of this "Farmer Field School Curriculum on Climate Smart Agriculture"

This curriculum is organized into ten segments:

Segment 1 provides key information on the importance of a CSA curriculum.

Segment 2 discusses the importance of implementing strategies and approaches to manage agriculture systems for climate change mitigation and adaptation.

Segment 3 discusses the CSA approach and how it can help farmers to better deal with climate change.

Segment 4 describes the conceptual framework of FFS and the general requirements to establish and run FFSs.

Segment 5 explains how to run a FFS session. It describes in detailed how to implement a FFS session to promote each of the 25 top CSA that were prioritized to reduce the vulnerability of producers in Belize to climate change and that are contained in the CSA manual. This segment also introduces segments 6, 7, 8, and 9.

Segments 6 to 9. Segment 6 deals with water management, Segment 7 deals with soil management and plant nutrition, Segment 8 deals with crop management, and segment 9 with animal management. The content of each session is presented as follows:

- General overview
- Learning objectives
- Expected results of this FFS session
- Knowledge requirements for the extensionist or facilitators
- Considerations for site selection
- Materials needed
- Timing considerations

Segment 10 describes enabling conditions required to improve the adoption of CSA practices, including gender consideration, agriculture insurance, and information systems through the implementation of early warning systems.

The CSA Curriculum should be used along with the "Training manual on CSA". These two documents complement each other and will be more effective if used together.

2. FARMER FIELD SCHOOLS DEFINITION AND KEY ELEMENTS FOR ITS IMPLEMENTATION

The Farmer Field School (FFS) is an experiential training methodology **grounded in the principles of adult education**. The methodology focuses on experimental learning, meaning that it focuses on group learning by discovery, experimentation and observation, group analysis of results and making better decisions (Aguilar et al. 2010).

2.1 Experimental learning: the importance and principles of non-formal education

The basic educational concept of the FFS is drawn from adult non-formal education. Non-formal education is a training method based on the assumptions of adult learning. Adults differ from children in the way they learn. Adults already have a lot of experience, knowledge, and skills. They have their own beliefs, values, convictions, and their own perceptions, biases, and feelings. This makes adult learners a very rich resource in the learning process, and that is why it is important that the learning process takes place in a participatory manner so that each learner can share their inputs in the training process (Áskorun, E and Vilhjálmsson 2009; Fenwick 2001).

Farmers need opportunities to experiment with new technologies or alternative practices, to learn how to evaluate different options systematically and to decide for themselves which are worthwhile. This realization can be found in the principles of adult education, which recognize that adults learn best from direct experience and when the topic they are studying is related to their everyday activities. Learning by doing, adds to farmers' knowledge and experience, and improves their capacity as farm managers. Knowledge obtained this way is more easily internalized ("owned") and put into practice after the training is over. Passive exposure to more general extension messages is not as powerful as the discovery-based learning takes place in FFS. Differences between formal and non-formal education are highlighted in Table 1.

2.2 Definition and scope of FFS

A Farmer Field School (FFS) is a season-long training program conducted in the field. The activities follow the different developmental stages of the crop, animal and their related management practices. There are different models for a FFS, but the process is always participant-centered, and relying on an experiential learning approach (FAO 2018; SUSTAINET 2010; FAO 2005)

Farmer Field Schools (FFS) consist of groups of farmers who get together to study a particular topic. FFS provide opportunities for learning by doing. It is also an opportunity where farmers and trainers debate observations, experiences and present new information from outside the community.

Table 1. Differences between formal and non-formal education (Adapted from FAO 2005).

FORMAL EDUCATION	NON-FORMAL EDUCATION
A teacher is involved, not a facilitator to enhance a learning experience	A facilitator is involved to enhance the learning experience
Trainees have to listen to the "teacher"	Participants can give inputs
Information "push", given according to the teacher decides	Information "pull". Information is given according to information needs
Hierarchy (teacher is the "boss")	The learning objective is identified by the group
The teacher has to prepare all sessions and forced into being "expert"	Informal, there is an open exchange of information and equal chance to participate
Trainees are passive receivers of information	Active cooperation and collaboration from all participants
Usually restricted to literates	Illiterates can learn
Teacher lectures trainees	The facilitator is considered a group member and will rely on inputs of the group for discussion of experiences, setting up experiments, etc.

The FFS approach contributes to developing critical analysis, decision-making and communication skills of small-scale and medium-scale farmers in many different contexts and environments, allowing them to build more efficient and sustainable productive systems**.** FFS are important because it empowers farmers with knowledge and skills making farmers experts in their own fields. It also sharpens the farmers' ability to make critical and informed decisions and raise awareness in new ways of thinking and problem-solving.

Core principles of FFS approach (FAO 2018)

- Empowerment comes from collective action
- Knowledge is gained through hands-on learning
- The field is the main learning tool. This is complemented by extension materials
- The curriculum is based on the interests and priorities of the community
- Focuses in developing skills and competencies rather than assimilating knowledge about new technology options
- Meetings are carried out regularly and frequently throughout a season's / production cycle and follow a systematic training process. The frequency of the meetings can vary according to the phases of production and seasons of the year.
- Learning is achieved through a guided process ("facilitation"), not teaching.
- Group members evaluate their FFS and define what follow-up activities are relevant.

2.3 Strengths of FFS

The main strengths of FFS are presented as follows:

- Empowers farmers with knowledge and skills to develop expertise in a farming community
- Makes farmers experts in their own fields
- Provides the opportunity to implement, validate and adapt specific CSA practices to local condition
- Sharpens farmers' ability to make critical and informed decisions
- Enables and provides methodologies for innovative thinking and problem solving
- Offers the opportunity to form farmers groups working together in common related activities and become a platform to initiate community action on a range of topics
- Provides an opportunity to influence local and/or national policies.

2.4 Essential characteristics of a FFS

Fundamental to the success of FFS is the training of trainers or facilitators of the FFS. This often requires re-training of extension personnel in a range of skills and attitudes that were not part of their initial training since they have been traditionally trained in technology/knowledge transfer rather than adult education and participatory learning. FFS require facilitators to have abilities in developing an understanding of the participants of agro-ecological processes, but not through 'lecturing' on these processes, but through facilitating the farmers in discovery exercises to find out and understand these processes (FAO 2005). Subsequently, CSA practices are implemented through the integration of local knowledge of the farmers and ecological knowledge from experience gained in the field.

The following are essential elements of a FFS:

- **Participants/members of a FFS:**

    - The target group of FFS in Belize will be small and medium-size farmers working with the farming systems and crops prioritized by MAFFESDI. The group generally comprises 20-25 individuals who have a common interest, forming the core of a FFS. Farmers should be interested and motivated in learning and implementing CSA practices, must be willing to share their knowledge with other farmers and be able to participate fully throughout the entire FFS.
    - Generally, women play a major role in rural community life and are important decision makers at the household level. It is important to make an analysis of the situation regarding labor division according to gender particularly taking into consideration women and youth at the first gathering of community members. This analysis can be the basis of a discussion on who should participate and the

appropriate learning methods to use. FFS aims at the active participation of women and youth both as facilitators and as participants in FFS. It is important to include women facilitators in any training program.

- **<u>The trained facilitator/extensionist</u>**

    - The role of the facilitator is crucial for successful learning and empowerment because FFS does not focus on teaching but on guiding FFS members through the learning process. To foster the learner center process, the facilitator remains in the background, listening attentively and reflectively, asking questions and encouraging participants to explore more in the field and present their ideas. The facilitator must stimulate FFS members to think, observe, analyze and discover answers by themselves and not deliver top-down instructions. Facilitation is not "teaching farmers", it is creating learning opportunities.
    - Before establishing a FFS, the facilitators must have received a training for the trainers of facilitators in order to implement the CSA practices with the farmers using this methodology. Once trained, the facilitator organizes the field school; facilitates the activities associated with the sessions of the field school; takes care of basic administrative and planning issues; maintains communication between the farmers and local government officials, NGOs and/or other agencies/organizations in the area where the FFS is located.
    - The facilitator is the key to succeed in a FFS. Selection of facilitators should, therefore, be very carefully considered. Facilitators should come from extension agencies that work directly in field level with farmers and/or from the farming community itself (farmer-facilitators). The project or agency that trains the facilitators should also find ways to support local facilitators to follow up on the activities after the FFS has been implemented.

- **<u>The researcher and technical experts</u>**

    - The FFS approach works because it is not top-down or prescriptive. It is a learning process open to examination, discussion, and adaptation by all those involved. This flexible process helps to fine-tune activities and practices to the local agronomic, economic and social context. Agriculture practices and techniques are drawn from formal research, traditional farmer knowledge and experiences from different programs and projects. Technical experts and researchers play an important role in providing advice and recommendations to implement the best suited practices.

- **The field as a classroom**

    - Participants observe and learn from the field work instead of from textbooks and lectures from extension workers. Improved farm practices must be suitable for the local context, which is usually influenced by local ecological and socio-economic conditions, as well as farmers' preferences. The field is the classroom; therefore, site selection is crucial to ensure the maximum learning experience. The farmer who manages the site should be cooperative, influential, have good leadership quality and must be willing to work with other farmers.

2.5 Steps in conducting FFS

Trained facilitators should consider the following steps to establish and conduct a FFS.

- **Step 1. Setting up the stage and organizing the ground working activities.** The facilitator should identify and prioritize problems and needs that local farmers might be facing in a specific community or region. The facilitator should choose the specific CSA practice required to address the specific problem that was previously identified. Use the Training manual on CSA, and the Climate Smart Curriculum to define the specific CSA practice. Once the CSA practice has been identified, it will be necessary to identify an adequate field site to implement the practice.

- **Step 2. Establishing and running FFS.** With the guidance of the facilitator, the group meets regularly and carries out the practice either through exercises, field trials/visits to learn how to implement the selected practice. The facilitator will be responsible for all the event planning and logistics prior to the implementation of the practice and for guiding the participants during the field day. The facilitator will take into consideration the group dynamics and provide all the tools and information needed so that the farmer can gain the knowledge, practical skills and feel confident to implement the practice.

- **Step 3. Learning stage.** Once the FFS season ends, farmers have the knowledge and confidence on how to implement the CSA practice. Farmers graduate and area awarded with certificates and are ready to start their own FFS. At this stage, it is important to evaluate the farmer´s learning process (positive and negative feedback) to improve the learning experience for future training events.

- **Step 4. Farmer implements FFS**. The farmer has the knowledge and skills to implement the practice and the ability to multiply the knowledge and skills with other farmers.

- **Step 5. Following up process.** Core facilitators will follow-up on FFS with farmers that have graduated. Facilitators can also document the impacts of the implemented CSA practice and evaluates the implementation process in terms of successes and new challenges that might arise in the field.

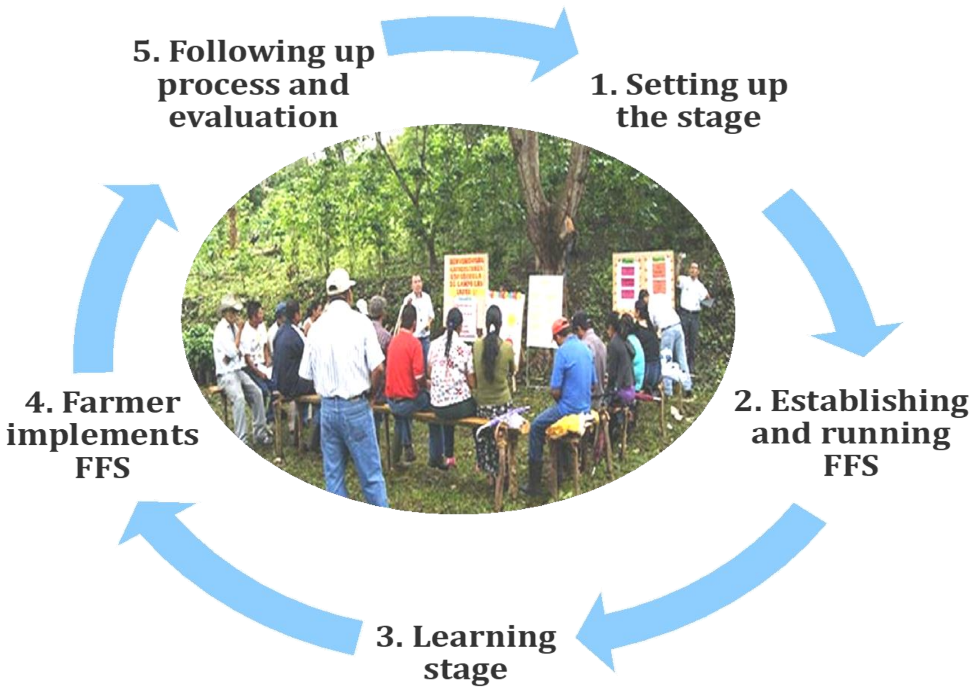

Figure 3. Steps in conducting FFS (Adapted from SUSTAINET 2010)

Conditions of a successful FFS

- Well trained facilitators
- Define the CSA practice to be implemented
- Organized community/farmers who are willing and committed
- Support and goodwill of the organizations/institutions involved during the training process
- Availability of the appropriate technology that will be used
- Proper identification and selection of facilitators and farmers that will participate in the FFS
- Good logistical support
- Proper and guaranteed supervision, monitoring and evaluation of FFS

3. FARMER FIELD SCHOOLS FOR CLIMATE SMART AGRICULTURE IN BELIZE

3.1. Context of FFS in Belize

The Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development and Immigration (MAFFESDI) is the government institution in Belize that in charge of the agriculture, forestry and agriculture sector. From the agricultural sector, the strategic work of MAFFESDI is centered on:

- Facilitating the growth of the agricultural sector to reduce rural poverty.
- Enabling a favorable environment to increase the efficiency, productivity, profitability, and competitiveness of the agriculture and collaboration with other sectors.
- Contributing to the diversification in agriculture production, processing, and exports.
- Improving and conserving the natural and productive resource base to ensure long-term sustainable productivity and viability.
- Improving access to productive resources and services and create economic opportunities for small/young farmers, women, and indigenous people, particularly in poor, marginal areas.
- Strengthening the institutional capacities to provide effective support in marketing and trade, research and extension, as well as relevant education and training.
- Implementing actions that can contribute to increasing food production, enhance food security and improve the nutritional status of the population, as well as increasing farm incomes.
- Strengthening inter-sectoral linkages, in particular with the social sectors of health and education, as well as with the strategy and action plan for poverty eradication.

MAFFESDI is considered to be the primary provider of extension service support, technology transfer and technical assistance in the country. Its main goal is to "train and build capacity among agricultural producers, women, and youth of the rural areas of Belize, to identity main problems and motivate people to find solutions to production problems". MAFFESDI also works in coordination with non-government agencies to develop different kinds of training programs including farmers training. Many of these training programs have focused on the integrated farming system, post-harvest technologies, pest control, improved genetic material, among others (CARDI, n.d.), this is the reason why the FFS training on Climate Smart Agriculture will be coordinated directly with MAFFESDI.

3.2. Why to use FFS in Belize?

Traditional training approaches in extension services have primarily focused on unidirectional teaching/ learning processes, where the participants (farmers) are passive recipients of the information. FFS is an opportunity to put together concepts, methods and practical experiences to reinforce the understanding through field learning exercises, experiments and multiple interactions with the group. The knowledge gained through the multiple interactions and practical experiences enables participants to learn and make a locally specific decision about crop management practices. As a result, participants empower themselves to adopt specific CSA practices which can bring benefits to the local farmers in different regions of Belize. FFS methodology also represents an effective mechanism for group training that can reach thousands of small-scale farmers with knowledge and technical content that each can adapt to their own unique circumstances. Beyond this, these processes empower farmers, both individually and collectively, to more effectively participate in the processes of agricultural development and management considering the climate risks of Belize.

4. THE CURRICULUM ON CLIMATE SMART AGRICULTURE

This section presents key information that will help extensionists to run FFS to promote CSA as a strategy to deal with the negative effects of climate change in Belize.

First background information on the effects of climate change in agriculture will be presented both globally and specifically for Belize. Extensionist should manage this information in order to justify the use of the CSA approach in Belize.

Next, the top 25 CSA practices prioritized for Belize are presented. These practices comprise the central body of work over which this curriculum is developed. The 25 practices represent practical tools to contribute to: (i) increasing agricultural productivity and incomes in a sustainable way, while ensuring food and nutrition security, (ii) adapting to climate change through improvements in water and soil management, the creation of favorable micro-climatic conditions, better use of agrobiodiversity, the rational management of crop, and animal production, (iii) contributing to reduce or capturing GHG emissions, when possible, in order to reduce the carbon footprint of the agriculture sector in Belize.

The 25 practices are presented in the "Training manual on CSA" grouped in four dimensions that are key to advance towards more resilient agriculture: water management, soil management and plant nutrition, crop management, and animal management. Therefore, this curriculum follows the same structure.

4.1 Climate change and the agriculture sector

4.1.1 Context of the CSA

Between now and 2050, the world's population will increase by one-third. Most of these additional 2 billion people will live in developing countries. At the same time, more people will be living in cities. If current income and consumption growth trends continue, FAO estimates that agricultural production will have to increase around 60 percent by 2050 to satisfy the expected demands for food and feed (FAO 2013).

Agriculture must, therefore, transform itself if it is to feed a growing global population and provide the basis for economic growth and poverty reduction. Climate change will make this task more difficult, due to the adverse impacts of climate change on agriculture. To achieve food security and agricultural development goals, adaptation to climate change and lower emission intensities per output will be necessary. This transformation must be accomplished without depletion of the natural resource base.

Climate change is already having an impact on agriculture and food security as a result of increased prevalence of extreme climate events and increased unpredictability of weather patterns. This can lead to reductions in agriculture production and lower incomes of small-scale farmers living in vulnerable areas. These farmers often lack knowledge about potential alternative options for adapting their production systems and have limited assets and risk-taking capacity to access and use technologies to implement better agricultural practices (FAO 2013).

Enhancing food security while contributing to mitigate climate change and preserving the natural resource base and vital ecosystem services requires the transition to an agricultural production system that is more productive, with less and more efficient use of inputs, and are more resilient to climate risks, shocks, and long-term climate variability. More productive and more resilient agriculture requires a major shift in the way land, water, soil nutrients, and genetic resources are managed to ensure that these resources are used more efficiently. Making this shift requires considerable changes in national and local governance, legislation, policies, and financial mechanisms to support these changes. This transformation will also involve improving farmers' access to markets. By reducing greenhouse gas (GHG) emissions per unit of land and/or agricultural product and increasing carbon sinks, these changes will contribute significantly to the mitigation of climate change (FAO 2013).

CSA is an approach that can contribute to developing the technical, political and investment conditions to achieve sustainable agricultural development for food security under climate change conditions. The magnitude, immediacy and broad scope of the effects of climate change on agricultural systems create a compelling need to ensure comprehensive integration of these effects into national agricultural planning, investments, and programs. The CSA approach is, therefore, an alternative designed to identify and operationalize sustainable agricultural development within the explicit parameters of climate change.

4.1.2 Agriculture as a source of Green House Gas (GHG) emissions

The Intergovernmental Panel on Climate Change (IPCC) estimates that 24% of global anthropogenic emissions of greenhouse gases in 2010 was originated from agriculture and land use change (Smith et al 2014). Around 10–12% came directly from agriculture (UNEP 2013; Tubiello et al 2013) and 10–13% from changes in land use largely associated with food production (Houghton et al 2012).

Most farm-related emissions come in the form of methane (CH_4) and nitrous oxide (N_2O). Livestock production (CH_4) and the addition of natural or synthetic fertilizers and wastes to soils (N_2O) represent the largest sources, making up 65 percent of agricultural emissions globally. Smaller sources include manure management, rice cultivation, field burning of crop residues, and fuel use on farms. At the farm level, the relative size of different sources will vary widely depending on the type of products grown, farming practices employed, and natural factors such as weather, topography, and hydrology.

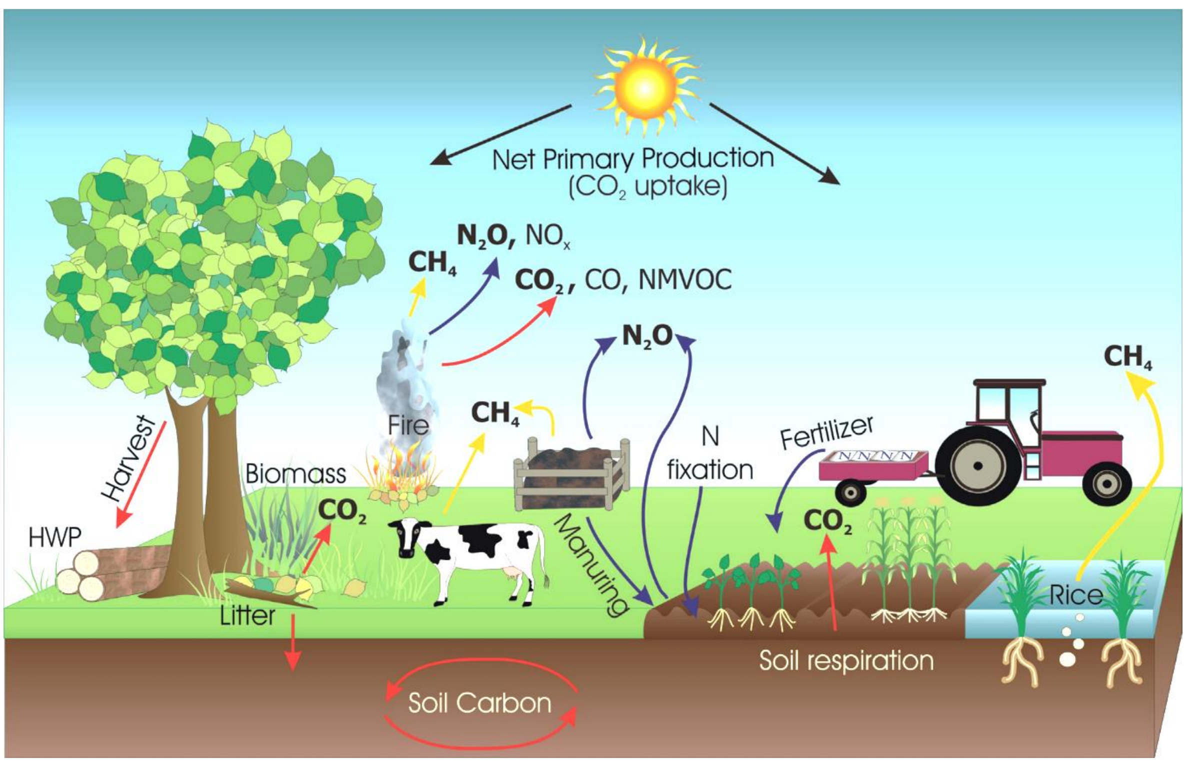

Figure 1. Farming emissions come from a variety of sources that differ depending on the type of farm. Here are some examples of GHG emissions that come from an agricultural system. *Source*: IPCC 2006.

Changes in both farming practices and food demand offer big opportunities. On the supply side, crop management practices—such as improved fertilizer management and conservation tillage—offer the greatest reduction potential at a relatively low cost. Better managing livestock lands—through rotational grazing and altering forage composition—and restoring degraded lands and improving soils to increase productivity are also important.

On the supply-side, shifting away from meat particularly from beef consumption and/or improving livestock production systems offers the most potential for reducing GHG emissions. A WRI research showed that about 24 percent of all calories currently produced for human consumption is lost or wasted in the food supply chain. Consequently, reducing food losses and wastes can also play an important role. These elements are integrated into the CSA (WRI. Green House Protocol).

4.1.3 Climate change adaptation in the agriculture sector

Agriculture is not only one of the main drivers of climate change, but it is one of the most vulnerable sectors to climate change. Vulnerability studies and assessments on the impacts of Climate Change on agriculture and food security in the sub-regions of Central America and the Caribbean including Belize indicate a reduction in yields for several key crops (Ramirez et al. 2013), increasing stress and reduction in livestock production, increased crop pests and animal diseases, continued degradation of recharged areas and scarcity of water, and a threat to the livelihood security of thousands of persons and their families who depend directly or indirectly on agriculture for their survival.

Specific adaptation strategies and actions are important to reduce climate change vulnerability of farmers and agriculture sector-dependent communities such that the expected negative impacts may be smaller or eliminated.

4.1.4 Climate change and the agriculture sector in Belize

The agriculture sector is of critical importance to foster social, economic and environmental sustainability in Belize. Agriculture is the second most important sector in the provision of employment and is a key contributor to Belize’s food and nutrition security. Belizean agricultural sector is also very vulnerable to the adverse effects of climate change and climate variability.

According to climate change and climate variability projections to 2050, climate change will impact agriculture systems; this will generate impacts in fertility, pest and disease control, and affect water availability. Higher temperatures will also cause increased stress on current livestock breeds, crop types, and varieties. Climate change and climate variability will very likely result in a decrease amount of rainfall and changes in the seasonal distribution of rainfall, leading to a drier or wetter set of conditions.

4.2 The climate-smart agriculture approach

4.2.1 Definition

Climate Smart Agriculture (CSA) may be defined as an approach for transforming and reorienting agricultural development under the new realities of climate change (Lipper et al. 2014). The most commonly used definition is provided by the Food and Agricultural Organization of the United Nations (FAO), which defines CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances the achievement of national food security and development goals".

4.2.2 The pillars of CSA

The main goal of CSA is to develop an agriculture that contributes to increasing food security and development (FAO 2013) through productivity, adaptation and climate change mitigation. These are the three interlinked pillars (Figure 2) necessary for achieving this goal. The three pillars of CSA are:

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

- **Adaptation:** CSA aims to reduce the exposure of farmers to short-term risks, while also strengthening their resilience by building their capacity to adapt and prosper in the face of climatic shocks and longer-stresses. Particular attention is given to protecting the ecosystem services provided to farmers and others. These services are essential for maintaining productivity and have the ability to contribute to climate change adaptation.

- **Mitigation:** Wherever and whenever possible, CSA should help to reduce and/or remove GHG emissions. This implies the reduction of emissions for each calorie or kilo of food, fiber, and fuel that is produced. It is important that we avoid deforestation from agriculture, and that we manage soils and trees in ways that maximize their potential to act as carbon sinks and absorb CO_2 from the atmosphere.

Figure 2. Pillars of the Climate Smart Agriculture approach. Modified from Source: Modified from CSA Guide n.d.

4.2.3. CSA as a strategy to reduce climate risk in agriculture

Climate change is already increasing average temperatures around the globe and, in the future, the temperature is projected to be warmer. This, in turn, will alter how much precipitation falls, where and when. Combined, these changes will increase the frequency and intensity of extreme weather events such as hurricanes, floods, heat waves, snowstorms, and droughts. They may also cause sea level rise and salinization, as well as perturbations across ecosystems. All of these changes will have profound impacts on agriculture, forestry, and fisheries (FAO 2013).

The agriculture sector is particularly vulnerable to climate change because different crops and animals thrive in different conditions. This makes agriculture highly dependent on consistent temperature ranges and water availability, which are the factors that climate change threatens to undermine. In addition, plant pests and diseases will likely increase in incidence and spread into new territories (Grist 2015) bringing new challenges for agricultural productivity.

Climate change is impacting in a significant way the agriculture sector; therefore, incorporating adaptation into agricultural plans, actions, investments, and policies is needed to maintain and improve the benefits obtained from the agriculture production systems. Reducing climatic risks involve increasing the resilience of production systems through improved management to increase productivity and resilience of local livelihoods.

The CSA approach seeks to answer the question "what steps can be taken now to move towards a more sustainable future in agriculture taking into consideration climate risks". Building and implementing CSA adapted to local conditions can improve the existing agro-ecological, and socio-economic situation of local communities.

4.2.4 Principles defining CSA practices

Agriculture must improve and ensure food security, and to do so, it needs to adapt to climate change taking into account natural resource pressures while contributing to mitigating climate change, when possible. These challenges, being interconnected, have to be addressed simultaneously, therefore, agriculture systems have to become more efficient and resilient at the same time and at different scales. They have to become more efficient in resource use and be more resilient to climate changes and shocks.

The major principles that need to be taken into account when promoting CSA practices include:

- **Increasing resource use efficiency in agricultural systems.** Agriculture is a driver of deforestation, therefore, reducing agricultural expansion through sustainable intensification on already cultivated land could have a major mitigation effect. Transforming sustainable intensification would be particularly efficient in areas with very low productivity systems. Crop systems and livestock systems can also be improved through a more integrated approach. Integrated crop and livestock systems, at various scales (on-farm and off-farm), increase efficiency and environmental sustainability. When livestock and crops are produced together, the waste of one is a resource for the other. Manure increases crop production and crop residues and by-products feed animals, improving their productivity.

- **Enhancing the resilience of agricultural systems and the people who depend upon them.** Climate change will profoundly affect, in any given place. It will affect existing risks and add new risks and uncertainties. Greater frequency of extreme events, increased temperatures, changes in rainfall patterns and greater intensity of rainfalls that are expected to result from climate change will increase uncertainty and risk in agricultural production. Long-term changes in temperature will slowly lead to fundamental changes in the plant and animal species that can be used for agriculture in a particular location. The emergence of new pests and diseases, as well as new trading patterns, are likely. To cope with these changes, land users need to be flexible and develop a learning attitude. The diversification of production and the management of the agricultural system provides this flexibility and facilitates risk management.

- **Seeking opportunities to reduce and remove green-house gas emissions when feasible.** Many agricultural systems can be designed to increase the carbon content of the soils and aboveground biomass, and enhance productivity and climate resilience. Mitigation co-benefits can be enhanced through integrated management of agriculture and landscapes by seizing mitigation opportunities through increased biomass production. Increasing or intensifying productivity in a sustainable way also offers important opportunities for mitigating climate change by decreasing deforestation, rehabilitating degraded lands and reducing pressure on surrounding natural ecosystems.

Despite the fact that CSA aims to attain all three objectives, it does not imply that every practice applied in every location should generate all these “triple wins”. This can be challenging in practice.

5. RUNNING SESSIONS ON THE 25 TOP CLIMATE SMART AGRICULTURE PRACTICES

As indicated before, this curriculum was developed around 25 CSA practices that were prioritized by Belizeans farmers and technicians in2018. They were prioritized taking into account current vulnerabilities, as well as future climate risks identified the National Adaptation Strategy to Address Climate Change in The Agriculture Sector in Belize (CCCCC 2015).

The 25 practices are presented in the “Training Manual on Climate-Smart Agriculture,” therefore, this curriculum should be used along with the training manual.

The 25 practices are presented grouped in four dimensions that are key to advance towards more resilient agriculture: water management, soil management and plant nutrition, crop management and animal management (Table 5.1). Therefore, this curriculum follows the same structure.

1. **Water management.** Water plays a key role in crop and agricultural production. The most direct impact of climate change on the water for agriculture will be related to increased variability of rainfall, higher temperatures, and water associated extreme weather events, such as droughts and floods. All of these events have been identified as some of the main factors that make farmers in Belize vulnerable to climate change. Due to water management complexity, many options for improved water management relate to other dimensions of the agriculture such as soil management, crop production, livestock management, Forestry, and Agroforestry, among others (FAO 2013 and (CCAFS, n.d.b). Four practices were included in this section three for dealing with water deficits, and one for dealing with a water excess.

2. **Soils management and plant nutrition. Maintaining or improving soil health is** essential for sustainable and productive agriculture. ‘Healthy’ soil will help push sustainable agricultural productivity close to the limits set by soil type and climate (CCAFS, n.d.b). The most direct impacts of climate change on soils in agriculture will be related to the decline of rainfall, and/or to occur in more intense rainfall events

and an increase in evaporation and transpiration rates. These changes will reduce the availability of soil moisture for plant growth. The higher temperatures will also increase the rate of Soil organic matter decomposition (mineralization), especially near the soil surface, which will affect the soil's potential capacity to sequester carbon and retain water. Six practices, three for soil nutrition management and three for plant nutrition are included in the Training Manual on CSA.

3. **Crop management.** Another effect of climate change will be variations in the geographic distribution and population dynamics of insect pests, as well as increases in the incidence of disease on both crops and animals. This reality calls for the use of integrated approaches such as **Integrate Pest and Disease Management (IPDM),** a holistic approach of managing pests, diseases, and weeds by working, as the first choice, with nature through encouraging beneficial organisms rather than by working against nature by killing noxious ones with pesticides. At the same time, farmers need to **optimize production** by using both **planning tools and practices to protect crops and the products once they are harvested**. Nine practices, four related to integrated pest and disease management, and five for production optimization practices are included in the Training Manual on CSA.

4. **Animal management.** Climate change is likely to have considerable impacts on livestock, poultry, and in general in animal production. These will include a substantial reduction in the quantity and quality of forage or other sources of local food, available. Impacts will also include the spread and severity of existing vector-borne diseases and macro-parasites, accompanied by the emergence and circulation of new diseases. At the same time, animal production will benefit from shifting to feed resources with a low-carbon footprint in order to reduce emissions, especially for concentrated pig and poultry production systems. (CCAFS, n.d.b). Six practices, two for livestock, two for poultry and two for bee keeping are included in the Training Manual on CSA.

Table 2. Twenty-five top CSA practices

DIMENSION		PRACTICE No.	NAME OF PRACTICE
1. **Water management**	Water deficit	1	Rainwater harvesting and storage
		2	Irrigation schedule
		3	Low energy precision irrigation application (LEPA)
	Water excess	4	Drainages
2. **Soil Management and Plant Nutrition**	Soil Fertility Management	5	Integrated soil fertility management
		6	Incorporation of organic matter
		7	Transformation and use of sugarcane bagasse
	Plant nutrition	8	Foliar and tissue analysis
		9	Foliar application of fertilizers
		10	Foliar application of inputs and irrigation
3. **Crop management**	Integrate Pest and Disease Management	11	Ecological management and control of pests
		12	Biological control of pests and diseases
		13	Visual monitoring of pests
		14	To alternate the use of pesticides
	Production Optimization	15	Farm and home garden planning
		16	Selection and use of improved varieties of seeds (drought-tolerant beans and maize)
		17	Protecting bananas against wind: Shoring and staking
		18	Production in protected environments
		19	Post-harvest management
4. **Animal Management**	Livestock Management System	20	Silvopastoral systems and improved pastures
		21	Grass silage
	Poultry Management System	22	Poultry health management
		23	Poultry nutrition with local and home-made concentrates
	Bee Keeping	24	Bee-friendly management of biodiversity (landscape and system level; corridors for biodiversity conservation and connectivity)
		25	Bee-friendly input management (Reduction of pesticides & organic agriculture)

6. RUNNING FARMER FIELD SCHOOL SESSIONS FOR WATER MANAGEMENT

Water plays a key role in crop and agricultural production. The most direct impact of climate change on the water for agriculture will be related to increased variability of rainfall, higher temperatures, and water associated extreme weather events, such as droughts and floods. All of these events have been identified as some of the main factors that make farmers in Belize vulnerable to climate change. Due to water management complexity, many options for improved water management relate to other dimensions of the agriculture such as soil management, crop production, livestock management, Forestry, and Agroforestry, among others (FAO 2013 and CCAFS, n.d.b, cited by CATIE 2018).

Water requirements and availability are critical factors that determine the extent of climate change impacts on agriculture (FAO 2011). Climate change and climate variability can also have adverse impacts on food production by increased water deficits resulting from growing water requirements (crop evapotranspiration) and reduced water availability from effective precipitation (Mimi and Jamous 2010), particularly during a dry period of time.

Water management is a key element of CSA. More productive and more resilient agriculture requires a major shift in the way land and water are managed to ensure that these resources are used more efficiently. This includes a range of practices and methods to both reduce water deficit by improving rainwater capture and storage, as well the efficiency in the use of water use, and practices to manage water excess. Four practices are included in the Training Manual on CSA and therefore are included in this curriculum as well. Three of the practices deal with water deficits, and one deal with a water excess.

6.1 FFS session for managing water deficit

6.1.1 CSA Practices for managing water deficit.

Three practices to deal with water deficit were prioritized by farmers and technicians in Belize. These three practices are explained in detail in the Training Manual on CSA. During the FFS session for managing water deficit, the extensionist/facilitator should constantly consult the data sheets 1 to 3 of the mentioned training manual. The data sheets contain most of the information needed to carry out this FFS session.

A summary of each practice is presented as follows:

	Data sheet	Summary
Managing Water Deficit	**CSA PRACTICE No. 1 Rainwater harvesting and storing**	Rainwater harvesting and storing consists of capturing and storing rainwater runoff for reuse. By using different types of storage structures or technologies, rainwater is collected during the wet period, in order to offset water deficit during dry periods. Rainwater harvested is used to supply the water needed by the crops or to implement agricultural practices required for the development of the crop and for other purposes such as domestic or animal use.
	CSA PRACTICE No. 2 Irrigation scheduling	Irrigation scheduling consists in synchronizing water supply with crop demand by taking into consideration rainfall availability to fully wet the plant's root zone by minimizing overwatering especially during very dry periods considering the different phases of the growing season.
	CSA PRACTICE No. 3 Low energy precision irrigation application – LEPA	LEPA is a type of irrigation system that supplies water at the point of use and reduces water consumption by increasing irrigation efficiency and water productivity. LEPA supplies irrigation water to crops very close to the soil surface or onto the crop canopies in order to reduce non-beneficial consumptive water uses.

6.1.2 General overview

Water deficit management practices improve both water availability and irrigation efficiency and reduce the risks of crop failure. The use of these two types of practices could result in larger yields and crop quality increases to growers, especially in the presence of water shortages (deficits) due to climate change and variability. These practices also represent a key climate-smart agriculture approach since they are centered on capturing and storing of water, as well as managing and increasing the productivity of water to stabilize and improve crop productivity, minimize energy use and costs and reduce vulnerability to climate risks.

6.1.3 Learning objectives

The learning objective of this FFS session is to contribute to enhancing the capacities of the participants to implement technologies to increase water availability during critical times of the year when water availability is limited for agriculture production. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of the CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand and apply concepts related to the design and construction of rainwater harvesting and storage to supply water during water deficit periods for different types of users and scales (from roof rainwater harvesting to lagoons)
- Understand how to design and implement water-efficient irrigation systems including:
    - LEPA systems for different types of users at different scales, and
    - irrigation scheduling for different users
- Familiarize the participants with the equipment components and their use to implement the rainwater harvesting and storage and irrigation efficiency systems

6.1.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the FFS training session:

- Knowledge strengthened on how to reduce vulnerability to water deficit through the use of rainwater harvesting and storage, and efficient use of water irrigation technologies (see points 1 to 4 of data sheets No. 1, 2, and 3)
- Knowledge strengthened about how water deficit technologies could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheets.
- Knowledge and practical skills strengthened in the design, construction, and management of rainwater harvesting and storage, and efficient use of water irrigation technologies. Please see point 6 and 7 of data sheets No. 1, 2, and 3.
- The hands-on experience acquired in designing, implementing and managing rainwater harvesting and storage systems, as well as in irrigation efficiency technologies to improve water efficiency and productivity. Please see point 6 to 7 of the data sheets.
- The clear understanding of the requirements and key challenges commonly faced when implementing these three practices. Please see point 7 of the data sheets No. 1, 2, and 3.

6.1.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.

- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- how to build, install rainwater, harvesting and storage systems.
- how to build, install irrigation efficient technologies
- be familiar with water balance methods to establish irrigation scheduling systems.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide the technical support for the design and implementation of both proper rainwater, harvesting and storage systems, as well as water irrigation technologies. Experts should be identified and invited to join the team.

6.1.6 Considerations for site selection

- For the **rainwater harvesting and storage system**, it is recommended to implement the system in a local farm that offers adequate conditions for the rainwater harvesting and storage structures. The climate adaptation strategy for the agriculture sector of Belize recommends the construction of one water catchments structure in each of the following districts of Orange Walk, Corozal, and Cayo. This with the objective to serve as demonstrations to farmers in terms of design, water storage and retention capacity (CCCCC 2015).

- Select the appropriate rainwater harvesting and storage system according to the specific water use required by the farmers and local conditions. For example: if it is for domestic use, consider harvesting water from roof tops and storing it in PVC or concrete tanks near the house or farm sheds. If it is for vegetable and animal production, consider roofs and other structures of the farm to capture the water such as farm sheds, road surfaces, tanks, ponds, lagoons, terraces, water retention ditches, among others. Some of these structures might require a large area of land. Consider issues related to the area required to install the type of rainwater harvesting and storage system as well as the types of conduits and distance required to move the water from the harvesting and storage systems to the final use.
- For the **LEPA system**, use visual didactic tools and design a LEPA system that can be adapted to the conditions and requirements for small and medium scale farms.
- For **irrigation scheduling,** it is required to have a water irrigation system that is adapted and best suited to the crop system e.g. drip irrigation, mist pipes, sprinklers, etc. Based on the irrigation system, calculate the soil water storage capacity, the estimated amount of water required by the crop system and the irrigation intervals.
- Visit the selected site at least a week before to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice.

6.1.7 Materials needed

- The Training Manual on CSA, data sheets Number 1, 2 and 3.
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Materials/equipment needed for the implementation of the practice, including the materials and equipment used to build the selected rainwater harvesting and storage system
- Visual materials to explain how the LEPA system works. Provide materials, equipment, and accessories to design and implement a simple LEPA system that could work on a small farm to show the functionality of the system.
- Include refreshments

6.1.8 Timing considerations

Any time of the year but it is recommended that the structures (rainwater harvesting, storage, and irrigation systems) be ready to be used before the rainy season starts, so the farmers can capture and store rainwater when is available to guarantee a source of water during the drier periods of time. It is also important to implement and test water irrigation systems and water scheduling before the dry season to maximize water efficiency and use it especially during the critical periods of the year.

6.2 FFS for managing water excess

An adequate supply of soil water is essential for plant growth and for transporting plant nutrients to roots, but the excess of water in the root zone is a problem for most crops. Excess of water in the soil could result in reduced crop yields. More productive and more resilient agriculture requires a major shift in the way land and water are managed to ensure that these resources are used more efficiently during critical times of the year.

6.2.1 CSA Practices for managing water excess

One practice to deal with water excess was prioritized by farmers and technicians in Belize. This practice is explained in detail in the Training Manual on CSA. During the FFS session for managing water excess, the extensionist/facilitator should constantly consult the data sheet number 4 of the mentioned training manual. The data sheet contains most of the information needed to carry out this FFS session.

A summary of the practice is presented as follows:

	Data sheet	Summary
Managing Water Excess	**CSA PRACTICE No. 4: Drainages**	Agricultural removes of water and/or salts present in excesses in the soil zone where roots are located. As a consequence, it is possible to provide an adequate oxygenated environment suitable for normal development of the roots. Keeping an adequate relative proportion of water and air content that matches the crop physiological needs enables soil sustainability for crop productivity. The hydraulic structures used to establish the drainages are usually integrated into a system of channels that are built on the surface of the field or under the surface. The system of channels can facilitate the drainage of water runoff in case of rainfall excess, floods or soil moisture increase, eliminating in this way the negative impact that these factors have on crops (Gurovich and Oyarce 2015) in order to increase plant growth and optimize crop production. Drainage is a suitable CSA practice to reduce the impacts of soil moisture surplus, and/flood/waterlogging in crops which are the major risks associated with a water excess.

6.2.2 General overview

Water excess management practices aim at providing an adequate oxygenated environment suitable for the roots of normal development. Keeping an adequate relative proportion of water and air content that matches the crop physiological needs enables soil sustainability for crop productivity.

6.2.3 Learning objectives

The learning objective of this FFS session is to contribute to enhance the capacities of the participants, to implement water drainage systems to eliminate excess water to increase plant growth and optimize crop production. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand and apply concepts to increase crop yields in poorly drained soils.
- Understand and apply concepts to improve soil quality and increase efficiency in fertilizer use.
- Understand and apply concepts to reduce the content of salts in the soils that have been waterlogged
- Familiarize the participants with the equipment components to build different types of drainages systems that can be implemented on the farm.

6.2.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the training:

- Knowledge strengthened on how to reduce vulnerability to water excess through the use of drainages (see points 1 to 4 of the data sheet)
- Knowledge strengthened about how technologies to manage water excess could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheet.
- Knowledge and practical skills strengthened in the design, construction, and management of drainage systems. Please see point 6 to 7 of the data sheets.
- Knowledge and practical skills on how to increase and improve crop production in waterlogged soils. Please see point 6 to 7 of the data sheets.
- A clear understanding of the requirements and key challenges commonly faced when implementing these two practices. Please see point 7 of the data sheets.

6.2.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills about:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- how to build water drainage systems.

If the extensionist/facilitator does not have this knowledge, experts should be identified and invited to join the team. In addition, in the case of drainage systems, it is important to receive the technical support of specialists that can implement and design a proper drainage system for specific crop needs.

6.2.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. The selected family or property owner should be willing to participate and be engaged throughout the training process and be willing to receive regular visits from the training team and a group of farmers.
- The selected family should be interested in implementing a drainage system that responds to specific farm use and type of crop system. Consider issues related to the amount of space required to install the type of drainage systems and the materials needed to implement the practice.
- Visit the selected site at least a week before to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice.

6.2.7 Materials needed

- The Training Manual on CSA, data sheet Number 4.
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed for the implementation of the practice. These include the materials and equipment used to build the selected drainage system.
- Use visual materials to explain how the different types of drainage systems. Provide materials, equipment, and accessories to design and implement it in the field.
- Include refreshments

6.2.8 Timing considerations

Any time of the year but it is recommended that the hydraulic structures be ready to be used before the rainy season starts in order for the farmer to be prepared to face the possible any possible adverse effects related to heavy rainfall and minimize the impacts of excess water in the crops.

7. RUNNING FARMER FIELD SCHOOL SESSIONS FOR SOIL MANAGEMENT AND PLANT NUTRITION

Soil fertility and plant nutrition encompasses the management of essential elements necessary for plant growth, typically to achieve good crop production. Actively managing soil nutrients to provide optimum plant nutrition is a core practice of agricultural production (McGrath et al. 2014). Maintaining or improving soil health is essential for sustainable and productive agriculture. The most direct impacts of climate change on soils in agriculture will be related to the decline of rainfall, and/or to occur in more intense rainfall events and an increase in evaporation and transpiration rates. These changes will reduce the availability of soil moisture for plant growth. The higher temperatures will also increase the rate of soil organic matter decomposition (mineralization), especially near the soil surface, which will affect the soil's potential capacity to sequester carbon and retain water. Six practices, three for soil nutrition management, and three for plant nutrition are included in the Training Manual on CSA.

7.1 FFS for soil fertility management

7.1.1 CSA Practices for soil fertility management

Three practices to deal with soil fertility management were prioritized by farmers and technicians in Belize. These three practices are explained in detail in the Training Manual on CSA. During the FFS session for managing water deficit, the extensionist/facilitator should constantly consult the data sheets 5 to 7 of the mentioned training manual. The data sheets contain most of the information needed to carry out this FFS session.

A summary of each practice is presented as follows:

	Data sheet	Summary
Soil Fertility Management	**CSA PRACTICE No. 5 Integrated soil fertility management**	Integrated soil fertility management (ISFM) is a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm, combined with the knowledge of how to adapt these practices to local conditions. It is aimed at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic principles. ISFM strategies center on the combined use of mineral fertilizers and locally available soil amendments (such as lime and phosphate rock) and organic matter (crop residues, compost, and green manure) to replenish lost soil nutrients.
	CSA PRACTICE No. 6 Incorporation of organic matter	Incorporation of organic matter consists of incorporating plant and animal residues in various stages of decomposition to the surface layers of the soil. These residues release nutrients as they decompose, which are then released into the soil, making them available to crops. Organic matter is any material of animal or plant origin that returns to the soil after a process of decomposition in which various microorganisms participate. Organic matter includes leaves, dead roots, exudates, manures, urine, feathers, hair, bones, dead animals, and microorganisms products (bacteria, fungi, and nematodes that contribute organic substances to the soil or their own cells when they die).
	CSA PRACTICE No. 7 Transformation and use of sugarcane bagasse	Bagasse is a dry pulpy residue obtained as a byproduct after the extraction of sugar from the sugar cane. Bagasse is 50% moisture, 45% fiber and 5% soluble solids. This is a very good composition for transforming this byproduct as organic fertilizer to improve soil fertility.

7.1.2 General overview

Fertility management integrates the disciplines of soil chemistry, soil biology, soil physics, and plant science to develop practices that can provide the essential elements required for adequate plant growth to maximize production while providing environmental protection. In the agricultural system, this may mean optimizing production for economic return (McGrath et al. 2014). Beyond the management of soil nutrients, soil fertility must also address factors contributing to the soil´s ability to supply nutrients and the plant´s ability to efficiently utilize nutrients present. This section will focus on three specific CSA practices: integrated soil fertility management, the importance of incorporating organic matter to the soil and transformation and use of sugarcane bagasse to improve soil fertility.

7.1.3 Learning objectives

The learning objective of this FFS session is to contribute to enhancing the capacities of the participants to improve the productivity of crops by improving soil fertility and soil properties to increase plant nutrient uptake and water retention/infiltration. The learning objectives of this session are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of the CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand the importance of assessing soil fertility and its implications in crop production
- Identify the requirements needed to conduct a soil analysis
- Identify the best practices to improve soil fertility management to improve the physical and chemical properties of soil
- Motivate the farmers to reduce the excessive use of chemical inputs to manage soil fertility
- Understand the importance of increasing the carbon content of the soil
- Familiarize the participant with protocols on how to make organic fertilizer

7.1.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the FFS training session:

- Knowledge strengthened on how to reduce vulnerability to water deficit through the use of rainwater harvesting and storage, and efficient use of water irrigation technologies (see points 1 to 4 of the data sheets)
- Knowledge strengthened about how water deficit technologies could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheets.
- Please see point 6 to 7 of the data sheets.
- Knowledge and practical skill to increase the carbon content in the soil

- Knowledge and practical skills on how to articulate adapt soil fertility practices to different types of crops and germplasms. Please see point 6 to 7 of the data sheets No. 5, 6 and 7.
- The hands-on experience acquired on how to elaborate and integrate organic inputs (stubbles or crop residues, vegetable cover, green manure, compost, sugarcane bagasse) to improve soil fertility. Please see point 6 to 7 of the data sheets No. 5, 6 and 7).
- A clear understanding of the requirements and key challenges commonly faced when implementing these three practices. Please see point 7 of the data sheets No. 5, 6 and 7.

7.1.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- soil fertility management and
- hands-on experience in organic fertilizer elaboration.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide technical support for the design and implementation of soil fertility management. Experts should be identified and invited to join the team.

7.1.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. Identify a family who is interested in implementing the practices. Find a farmer that is implementing the use of some alternative organic inputs. If the farm doesn´t have sugarcane, find another that has in order to implement the practice of elaborating sugar cane bagasse compost
- Visit the selected prior to the group to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice and explain to the family any formats required to compile the information in the field.

7.1.7 Materials needed

- The Training Manual on CSA, data sheets Number 5, 6 and 7.
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.

- Provide all the materials/equipment needed to elaborate the alternate inputs for the implementation of the practice.
- Prepare visual didactic tools and prepare in advance the description of any protocols to elaborate organic inputs. Include any visual information to complement the materials.
- Include refreshments

7.1.8 Timing considerations

The elaboration of alternative/organic inputs to improve soil and crops is an activity that needs to be incorporated into a farm on a daily basis. It is important to have access to the inputs throughout the cycle of the crop. It is recommended to implement the practices any time of the year, preferably before the beginning of the rainy season since it is during the rainy season that farmer establishes their annual and perennial crops. Plan the visits during the morning to avoid the possibility of rains.

7.2 FFS on plant nutrition

Plant nutrition is the study of the chemical elements and compounds necessary for plant growth, plant metabolism, and external supply. Plants require macronutrients and micronutrients or trace minerals. These crop nutrients are elements which are essential in providing healthy and vigorous plants and are vital for crop development.

These elements are found in the soil, so plants can consume it. Most soil conditions can provide plants sufficient nutrition for a complete life cycle, without the addition of nutrients such as fertilizer. However, if the soil is cropped it is necessary to artificially modify soil fertility through the addition of fertilizers to promote vigorous growth and increase or sustain yield. This is done because, even with adequate water and light, nutrient deficiency can limit growth and crop yield.

7.2.1 CSA Practices for plant nutrition.

Three practices to deal with plant nutrition were prioritized by farmers and technicians in Belize. These three practices are explained in detail in the Training Manual on CSA. During the FFS session for plant nutrition, the extensionist/facilitator should constantly consult the data sheets number 8 to 10 of the mentioned training manual. The data sheets contain most of the information needed to carry out this FFS session.

A summary of the three practices is presented as follows:

	Data sheet	Summary
Managing Plant Nutrition	**CSA PRACTICE No. 8 Foliar and tissue analysis**	Foliar and tissue analysis refers to the procedure of taking samples from leaf and other plant tissues and submit them to chemical analysis in order to reveal the real nutrient status. By doing this, nutrient imbalances can be detected before the deficiencies (or, in some cases, the excesses) of nutrients can become so severe that they become evident as marked discolorations. This is also an important tool to help identify ways to use nutrients more efficiently, and to identify unseen nutrient imbalances or toxicities, as well. It also measures the efficacy of fertilization and nutrient programs, as well as the levels of nutrients, such as copper, iron, sulfur, and others not observed in routine soil tests.
	CSA PRACTICE No. 9 Foliar application of fertilizers	Foliar application of fertilizers is a practice that is used to complement soil fertilization in order to improve the nutritional status of plants. Foliar sprays are often used to increase the fruit set and yield of fruit trees, such as citrus avocado, bananas.
	CSA PRACTICE No. 10 Foliar application of inputs and irrigation	This practice consists of supplying high volumes of water to the plant at the time that aerial application of agricultural inputs (fertilizers, pesticides, and others) is taking place. In this way, it is ensured that water requirements necessary for the physiological development of the plant are met and the plant can use the inputs more efficiently. The implementation of this practice requires to take into account the time of the application, the type of soil, the density of planting, the varieties used, and the water available in the productive area.

7.2.2 General overview

There are a number of methods used to help meet the nutrient requirement of crops. They range from plant foliar and tissue analysis (CSA PRACTICE No 8) to foliar application of fertilizers (CSA PRACTICE No 9) and foliar application of inputs and irrigation (CSA PRACTICE No 10). If used together, these methods are more efficient. The monitoring of foliar and tissue levels of nutrients and the corrective actions in the form of solid or liquid nutrient applications allows the crops to better resist the impact of the anticipated extreme climatic events. Foliar applications, on the other hand, will provide instantly available nutrients at times of maximum demand in order to favor growth, fruit set, production, and to strengthen the plant defenses against diseases and pests. Optimally fertilized crops show stronger growth, have better defenses against pests and diseases, and can better withstand temporary water deficits since they are likely to have a stronger and deeper root system and have higher reserves of carbohydrates and nutrients in their biomass. Consequently, these practices will contribute to significantly reduce the vulnerability to extreme events.

7.2.3 Learning objectives

The learning objective of this FFS session is to contribute to enhancing the capacities of the participants to improve the nutritional status of crops for optimum production, and to strengthen the plant defenses to combat diseases and pests. The specific learning objectives of this session are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand how to detect and assess nutrient imbalances of plants by visual identification of nutrient deficiency symptoms and the interpretation of foliar and tissue analysis
- Familiarize the participant with protocols for foliar and tissue sampling and foliar analysis
- Understand how to interpret the results of the analysis and identify specific measures to implement to improve the nutritional status of crops
- Familiarize the participant with different types of equipment that can be used for foliar applications of fertilizer
- Motivate the farmers to elaborate and use foliar fertilization sprays effectively

7.2.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the training:

- Knowledge strengthened on how to reduce vulnerability to water deficit through the use of rainwater harvesting and storage, and efficient use of water irrigation technologies (see points 1 to 4 of data sheets No. 8, 9 and 10)

- Knowledge strengthened about how water deficit technologies could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of data sheets No. 8, 9 and 10.

- Knowledge and practical skills strengthened to detect and assess crop nutrient imbalances. Please see point 6 to 7of data sheets No. 8, 9 and 10.

- Knowledge and practical skills to identify in the field of nutrient deficiency symptoms. Please see point 6 to 7 of data sheets No. 8, 9 and 10.
- Knowledge and practical skills on how to use different protocols to sample and analysis crop plant tissues. Please see point 6 to 7 of data sheets No. 8, 9 and 10.
- Hands-on experience on how to elaborate foliar fertilizers. Please see point 6 to 7 of the data sheets.
- A clear understanding of the requirements and key challenges commonly faced when implementing these three practices. Please see point 7 of data sheets No. 8, 9 and 10.

7.2.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- plant nutrition with practical knowledge on how to detect nutrient deficiency
- the different protocols used to perform foliar tissue analysis and on how to elaborate foliar fertilizers.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide the technical support for the design and implementation of both foliar and tissue analysis, as well as, foliar application of inputs. Experts with this knowledge should be identified and invited to join the team.

7.2.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. Identify a family who is interested in implementing the practices.
- Identify a laboratory that will be able to analyze the leaf tissues once they are collected in the field.
- Visit the selected site prior to the arrival of the group to organize and implement the practice. Provide all the materials/equipment and if possible the results of the foliar analysis to complement the observation that will be collected in the field.
- Explain to the family any formats required to compile the information in the field.

7.2.7 Materials needed

- The Training Manual on CSA, data sheets Number 8, 9 and 10.

- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed to do the leaf tissue sampling, such as plastic bags, cutters or scissors. Samples for the foliar analysis will be shipped and analyzed at a commercial laboratory.
- Make sure that materials are available to make the foliar fertilization.
- Prepare visual didactic tools and prepare in advance the description of any protocols used for nutrient deficient detection, leaf/tissue sampling, and analysis. Include any visual information, the materials, and equipment needed to efficiently use agricultural inputs and water in pineapple plantations.
- Include refreshments

7.2.8 Timing considerations

It is recommended to implement the practices any time of the year, preferably before the beginning of the rainy season since it is during the rainy season that farmer establishes their annual and perennial crops, and this will be a good time of the year to fertilize. Plan the visits during the morning to avoid the possibility of rains.

8. RUNNING FARMER FIELD SCHOOL SESSIONS FOR CROP MANAGEMENT

Climate variability and change will affect the geographic distribution and population dynamics of insect pests, as well as increases in the incidence of disease on both crops and animals. This reality calls for the use of integrated approaches, such as Integrate Pest and Disease Management (IPDM), a holistic approach of managing pests, diseases, and weeds by working, as the first choice, with nature through encouraging beneficial organisms. At the same time, farmers need to optimize production by using both planning tools and practices to protect crops and the products once they are harvested.

8.1. FFS for integrated pest management

8.1.1 CSA Practices for integrated pest and disease management.

Four practices to deal with pest and diseases in an integrated manner were prioritized by farmers and technicians in Belize. These four practices are explained in detail in the Training Manual on CSA. During the FFS session for integrated pests and diseases management, the extensionist/facilitator should constantly consult the data sheets 11, 12, 13 and 14 of the mentioned training manual. The data sheets contain most of the information needed to carry out this FFS session.

A summary of each practice is presented as follows:

	Data sheet	Summary
Integrated pest and disease management	**CSA PRACTICE No. 11** Ecological Pest Management' (EPM) and 'Integrated Pest Management' (IPM)	EPM and IPM refer to a holistic approach of managing pests, diseases, and weeds by working, as the first choice, with nature through encouraging beneficial organisms, rather than by working *against* nature by killing noxious ones with pesticides. While pesticide applications in conventional agriculture are targeted at reducing the populations of damaging organisms, and by doing so often cause substantial and persistent collateral harm to non-target species, the environment, and human health; IPM focuses on encouraging the presence and effectiveness of beneficial organisms and of agroecological control mechanisms to avoid the buildup of harmful populations of pests, diseases, and weeds in the first place. Therefore, EPM includes both actions for pest and disease prevention as well as actions for biological and mechanical control.
	CSA PRACTICE No. 12 **Biological pest control**	This is the practice at the heart of Ecological Pest Management (EPM) and Integrated Pest Management (IPM), oriented towards managing pests, diseases, and weeds by working *with* nature through encouraging beneficial organisms rather than by working *against* nature by killing noxious ones with pesticides. While pesticide applications aim at reducing the populations of damaging organisms, the environment, and human health, biological control harnesses the presence and effectiveness of beneficial organisms and of agroecological control mechanisms so as to avoid the buildup of harmful populations of pests, diseases, and weeds in the first place. Therefore, biological control includes both actions for pest prevention and actions for reducing the incidence of pests by means of biological and mechanical control.
	CSA PRACTICE No. 13 **Visual monitoring of pests and diseases**	It refers to actions needed in order to detect the incidence and severity of pests and diseases, and also the abundance of beneficial organisms in the agriculture system. These actions can help the farmer to establish an early warning system to detect potential pest outbreaks and determine overtime the types of control measures to manage pests and diseases.

	CSA PRACTICE No. 14 **Alternating the use of pesticides**	In certain agriculture systems that relies on onheavy use of chemicals, pesticides are inputs that will be used to control certain types of pests, so it is a form of resistance management strategy designed to preserve or sustain pesticide effectiveness. Continuous use of one type of pesticide leads to resistance, and as a consequence, the pesticide loses effectiveness since it will no longer kill a sufficient number of individuals per application (Cloyd and Cowles 2010).

8.1.2 General overview

Extreme intense rainfall, flooding, and moisture surplus, as well as droughts and moisture deficits, can affect not only the spread and aggressiveness of pests and diseases but also the survival and activity of beneficial organisms. The successful implementation of EPM and IPM will depend on the design and management of agro-ecosystems and landscapes that are pest-suppressive. Direct benefits of EPM and IPM for reducing the impact of climatic risks in Belize are strongest when, as a result of the implementation of this practice, the landscapes become enriched with a diversity of plants which form physical barriers that contribute to protecting crops, soils, and other system components from the impact of extreme wind and rainfall events. Such physical barriers may include hedges, windbreaks, shelterbelts, riverine forests, soil protection plantings along water bodies, 'islands of wild plants', forest patches, and other planting arrangements. These living structures increase the 'roughness' of the landscape leading to a decrease in wind speed, thus, protecting crops, soils, and beneficial organisms. Consequently, while pest and disease monitoring by itself cannot reduce the mentioned climate risks directly, early detection of pest or disease issues contribute significantly to reduce the impact of these climatic events on the crops and, therefore, on crop losses. Without monitoring, the increasing climatic variability would result in strongly increased risks of stronger pest outbreaks with grave implications for food security and income.

There is a growing awareness regarding the negative repercussions of the indiscriminate use of chemical pesticides, which are not only toxic to human life but also lead to environmental as well as ecosystem pollution. The long-term use of a broad spectrum of chemical pesticides has been identified as one of the major causes of environmental pollution and contributes to the deterioration of agricultural land and the ecosystem as a whole. The magnitude of the problem can be minimized avoiding heavy use of chemicals in combination with biological, physical and cultural control measures for more integrated management to control pests and diseases (Mukerji and Cianco 2007).

8.1.3 Learning objectives

The learning objective of this FFS session is to contribute to enhance the capacities of the participants to improve local farm productivity by understanding the importance of implementing practices in integrated pest and disease management. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of the CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand the importance of biological control for EPM and IPM
- Motivate farmers to reduce the use of chemical inputs to control pests and diseases, when possible
- Understand the pillars of EPM and IPM in order to design more sustainable and productive agro-ecosystems with improved soil fertility, crop health, and ecosystem health
- Understand the ecological roles of beneficial organisms in agro-ecosystems and how these can contribute to reducing incidences of pests and diseases.
- Understand the relevance of different groups of beneficial microorganisms used for biological control.
- Familiarize the participant with protocols to monitor pests and diseases
- Understand how to reduce the resistance of pathogens and pests to determined chemical products in order to preserve its effectiveness, without having to increase the number of application or the concentration of the pesticides to be applied.

8.1.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the FFS training session:

- Knowledge strengthened on how to reduce vulnerability to pests and diseases through the use of an integrated approach to deal with pests and diseases (see points 1 to 4 of the data sheets)
- Knowledge strengthened about how innovations to manage pests and diseases using and integrated approach could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheets.
- Knowledge and practical skills strengthened in IPM and EPM in order to implement preventive management practices, crop-specific practices, and reactive management to correct any persisting problems associated with pests and diseases. Please see point 6 and 7 of data sheets No. 11, 12, 13, 14.

- Knowledge and practical skills strengthened to use alternative practices to control pests and diseases. Please see point 6 to 7 of the data sheets.
- Hands-on experience on how to implement a sampling protocol to evaluate the incidence and severity of pests and diseases and determine that type of measures needed to control it and improve the crop conditions. Please see point 6 to 7 of the data sheets.
- Knowledge and skills to design productive systems that rely in less chemical inputs. Please see point 6 to 7 of data sheets No. 11, 12, 13, 14.
- Knowledge on how to alternate the use of pesticides with different types of active ingredients to reduce the development of pathogen resistance. Please see point 6 to 7 of the of data sheets No. 11, 12, 13, 14.
- A clear understanding of the requirements and key challenges commonly faced when implementing these four practices. Please see point 7 of data sheets No. 11, 12, 13, 14.

8.1.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how such risks vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- EPM and IPM and experience in implementing sampling protocols to monitor pests and diseases.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide the technical support for the design and implementation of EPM and IPM. Experts should be identified and invited to join the team.

8.1.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. Identify a family who is interested in implementing IPM and EPM or is already applying IPM/EPM. IPM and EPM field visits will be focused on crop and soil management to reduce pest and disease and crop-specific pest/disease prevention. It is important to find a diverse integrated farm and/or an organic farm. Its success will depend on the implementation of biological control measures. If possible, include visits to institutions and/or farmers that are reproducing or selling biological control agents such as fungi or insects.
- Find a family with a banana plantation to implement the exercise on alternating the use of pesticides with different active ingredients.

- Visit the selected prior to the group to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice and explain to the family any formats required to compile the information in the field.

8.1.7 Materials needed

- The Training Manual on CSA, data sheets Number 11, 12, 13 and 14.
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed to elaborate the alternate inputs for the implementation of the practice.
- Prepare visual didactic tools and prepare in advance the description of any protocols to measure pest/disease incidence and severity that will be implemented in the field. Include any formats, tables or diagrams/pictures to compile the information.
- Include refreshments

8.1.8 Timing considerations

Any time of the year, preferably at the beginning of the rainy season since it is during the rainy season that farmer establish their annual and perennial crops. Plan the visits during the morning to avoid the possibility of rains.

8.2. FFS for production optimization

Farmers need to optimize production by using both planning tools and practices to protect crops, and the agriculture products once they are harvested. A set of practices that aims at making efficient use of farm's resources including land and inputs is critical to optimize and sustainably intensify production, while considering external factors, such as climate and weather. Five practices were prioritized by farmers and technicians in Belize. These five practices are explained in detail in the Training Manual on CSA.

For the purposes of fostering production optimization in Belize, we have organized the CSA practices in three different FFS that are presented as follows:

8.2.1. FFS for farms and vegetal gardens plans and use of improved materials

8.2.1.1. CSA Practices

Two practices to deal with crop optimization were prioritized by farmers and technicians in Belize. These practices are explained in detail in the Training Manual on CSA. During the FFS sessions for crop production optimization, the extensionist/facilitator should constantly consult the data sheets 15 and 16 of the mentioned training manual. The data sheets contain most of the information needed to carry out this FFS session.

A summary of each practice is presented as follows:

	Data sheet	Summary
Crop Optimization	**CSA PRACTICE No. 15 Farm and vegetable garden planning**	Farm and vegetable garden planning is a methodological tool created to support farmers and agricultural families in making more informed production decisions based on the characteristics of their farm and vegetable garden(s), the farming systems and crops they own, and their livelihoods options while considering external factors such as climate and weather. Through the implementation of a plan, families will have the opportunity to maximize the use of their land and resources by choosing the type of farming systems and crops that reflects their specific needs.
	CSA PRACTICE No. 16 Selection and use of improved varieties, seeds, and other reproductive materials	This practice refers to the selection and use of varieties or genetically improved reproductive materials or crops that have been bred and tested for negative factors that affect crop productivity and therefore, have increased tolerance to such factors. In order to deal with climatic stresses such as water deficiencies or excess, high temperatures, as well as phytosanitary problems triggered by weather events, many varieties have been selected or genetically improved, by either increasing the physiological resilience to climatic extremes or by developing early-maturing varieties that allow cropping calendars to be adjusted to cope with seasonally unfavorable conditions.

8.2.1.2 General overview

In order to reduce climate risks, vegetable producers will need to implement farm and home garden practices to manage both excess and deficits of water, as well as an increase in temperature. The formulation of farm and vegetable garden plans allows the farmer and their family to reorganize and restructure their farming systems in function of multiple objectives, considering their strengths and vulnerabilities in order to integrate a better spatial configuration considering ideal forms of association of crops and staggering production, while considering external factors such as climate and weather. A better spatial configuration and management of crops will increase profitability in production, adaptive capacity, and overall resilience to climate change and variability. This planning exercise is key in the identification of practices that will help them in optimizing and stabilizing yields in a sustainable way taking into consideration limiting factors, such as extreme climate events.

One key practice to be incorporated within the farm and vegetable garden plan is the use of improved materials that help to maintain or increase crop productivity, reducing yield variability and avoiding production loses under unfavorable climate conditions.

This practice will be more effective if it integrates farm and home garden planning, water management strategies (see practices No. 1, 2 and 3).

8.2.1.3 Learning objectives

The learning objective of this FFS session is to contribute to enhance the capacities of the participants, to improve local farm and vegetable gardens productivity by understanding the importance of spatial configurations and arrangements of the agriculture systems, the use of improve of varieties of seeds and crops, production efficiency, food security, nutrition under potential climatic risks. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand how to formulate a farm and home garden plan to allow the farmer and their family to reorganize and restructure their farming systems in function of multiple objectives, considering their strengths and vulnerabilities.
- Sensitize farmers about the importance of social roles and gender equity and social inclusion approaches in farm and home garden planning
- Motivate the local farmers to integrate a farm or home garden plan to improve the spatial configuration of the farm and improve agricultural productivity and food security
- Understand the importance of selecting and using improved varieties of seeds, crops and vegetable materials to maintain or improve productivity in a changing environment.

8.2.1.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the training:

- Knowledge strengthened on how to reduce vulnerability to external factors such as extreme climate and weather events through the use of a planning tool (farm and garden plans) and the use of improved materials (see points 1 to 4 of the data sheet)
- Knowledge strengthened about how the formulation and implementation of farm and vegetable gardens, as well as the use of improve materials, could contribute to

the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheets.

- On-hand experience in developing a seasonal calendar, as well as in Identifying climate risks and crop sensitivity to such risks. Please see point 6 to 7 of the data sheets.
- On-hand experience on how reviewing historical climate information. Please see point 6 to 7 of the data sheets.
- Skills in developing a future vision for the farm and home garden integrating specific goals in order to achieve the projected vision. Please see point 6 to 7 of the data sheets.
- Knowledge in terms of the relevance of the gender role in farm and home garden planning. Please see point 6 to 7 of the data sheets.
- Knowledge and practical skills to improve crop varieties through seed selection, seed production, and storage. Please see point 6 to 7 of the data sheets
- Understand the relevance to implement seed exchanges to improve breeding and seed production. Please see point 6 to 7 of the data sheets
- Practical skills strengthened in the design, implementation, and monitoring of a farm and a home garden plan. Please see point 6 to 7 of the data sheets
- A clear understanding of the requirements and key challenges commonly faced when implementing these two practices. Please see point 7 of the data sheets.

8.2.1.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- how to map resources in a farm
- how to analyze historical weather information
- how to implement farm and home garden plans,
- gender and social inclusion approaches in farm management
- have a strong background in germplasm management.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide technical support for the design and implementation of crop optimization. Experts should be identified and invited to join the team.

8.2.1.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. Identify a family that is implementing agronomical diversification practices and is interested in managing the farm under an agroecological approach.
- The family should be interested in implementing a farm and home garden plan and do the following up process to share with any visiting groups.
- Visit the farm prior to the FFS session to coordinate with the host family. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice and explain to the family any formats required to be completed during the FFS session.

8.2.1.7 Materials needed

- The Training Manual on CSA, data sheet Number 15 and 16.
- Historical weather information
- The flipchart where the participants will develop the farm and vegetable plan
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed for the implementation of the practice.
- Prepare in advance any formats or tables to compile the information in the field.
- Include refreshments

8.2.1.8 Timing considerations

Any time of the year, preferably when it is not the raining season so that the participants can work around the farm to see the practices or compile the information. Or plan the visits during the morning to avoid the possibility of rains. It is important to consult the family the most appropriate time for the visit since some of the family members might have responsibilities to attend. It is important to have in presence most of the members of the family.

8.2.2 FFS for crop protection strategies

Crop protection is the practice of managing weather, weeds, pests, and diseases that damage or inhibit the growth of crops. Proper protection is important to produce higher quality crops with minimal waste. Since climate variation is also a threat to agricultural production, employment of appropriate adaptation strategies is important to reduce its negative effect.

8.2.2.1 CSA Practices

Two practices to deal with crop protection were prioritized by farmers and technicians in Belize. Both practices can help to increase productivity, can maximize production, water usage and reduce labor. These practices are explained in detail in the Training Manual on CSA. During the FFS session for crop protection, the extensionist/facilitator should constantly consult the data sheets number 17 and 18 of the mentioned training manual. The data sheet contains most of the information needed to carry out this FFS session.

A summary of each practice is presented as follows:

<table>
<tr><th rowspan="3">Crop Optimization</th><th>Data sheet</th><th>Summary</th></tr>
<tr><td>CSA PRACTICE No. 17 Shoring and staking</td><td>This practice is implemented for preventing the toppling of banana plants due to the action of strong winds, the weight of the banana bunch, the elongation of the pseudostem, or the death of roots. The practice is based on the use of some rigid material that serves as a support and prevents the toppling of the plant. The most commonly used materials are stakes made of wood, bamboo or nylon ropes to tie the plant together with other plants (Araya et al. 2011). Intensive rain patterns caused by tropical storms can generate flood and water logging, making banana plantations highly vulnerable to increases in water level, which causes the weakening of plants by the death of the root systems and loss of anchorage which favors the toppling of plants by the impacts of strong winds. Implementing shoring and staking of bananas will reduce productivity loss, caused by the toppling of banana plants. It will also decrease the detriment in the quality of the fruits due to contamination, finger malformation and physical damage caused by the toppling.</td></tr>
<tr><td>CSA PRACTICE No. 18 Vegetable production in protected environments</td><td>This practice refers to a set of practices that protect crops from temperature and moisture extremes and that reduce the incidence of pests and diseases. The practices range from the simple setting up of shade cloth during hot periods of the year or of plastic bands to protect individual crop rows from excessive rain, all the way to hoop houses, and, ultimately, greenhouses which allow different levels of controlling climatic and biotic factors. The infrastructure that can be used to protect the crops (shade cloth, plastic bands, transparent roofs, screens against insects, etc.), first and foremost, reduces the impact of extreme climatic events such as strong rains, drought, or winds, thereby reducing the vulnerability of the crops. Furthermore, this infrastructure allows to better control the environmental variables which determine crop growth and can reduce the incidence of pests and diseases.</td></tr>
</table>

8.2.2.2 General overview

Production in protected environments is particularly important for zones with adverse climatic factors. The major benefits of applying this CSA practice are generated in environments where crops need to be protected from excessively intense and/or frequent rainfall events, strong winds, or cool temperatures. It is of special importance for high-value crops, which allows recovering the investment in the protective structures rapidly.

8.2.2.3 Learning objectives

The learning objective of this FFS session is to contribute to enhancing the capacities of the participants to implement a different type of practices to protect crops. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along with the participants how this practice contributes to the three pillars of CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand and apply concepts in the field on how to implement different types of structures and materials for shoring that could be used in order to protect bananas from strong winds
- Understand the different specific types of designs of protected environments that could be used for vegetable production for a different type of vegetable producers
- Familiarize the participant with the different types of materials and equipment to build protected environments for vegetable production
- Understand and develop practical skills to prepare adequate soil substrates to improve crop nutrition.
- Understand the different types of irrigation systems that could be used in protected environments to increase water efficiency and crop productivity.
- Learn how to germinate, cultivate and transplant different types of crops.

8.2.2.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the training:

- Knowledge strengthened on how to reduce vulnerability to water excess through the use of drainages (see points 1 to 4 of the data sheet)
- Knowledge strengthened about how technologies to manage water excess could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheet.
- Knowledge and practical skills strengthened to implement different types of shoring in banana plantations. Please see point 6 to 7 of the data sheets.

- Hands-on experience on how to build protected environments for vegetable production considering all the different elements required for proper management: soil substrates, irrigation system, seed germination, crop production, and transplants. Please see point 6 to 7 of the data sheets.
- A clear understanding of the requirements and key challenges commonly faced when implementing these two practices. Please see point 7 of the data sheets.

8.2.2.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- banana production systems and on how to build supporting structures such as shoring for banana plantations without harming the plants
- how to build different types of protected environments for vegetable production, and how to control environmental conditions such as adequate ventilation to avoid excessive temperatures and humidity within the structures
- soil substrate preparation and agronomic experience on maintenance and production of different types of vegetables.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide technical support for crop protection. Experts should be identified and invited to join the team.

8.2.2.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. The shoring practices will need to be implemented in a banana plantation or in a farm that also produces bananas or plantains.
- In the case of vegetable production in protected environments, identify a family that is interested in building a protected environment for vegetable production. Define with the family the type of design based on their specific needs
- Visit the selected prior to the group to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice.

8.2.2.7 Materials needed

- The Training Manual on CSA, data sheets Number 17 and 18.
- Flipcharts, color markers, masking tape, and didactic materials for the farmers.
- Use visual and didactic tools to explain the construction of the protected environment
- Provide all the materials/equipment needed for the implementation of the practice shoring in bananas plantations and for the protected environments. For the protected environments consider the materials needed to elaborate soil substrate preparation and suggested irrigation systems that will be implemented.
- Include refreshments

8.2.2.8 Timing considerations

Any time of the year, preferably when it is not the raining season such that the participants can implement the practice easily. Or plan the visits during the morning to reduce the possibility of rains.

8.2.3 FFS for post-harvest management

Agriculture plays a significant role in human nutrition and is associated with health benefits. Both quantitative and qualitative losses occur in agriculture commodities between harvest and consumption. Qualitative losses include loss in edibility, nutritional quality, caloric value, and consumer acceptability of fresh products. Quality standards, consumer preferences, and purchasing power can also influence marketability and the magnitude of post-harvest losses.

Post-harvest losses vary greatly across commodity types, within production areas and the season of production. Global post-harvest food losses are estimated at around 25%. For vegetables and fruits, this figure may even reach 50% and more under unfavorable conditions due to a lack of capacity to transform, preserve, store, transport, and market the products in efficient ways. Reduction of post-harvest losses can increase food availability, decrease the area needed for production, and conserve natural resources. Strategies for loss prevention include: (1) use of genotypes that generate longer post-harvest-life, (2) use of integrated crop management systems and good agricultural practices that result in good keeping quality of the commodity, and (3) use of proper post-harvest handling practices in order to maintain the quality and safety of fresh produce.

8.2.3.1 CSA practice

One practice to deal with post-harvest management was prioritized by farmers and technicians in Belize as a practice that could contribute to optimizing production. This practice is explained in detail in the Training Manual on CSA. During the FFS session for post-harvest management, the extensionist/facilitator should constantly consult the data sheets number 19 of the mentioned manual. The data sheet contains most of the information needed to carry out this FFS session.

A summary of the practice is presented as follows:

	Data sheet	Summary
Crop Optimization	**CSA PRACTICE No 19: Post-harvest management**	This practice refers to all activities that are required between the harvesting of crops and their consumption. Therefore, in this case, post-harvest activities comprise actions of cleaning, drying, cooling, packaging, storing, and transporting agricultural crops before they reach the final consumer. While the implementation of the activities that relate to post-harvest management cannot reduce the climatic risks themselves, they have great potential for reducing their impacts on food security.

8.2.3.2. General overview

Post-harvest management practices aim at minimizing food losses along the value chain of the agriculture product. Taking into account that with increasing climatic uncertainties, it is likely that there will be larger fluctuations in production between different seasons and years, it will be of increasing importance to be able to process excess production in times of peak harvest so that they can later be used in times of scarcity.

Improving the capacity of farmers and other actors to dry, store, preserve, and market crops even at times after the main harvest season, will have great benefits for reducing the vulnerability to climatic events described in the climate adaptation strategy of Belize.

8.2.3.3 Learning objectives

The learning objective of this FFS session is to enhance the capacities of the participants to understand how post-harvest management could contribute to reducing product losses along its value chain. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand and apply key concepts of post-harvest management to reduce spoilage and losses of grains, vegetables, and fruits
- Familiarize the participant with different types of technologies that can be used to improve post-harvest management

- Understand what actions are required to improve the shelf life and storability of the products, improve the presentation, ensure quality control during storage, distribution, and sale before it reaches to the consumer.

8.2.3.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the training session:

- Knowledge strengthened on how to reduce vulnerability to water excess through the use of drainages (see points 1 to 4 of data sheet No. 19).
- Knowledge strengthened about how technologies to manage water excess could contribute to the three pillars of CSA (production, adaptation, and mitigation of climate change). Please see point 5 of the data sheet No. 19.
- Knowledge and practical skills strengthened in post-harvest management along the value chain of the agriculture product. Please see point 6 to 7 of data sheet No. 19.
- The understanding gained about the different types of post-harvest technologies to reduce spoilage and losses especially those that relate to vegetable and basic grain producers. Please see point 6 to 7 of data sheet No. 19.
- A clear understanding of the requirements and key challenges commonly faced when implementing this practice. Please see point 7 of the data sheet No. 19.

8.2.3.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- post-harvest management
- different types of practices and technologies to conserve, store and maintain the quality control of agriculture products until it reaches the consumer. This includes washing, drying, storage, chemical treatments, processing, packaging, and transportation.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide technical support for the design and implementation of post-harvest management. Experts should be identified and invited to join the team.

8.2.3.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group, preferable a farm that produces vegetables or grains. Select a specific crop in order to do the post-harvest analysis along the value chain.
- Use visual didactic tools to complement the field visits to see the specific practices and technologies used for post-harvest management.
- Visit the selected site at least a week before to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice.

8.2.3.7 Materials needed

- The Training Manual on CSA, data sheets Number 19
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed for the implementation of the practice.
- Include refreshments

8.2.3.8 Timing considerations to implement the practice

Any time of the year, preferably when it is not raining so that the participants can work around the farm to see the practices.

9. RUNNING FARMER FILED SCHOOLS SESSIONS FOR ANIMAL MANAGEMENT

Climate change is likely to have considerable impacts on livestock, poultry, and in general in animal production. These will include a substantial reduction in the quantity and quality of forage or other sources of local food, available. Impacts will also include the spread and severity of existing vector-borne diseases and macro-parasites, accompanied by the emergence and circulation of new diseases. At the same time, animal production will benefit from shifting to feed resources with a low-carbon footprint in order to reduce emissions, especially for concentrated pig and poultry production systems. (CCAFS, n.d.b). Six practices, two for livestock, two for poultry and two for bee keeping are included in the Training Manual on CSA.

9.1 FFS for livestock management systems

Livestock systems have long been one of the main pillars of rural livelihood strategies, and at the same time, it has been a powerful driver for the degradation of forest and tree resources worldwide. In recent years, silvopastoral systems have been advocated as promising alternatives, reconciling conservation and development needs. These systems not only foster the sustainable management of natural resources, but they can also alleviate rural poverty. When silvopastoral systems combine improved pastures with nutritious trees in living fences, as dispersed trees, or in fodder banks, the production of beef and milk tends to increase substantially while, at the same time, the system becomes more resilient to climate change and the emissions of greenhouse gases per unit produced decline. Therefore, intensive silvopastoral systems with improved pastures represent an attractive approach to climate-smart animal farming in the tropics.

9.1.1 CSA Practices for managing livestock systems

Two practices to deal with livestock systems management were prioritized by farmers and technicians in Belize. These two practices are explained in detail in the Training Manual on CSA. During the FFS session for managing livestock systems, the extensionist/facilitator should constantly consult the data sheets No. 20 and 21 of the mentioned training manual. The data sheets contain most of the information needed to carry out the FFS session.

A summary of each practice is presented as follows:

	Data sheet	Summary
Animal Management	**CSA PRACTICE No. 20 Silvopastoral systems**	This practice combines trees with pastures and livestock for mutual benefits. In addition to the pasture grasses, silvopastoral systems may include dispersed trees for fodder and shelter, as well as closely spaced trees for living fences, windbreaks, and fodder banks or alleys. When possible, highly nutritious, often N-fixing, species are preferred in order to enrich the system with nitrogen without having to depend exclusively on synthetic fertilizers (Pezo and Ibrahim 2001). 'Improved pastures' is a commonly used term for forage species, primarily grasses and legumes, often introduced from other regions, that are well adapted to the local agroecological conditions and that, with adequate management, produce large quantities of nutritious forage to improve animal production while protecting the environment (Pezo 2018).
	CSA PRACTICE No. 21 Grass silage	This the other hand is animal forage that has been transformed during an anaerobic fermentation process of chopped young plant materials that were harvested when the plants were still green and prepared to be used when fresh biomass is scarce or not available.

9.1.2 General overview

The establishment of silvopastoral systems could help to reduce the impact of climatic risks in Belize because, as a result of tree planting, landscapes will become enriched with a diversity of plants forming physical barriers to protect animals, pastures, crops, and soils from the impact of extreme wind and rainfall events, on the one hand, and from scorching sun and heat during dry spells on droughts and high temperatures on the other. Such physical barriers may include hedges, windbreaks, shelterbelts, fodder banks, riverine forests, soil protection plantings along with water bodies, 'islands of wild plants', forest patches, and other planting arrangements. These living structures increase the 'roughness' of the landscape leading to a decrease in wind speed and, hence, fostering the protection of pastures, animals, soils, and beneficial organisms.

High-diversity ecosystems are known to better resist extreme environmental impacts (Muschler 2016). Therefore, practices that foster higher biodiversity at a landscape level, including silvopastoral systems, can contribute substantially to increase the resilience of livestock operations to the extreme climatic events described in the climate adaptation strategy of Belize. Clearly, the mentioned climatic risks from increasing temperatures and more extreme rainfall and drought events will pose additional strain on pastures and animals, making it all the more imperative to reduce the stress by providing trees for food and shelter and by introducing improved pastures and production of grass silage to feed the animals in times of water deficit and in times of excess of water.

9.1.3. Learning objectives

The learning objective of this FFS session is to contribute to enhance the capacities of the participants to implement practices in livestock systems to improve animal production while protecting the environment by conserving and restoring important ecosystem services such as biodiversity, soil, and water. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of the CSA approach (productivity, adaptation, and mitigation of climate change
- Understand and apply concepts to foster, produce and preserve high-quality fodder for animal production
- Understand how to minimize the environmental impact of animals and improve pasture management
- Promote the diversification and implementation of silvopastoral systems among farmers

9.1.4. Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the training:

- Knowledge strengthened on how to reduce vulnerability to water deficit through the use of rainwater harvesting and storage, and efficient use of water irrigation technologies (see points 1 to 4 of the data sheets)
- Knowledge strengthened about how water deficit technologies could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheets.
- Knowledge and practical skills strengthened in the design and diversification of silvopastoral systems taking into consideration appropriate plant species selection for fodder and shade. Please see point 6 to 7 of data sheet No. 20 and 21.
- Knowledge and practical skills on cultural practices to improve pasture management such as application of fertilizers, composts, and beneficial microorganisms, weeding, among others. Please see point 6 to 7 of data sheet No. 19.
- Knowledge and practical skills to improve livestock productivity and improve ecosystems services present on the farm and in the landscape. Please see point 6 to 7 of data sheet No. 20 and 21.
- Hands-on experience on how to elaborate grass silage and be familiarize with proper storage facilities. Please see point 6 to 7of data sheet No. 20 and 21.
- A clear understanding of the requirements and key challenges commonly faced when implementing these two practices. Please see point 7 of the data sheet No. 20 and 21.

9.1.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- livestock management and animal nutrition
- silvopastoral systems.
- practical knowledge on how to select, prepare and store grass silage.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide technical support for the design and implementation of livestock system management. Experts should be identified and invited to join the team.

9.1.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. The primary focus of the farm should be livestock production systems. Select a farm that has a species-rich system. Consider the appropriate species of plants to establish different structures, such as windbreaks and fodder banks and species that can be reproduced vegetatively. It would be interesting to include farms that have shelters and stables and/or experiences with biodigesters to treat animal manure.
- Use visual didactic tools and also field visits to see and contrast the implementation of different practices.
- Visit the selected site at least a week before to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice.

9.1.7 Materials needed

- The Training Manual on CSA, data sheet Number 20 and 21.
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed for the preparation of grass silage: chopped grasses, grains, plastic bags/ tarps.
- Include refreshments

9.1.8 Timing considerations

Any time of the year, preferably when it is not raining so that the participants can work around the farm to see the practices.

9.2 FFS for poultry management systems

The successful production of poultry depends on good nutrition and effective health management. When feed is provided, it should be given in quantities that can be ingested at that time. The use of feeders helps in reducing waste. Using homemade feeders with a cover that prevents the chicken from perching on the feeder will keep the feed clean.

9.2.1 CSA practices

Two practices to deal with poultry management were prioritized by farmers and technicians in Belize. These two practices are explained in detail in the Training Manual on CSA. During the FFS session for poultry management, the extensionist/facilitator should constantly consult the data sheets number 22 and 23 of the mentioned manual. The data sheets contain most of the information needed to carry out the FFS session.

A summary of each practice is presented as follows:

<table>
<tr><th rowspan="3">Animal Management</th><th>Data sheet</th><th>Summary</th></tr>
<tr><td>CSA PRACTICE No. 22 Poultry health management</td><td>This practice refers to all aspects that need to be met in order to guarantee poultry good health as a requirement for high production and reproduction.</td></tr>
<tr><td>CSA PRACTICE No. 23 Poultry nutrition with local and home-made concentrates</td><td>This practice refers to the practice of providing a locally made feed that meets the nutritional requirements of poultry for good health and high production and reproduction. The success of these practices depends on the parallel implementation of complementary actions for appropriate environmental management (housing, hygiene, temperature, ventilation, etc.), water supply, as well as on disease prevention and treatment.</td></tr>
</table>

9.2.2 General overview

The actions needed for successful 'poultry health management' include the provision of good quality feed and of clean and fresh water at all times, the implementation of hygiene, and the protection of chickens from excessive temperatures and moisture during extreme climatic events. Even in times of strong rains, winds, or droughts, the chickens, protected in the adequate shelter and maintained in good health, can stay productive without being exposed to drastically increased health risks.

9.2.3 Learning objectives

The learning objective of this FFS session is to contribute to enhancing the capacities of the participants to implement practices to keep the animals healthy for good production and reproduction. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of CSA approach (productivity, adaptation, and mitigation of climate change)
- Understand and apply concepts in poultry management to avoid stress and exposure to disease agents

- Understand and apply concepts in poultry health and nutrition during different development stages
- Develop practical skills on how to elaborate homemade feed

9.2.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the training session:

- Knowledge strengthened on how to reduce vulnerability to water excess through the use of drainages (see points 1 to 4 of the data sheet)
- Knowledge strengthened about how technologies to manage water excess could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheet.
- Knowledge and practical skills strengthened in poultry management including aspects related to housing, health, hygiene, nutrition and disease prevention, and treatment. Please see point 6 to 7 of the data sheets.
- Hands-on experience in homemade feed elaboration to reduce vulnerability to high prices of commercial feeds and respond to the limitations imposed by climatic extremes. Please see point 6 to 7 of the data sheets.
- Motivate farmers to improve poultry management to improve meat and egg production. Please see point 6 to 7 of the data sheets.
- The clear understanding of the requirements and key challenges commonly faced when implementing these two practices. Please see point 7 of the data sheets.

9.2.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on:

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- skills in poultry production with an emphasis on poultry health and nutrition

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide technical support for the design and implementation of poultry management. Experts should be identified and invited to join the team.

9.2.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. Select a poultry farm. The selected family should have an interest in implementing management practices and willing to elaborate homemade feed.
- Use visual didactic tools to illustrate some of the concepts and plan a field to see various aspects of poultry management.
- Visit the selected site at least a week before to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice.

9.2.7 Materials needed

- The Training Manual on CSA, data sheets Number 22 and 23
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed for the implementation of the practice. Prepare in advance the ingredients to prepare the homemade feed
- Include refreshments

9.2.8 Timing considerations

Any time of the year. Consider when are available the raw materials needed to elaborate the homemade feed.

9.3 FFS for bee keeping

Bee keeping conveys many benefits including improvement of income and food security and employment opportunities. Also, bee pollination is essential for the production of various crops. Bees are crucial in maintaining biodiversity by pollinating numerous plant species including agricultural crops whose fertilization requires an obligatory pollinator.

Managed honeybees, however, have been suffering increasingly in recent years. Researchers think that this is attributed by the Colony Collapse Disorder caused by a number of interwoven factors: 1) global warming, which has caused flowers to bloom earlier or later than usual. When pollinators come out of hibernation, the flowers that provide the food they need to start the season have already bloomed, 2) Pesticide use on farms. Some toxic pesticides meant to kill pests can harm the honey bees needed for pollination, 3) Parasites such as harmful mites 4) Habitat loss brought about by development, abandoned farms, growing crops without leaving habitat for wildlife, and growing gardens with flowers that are not friendly to pollinators (Greenpeace 2013; Bekic et al. 2014)

As a consequence, bees number in different parts of the world is reducing, and as a result, the yields of main agricultural crops are also reducing. This phenomenon could affect crop production but also livestock production, by reducing the yield of forage crops (Spivak et al. 2011).

Any progress in transforming the current chemical-intensive agricultural system into ecological farming systems will have many associated benefits on other dimensions of the environment and on human food security, quite apart from clear benefits to global pollinator health. In the short to medium term, there are specific issues that society can begin to address straight away, in order to benefit bee pollinator health. The benefits could become evident almost immediately. Based on analysis of the current science on bee pollinator health, it will be important to promote pollinator health through bee friendly management of biodiversity in systems and landscapes and through bee friendly input management by reducing pesticide use and organic agriculture production.

9.3.1 CSA Practices for beekeeping

Two practices to deal with beekeeping management were prioritized by farmers and technicians in Belize. These two practices are explained in detail in the Training Manual on CSA. During the FFS session for beekeeping, the extensionist/facilitator should constantly consult the data sheets number 24 and 25 of the mentioned manual. The data sheet contains most of the information needed to carry out this FFS session.

A summary of each practice is presented as follows:

	Data sheet	Summary
Animal Management	**CSA PRACTICE No 24: Bee-friendly management of biodiversity**	This practice refers to activities that foster the provision of habitat and food conditions that favor the reproduction and activity of bees. This includes the protection or planting of flowering plants in different spatial arrangements and temporal sequence in such a way that the bee's requirements are met year-round in order to assure their survival and long-term services for crop productivity and sustainability.
	CSA PRACTICE No 25: Bee-friendly input management	This practice focuses on promoting interventions to reduce the risks for bees and other pollinators from agrochemicals in order to assure their survival and long-term services for crop productivity and sustainability.

9.3.2. General overview

Both bee-friendly practices will contribute to reducing climatic risks face by beekeepers in Belize, due to the fact that increased tree cover and protection of forest fragments in farms and landscapes benefit pollinators and other beneficial organisms. The presence of windbreaks and other physical barriers will contribute to crop and soil protection offsetting impacts of extreme events, such as extreme wind and rainfall or alleviate extreme hot conditions and ensure better protection of water resources. Increased diversification and tree cover will contribute to increasing climate change mitigation.

In the case of bee-friendly input management, it will primarily target the reduction or substitution of potentially harmful agrochemicals. As a result, there will be a reduction of GHG emissions which will allow the persistence of bees of different species and maintain pollination services which will important to sustain crop production and maintain ecosystem and agro-ecosystem health.

9.3.3 Learning objectives

The learning objective of this FFS session is to contribute to enhancing the capacities of the participants to implement bee-friendly practices in local farms to promote bee pollinator health and avoid harm to pollinators by eliminating exposure to potentially harmful substances. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that this practice can help to respond to
- Identify along the participants how this practice contributes to the three pillars of the CSA approach (productivity, adaptation, and mitigation of climate change

- Understand and apply concepts in the field for bee-friendly management of biodiversity in systems and landscapes
- Understand and apply concepts in the field for bee-friendly bee input management by reducing pesticide use and organic agriculture production.

9.3.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the FFS training session:

- Knowledge strengthened on how to reduce vulnerability to water deficit through the use of rainwater harvesting and storage, and efficient use of water irrigation technologies (see points 1 to 4 of the data sheets)
- Knowledge strengthened about how water deficit technologies could contribute to the three pillars of CSA (productivity, adaptation, and mitigation of climate change). Please see point 5 of the data sheets.
- Knowledge and practical skills strengthened in bee-friendly management of biodiversity in systems and landscapes as well as in input management. Please see point 6 to 7 of the data sheets.
- The hands-on experience acquired on specific practices that can be implemented in a farm to protect bees pollinators and avoid its harm in order to enhance the pollination services and benefits for honey production and agriculture. Please see point 6 to 7 of the data sheets.
- A clear understanding of the requirements and key challenges commonly faced when implementing these two practices. Please see point 7 of the data sheets.

9.3.5 Knowledge requirements for the extensionist or facilitators

The extensionist/facilitator needs to have previous knowledge and practical skills on: data sheet No. 20 and 21

- the main climatic risks that farmers face in their respective locations, and how vulnerable they are to such risks.
- how the proposed innovations will help in facing the identified climatic risks and contribute to sustainable increase productivity, adaptation, and mitigation to climate change (the three pillars of CSA)
- apiculture and understand the benefits of bee production, pollination services, and integrated farm and landscape approaches to enhance pollinations services in productive systems.

If the extensionist/facilitator does not have this knowledge, it is important to involve specialists who can provide technical support for the design and implementation of beekeeping management. Experts should be identified and invited to join the team.

9.3.6 Considerations for site selection

- Select an adequate local farm for the practice that is easily accessible for the group. The farm should also have an aerial view of different types of patches that include production systems, agroforestry and forestry systems in order to highlight the importance of diverse landscape mosaics in the provision of different types of ecosystem services.
- Use visual didactic tools and also field visits to see and contrast the implementation of different practices for example windbreaks, forest patches, the contrast between monocultures vs a polyculture, chemical-based vs organic production systems, trees species that can attract bees and highlight how these practices impact bee populations and production systems.
- Visit the selected site at least a week before to organize and implement the practice. Provide all the materials/equipment needed for the implementation or for the demonstration of the practice.

9.3.7 Materials needed

- The Training Manual on CSA, data sheets Number 24 and 25.
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Provide all the materials/equipment needed for the implementation of the practice.
- Include refreshments

9.3.8 Timing considerations

Any time of the year, preferably when it is not raining so that the participants can work around the farm to see the practices.

10. ENABLING ENVIRONMENT FOR CSA ADOPTION

The adoption of CSA practices needs to be facilitated by a series of conditions or enabling environment, that help to overcome barriers that may hinder their adoption. Among that condition are policies, legal frameworks, a gender equity approach, institutional arrangements, infrastructure, financial instruments such as insurances, as well as information and extension or advisory services. The existence of such conditions builds institutional capacity and reduces the risks that discourage farmers from investing in new technologies and practices.

For the purpose of this manual we describe three measurements that contribute to the creation of a favorable environment to facilitate the adoption of CSA practices, these are: a gender approaches build within the FFS, early warning systems, and index-based agricultural insurance.

10.1. Reducing risk to facilitate the adoption of CSA practices

Risk and shocks are an ever-present feature of life for farmers everywhere. Some mechanisms have been developed to reduce such risks and to facilitate the adoption of innovative practices in order to deal with climate variability and change.

One of such mechanisms are the "Early warning systems (EWS)" in agriculture, which comprehends capacities, mechanisms and/or tools for detecting natural, physical or climate-related risks and hazards in agriculture, providing and disseminating timely warning information to farmers and responsible authorities to anticipate, prepare and act for preventing or reducing the impact of projected events on crops, and for designing more precise crop planning form short to long term, in order to ensure food security and local livelihoods. In the other hand,

Another risk management mechanism commonly used in high-income countries are agricultural insurances. This type of insurance has been used in such economies for a long time, unfortunately, access to this type of instruments is not common in developing countries. Agricultural insurances do not reduce total risk but can be effective in reducing the burden on individual farmers either by transferring the risk to other institutions or organizations who are better able to bear the risk, or by pooling risks across space, crop sectors, and other economic sectors.

10.1.1 FFS session for early warning systems and index-based agricultural insurance

These two measurements were prioritized by MAFFESDI as a strategy to reduce risk and create a better environment for the adoption of the CSA practices contained in the Training Manual for CSA. A summary of each mechanism is presented as follows.

	Data sheet	Summary
Reducing risk to facilitate the adoption of CSA practices	**CSA PRACTICE No 26: Early Warning Systems for agriculture**	EWS main objective is to reduce the vulnerability and the adverse impacts of extreme climate events by enhancing the preparedness of decision-makers and private individuals for climate-related natural hazards, as well as their readiness to harness favorable weather conditions
	CSA PRACTICE No 27: Index-based agricultural Insurance	In this type of insurance, farmers can purchase coverage based on an index that is correlated with losses, such as wind speed or the amount of rain during a certain window of time. Payouts are then triggered when this index falls above or below a pre-specified threshold.

10.1.2 General overview

The implementation of an EWS for agriculture in the country may have the potential to create appropriate mechanisms that constantly inform farmers and increase knowledge about weather and climate risk projections, to design more precise farm planning, enhancing their readiness to anticipate overcome damages on their farms, reducing vulnerability and improving net incomes. In addition, taking into account current vulnerabilities and 2050 climate projections, it is clear that the implementation of an Index based insurance scheme is a desirable strategy to deal with current and future climate risk in Belize. Taking into account that risks faced by farmers are specific to their location, climate, and local agricultural production systems, the implementation of this mechanism will need to respond to the specificity of each location.

10.1.3 Learning objectives

The learning objective of this FFS session is to create awareness about the role, importance and how to take advantages of an EWS and Index-based Insurances. The specific learning objectives are:

- Identify along with the participants the type of climatic risks that these two practices can help to respond to
- Identify along the participants how these practices contribute to the three pillars of the CSA approach (productivity, adaptation, and mitigation of climate change
- Identify how an EWS may allow farmers from different districts to be informed and aware of the potential impacts of climate events to which they are exposed to during different periods of the year
- Increase knowledge about weather and climate risk projections to design more precise farm planning, enhance their readiness to anticipate and overcome damages,
- Identify the type of early actions that can be taken to be prepared to face weather and climate changing conditions and forecasts in order to reduce vulnerability
- To learn about Index-Based Insurances and how different they are from conventional agriculture insurances
- To understand how an Index-Based Insurance is designed, the type of information that is required for design and implementation, including the type of weather data required
- To learn if Belize has the conditions to develop and implement this type of insurance

10.1.4 Expected results of this FFS session

The following results are expected to enhance the capacity of the participant by the end of the FFS training session:

- Knowledge strengthened on how to reduce vulnerability to weather and climate risk projections through the use of these mechanisms (see points 1 to 4 of the data sheets 26 and 27)
- Knowledge strengthened about how EWS and Index-Based Insurances could contribute to the three pillars of CSA (production, adaptation, and mitigation of climate change). Please see point 5 of the data sheets 26 and 27.
- A clear understanding of the requirements and key challenges commonly faced when implementing these two practices. Please see points 6 and 7 of data sheets 26 and 27.

10.1.5 Knowledge requirements for the extensionist or facilitator and for other local institutions

These two practices are very demanding in terms of specialized knowledge. It is recommended that the extensionist/facilitator involve from the beginning specialists who can provide technical support in the following topics:

- Have access and manage climate and weather information, historical climate data, as other relevant information, to obtain risk and forecast potential impacts on farms and in productivity
- Data processing and analysis and continuous monitoring from experts to evaluate current climate and weather conditions, to make predictions and simulation models about future events
- Dissemination and communication of the alerts and warnings according to information evaluation and systematization
- Generate response and action capacity to alerts and warnings from different responsible agencies and in a local or community level

10.1.6 Considerations for site selection

- For the implementation of this session, it is recommended to work in an office with a connection to the internet, so farmers can have access to existing EWS in Belize or elsewhere and to examples of successful implementation of Index-based insurance.

10.1.7 Materials needed

- The Training Manual on CSA, data sheet 26 and 27
- Paper, flipchart, color markers, masking tape, video projector, computer and didactic materials for the farmers.
- Visual materials to explain how an EWS works. Include refreshments

10.1.8 Timing considerations

This session can be implemented at any time of the year.

Box 1. Climate information services and their contribution to CSA

It is important that farmers have access to reliable and easy to understand climate information to support decision making processes regarding the implementation and adoption of CSA practices.

Climate information services encompass the entire process of generating and providing climate information, its storage and processing into specific end products for use by different sectors that might be affected by climate change and variability. This information is relevant to vulnerable communities to reduce the risks associated with climate, particularly from extreme events, which are now increasing in frequency (WMO 2011), as well as allowing different sections of the economy to make informed decisions.

A major goal of climate information services is to enable better management of the risks of climate variability and change at all levels through the development of science-based climate information and prediction services and products that can be in the implementation of measures, planning and policies that can affect the different sectors including the agriculture sector (WMO 2011).

Climate information services contribute to CSA by providing climate information that can facilitate the implementation of CSA practices. Understanding and knowing how to interpret climate information is important to implement CSA practices in vulnerable regions of Belize that pose the highest climatic risks and involve institutions and practicing extension agents in implement the most adequate practices to reduce the vulnerability of crop production systems

CARE (2014) highlighted the following contribution that climate information systems makes to CSA based on their pillars:

Productivity. Access to adequate and timely weather information can help farmers make decisions on the timing of agricultural activities and the variety of crops to be planted, thus increasing productivity. Farm planning needs to be based considering a wide range of climate possibilities. It supports decision-making on which options to invest in and when and how to invest. For example, a farmer may decide to grow a high-yielding maize variety, given a forecast of a good season for rainfall. The farmer may decide to diversify and add the value of the harvested maize to other projects such as poultry in order to increase income.

Adaptation through risk management. The effective use of climate information services contributes to climate change resilience by enabling farmers to manage the negative impacts of weather-related risks in poor seasons better, while also taking greater advantage of average and better than average seasons. A climate information system is the key to understanding climate as a major influence on livelihoods, ecosystems and development. It allows effective adaptation, which involves developing adaptation options with the flexibility to switch from one strategy to another or to combine strategies.

Mitigation. Climate information services can contribute to CSA by providing information that supports the more efficient use of fertilizers so as to reduce emissions of GHGs.

10.2. Gender equity and equality as a cross-cutting approach

A gender gap exists. The 2017 Global Gender Gap Index report indicates that weighted by population, in 2017, the average progress on closing the global gender gap stands at 68.0%, meaning an average gap of 32.0% remains to be closed worldwide. In Latin America and the Caribbean, the gap represents 29.8%. This means that on average, women have less access to Economic Participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment. Numerous studies have suggested that improving gender parity may result in significant economic dividends (World Economic Forum. 2017).

In agriculture, the gender gap also exists. Female farmers produce less than their male counterparts because they have less access to or ownership of land, use fewer inputs and have less access to important services such as extension services. In many countries, women are only half as likely as men to use fertilizers. If women had the same access to productive resources as men, they could increase yields on their farms by 20–30%. This could raise total agricultural output in developing countries by 2.5–4%, which could, in turn, will help to reduce the number of hungry people in the world by 12–17% (FAO 2011).

The gender gap also shapes the contributions and the way both men and women respond and adapt to climate change. Building resilience within this context is a matter of understanding how gender norms and relations, age, disability, and sexual orientation all affect differences in access, power, and decision making in regard to adaptive capacity (Jost et. al, 2014).

Gender in the Farmer Field Schools

One way to help to close the gender gap in agriculture is by incorporating an equity gender approach within the FFS. In this way, gender equity awareness to foster equitable relationships at different levels could be foster.

With this aim in mind, CATIE developed the toolkit entitled "Gender in the Farmer Field Schools. Capsules for learning and inclusion." This tool consists of eleven modules named "capsules" that are introduced during the training process that takes place within a FFS (Box 1.). It is not necessary to have a session devoted exclusively to the capsules but to implement them within a regular FFS session (Ramirez 2012).

The learning process includes reflections on gender equity in different roles (reproductive, productive and community) and decision making. It is carried out during a FFS sessions and can last 40-minute per thematic capsule.

Gender capsules are designed to focus on specific issues of gender. They contain basic concepts for understanding and learning about gender equity through group reflection.

Box 1. Major topics and contents of the toolkit "Gender in the Farmer Field Schools Modules or Capsules for learning and inclusion."

- ✓ Capsule 1. Concepts of sex and gender
- ✓ Capsule 2. Division of labor according to gender
- ✓ Capsule 3. Gender equity
- ✓ Capsule 4. Community development: livelihoods and community capitals with a gender focus (human capitals)
- ✓ Capsule 5. Community development: livelihoods and community capitals with a gender focus (material capitals)
- ✓ Capsule 6. Power and control of resources or capitals
- ✓ Capsule 7. Participation and leadership
- ✓ Capsule 8. My personal leadership
- ✓ Capsule 9. Inclusive language
- ✓ Capsule 10. Women's participation in decision making in organizations, cooperatives and associative enterprises
- ✓ Capsule 11. Gender and value chains

Source: Ramirez 2012.

Each capsule is organized as follows:

i. An educational objective is identified
ii. Information about the time and materials required to develop the subject is agreed
iii. Instructions about how to conduct the session are established
iv. A practical exercise is included, and
v. A group reflection on the topic takes place at the end of the session

Using the "Gender in the Farmer Field Schools Modules or Capsules for learning and inclusion" tool, it is possible that within the FFS, the contributions and roles of different family members (young people, women, men) are highlighted.

Extensionists/facilitators are encouraged to access the **"Gender in the Farmer Field Schools. Capsules for learning and inclusion" at www.com.** Each module or capsule contains precise indications on how to initiate, conduct and finalize it, as well as the type of supporting material that the facilitator or extensionist should have available to successfully implement the module/capsule within a regular FFS session.

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