Food and Agriculture
Organization of the
United Nations

CLIMATE-SMART AGRICULTURE

TRAINING MANUAL

A reference manual for agricultural extension agents

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Food and Agriculture Organization of the United Nations

Rome, 2018

Required citation:
FAO. 2018. *Climate-smart agriculture training manual – A reference manual for agricultural extension agents*. Rome. 106 pp. Licence: CC BY-NC-SA 3.0 IGO.

ISBN 978-92-5-131065-6

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Acknowledgements

This training manual on climate-smart agriculture was prepared by FAO as one of the outputs of the project "Climate-Smart Agriculture: Capturing the synergies between mitigation, adaptation and food security", founded by the European Commission. The project has developed and tested climate-smart agriculture methodology in three countries – Zambia, Malawi and Viet Nam – over the period 2012 to 2015. Most of the practices and case studies contained in this manual are taken from training materials developed by FAO, the partner organizations and consultants during the implementation of the project and have been tested in training workshops with farmers in the three countries.

The development of the manual has been coordinated by Alessandro Spairani under the overall guidance of Ada Ignaciuk in the Agricultural Economics Development Division (ESA). A number of FAO experts provided valuable contributions, including the current and former members of the Economics and Policy Innovations for Climate-Smart Agriculture (EPIC) team in ESA: Romina Cavatassi who initiated this project, Tessa Adamson, Valentina Conti, Uwe Grewer, Nicholas Sitko, Adriana Paolantonio and experts from different FAO divisions: Alexandre Meybeck (Agriculture and Consumer Protection Department); Anne Mottet, Felix Teillard (Animal Production and Health Division); Patrick Kalas (Capacity Development Unit); Josef Kienzle, Rémi Cluset and Sandra Corsi (Plant Production and Protection Division); Ilaria Sisto and Szilvia Lehel (Social Policies and Rural Institutions Division); Misael Kokwe, (FAO Zambia); Florence Rolle and George Phiri (FAO Malawi); Beate Scherf (Sustainable Agriculture Programme); Delgermaa Chuluunbaatar (Research and Extension Unit); Rima Al-Azar, Marwar Ladki, Mirella Salvatore, Federica Matteoli, Sibyl Nelson and Bianca Dendena (Climate and Environment Division).

The authors would also like to acknowledge the contribution of those who drafted the training manuals in Zambia, Malawi and Viet Nam: Angel Elias Daka, Lydia Ndulu and Chabala Mutuna (NIRAS Consultants) and Morton Mwanza and Reynolds Shula (Ministry of Agriculture) of Zambia; John Kazembe and Judith Kamoto (consultants) of Malawi; and Phạm Thị Sến (Northern Mountainous Agriculture and Forestry Science Institute), Mai Văn Trịnh (Agricultural Environment Institute), Trần Thế Tưởng (Department of Crop Production), Bùi Mỹ Binh (International Cooperation Department, Ministry of Agriculture and Rural Development) of Viet Nam. Further editorial support has been provided by Paul Mundy, Nikola Stalevski and Catherine McMullen, while Anastasia Clafferly has elaborated graphic design and layout.

Acronyms

AEZ	Agro-Ecological Zone
AFOLU	Agriculture, Forestry and Other Land Use
CH_4	Methane
CO_2	Carbon dioxide
CSA	Climate-smart agriculture
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the UN
F-gases	Fluorinated gases
GHG	Greenhouse gas
GWP	Global Warming Potential
IMHEN	Viet Nam Institute of Meteorology, Hydrology and Climate Change
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land-Use Change and Forestry
MONRE	Ministry of Natural Resources and Environment (Vietnam)
N_2O	Nitrous oxide
NO_2	Nitrogen dioxide
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization

Introduction

Population growth, rapid urbanization, and dietary changes are placing tremendous pressure on food systems, particularly in developing countries. Based on current income, population and consumption trends, the Food and Agriculture Organization of the United Nations (FAO) estimates that, by 2050, some 50 percent more food will be needed to satisfy the extra demand compared to 2013 (Alexandratos and Bruinsma, 2012). The challenges posed by rapid growth in food demand are intensified by the effects of climate change on agricultural systems, including crops, livestock, forestry and fisheries.

The effects of climate change will vary by region, country and location and will affect people differently depending on their vulnerability and capacity to adapt. Some areas are expected to become drier and more drought-prone, while others will witness more intense rains or altered rainfall patterns. Increasing temperatures will change the length of the growing seasons and affect yield in some areas, while at the same time modify the distribution of fish populations in rivers and oceans. This added variability changes the conditions in which agriculture is practiced and requires context and site-specific strategies and responses. At the same time, across the globe, climate change will increase the frequency and severity of extreme weather events, including floods, droughts and heatwaves. These events threaten food production and the livelihoods of food producers, particularly those with the weakest adaptation capacity who are too often located in areas exposed to the most severe changes. Moreover, for agricultural systems to sustainably contend with climate change, their contribution to greenhouse gas (GHG) emissions must also be addressed. In fact, agriculture, and associated deforestation, produces an estimated 24 percent of total global GHG emissions (IPCC, 2014a).

Increase agricultural productivity in a sustainable manner to meet the growing global demand, while at the same time adapt to a changing climate and reduce the GHG released in the atmosphere are three interlinked challenges that the agricultural sectors need to overcome in the next decades. To meet these challenges, agricultural production and food systems need to undergo a profound transformation. Such a transformation will involve a variety of stakeholders along the agricultural supply chains and at policy levels. Food producers will have to adapt their farming system techniques in the context of new climate conditions, and increasingly limited natural resources, while at the same time reducing GHG emissions. For this reason, in 2010 FAO introduced the concept of climate-smart agriculture at The Hague Conference on Agriculture, Food Security and Climate Change. Climate-smart agriculture is an approach designed to link agricultural production and food security to climate change adaptation and mitigation, in order to guide the management of agriculture and food systems under climate change at multiple scales: from the farming household to landscape, national and global levels.

The promotion of climate-smart agricultural activities and outcomes requires integrating a wide range of concepts, information and practices from different disciplines and stakeholders. This training manual is specifically designed to provide agricultural extension agents, who are at the front line of agricultural system changes, with a broad range of information and strategies to achieve climate-smart outcomes. By bringing together information on climate science and agricultural science – as well as social, economic and policy analysis – with knowledge keyed to local practices, this manual seeks to increase extension agents' awareness and understanding of climate change and the relevance of the climate-smart approach, and to support them in developing training programmes on climate-smart agriculture in their own countries and communities.

PURPOSE OF THIS MANUAL

This manual is intended for agricultural extension agents and others interested in developing training courses on climate-smart agriculture, which is often abbreviated to CSA.

Specifically, this manual intends to answer the following questions:

- What is climate change and what are its causes?
- How will climate change affect agriculture?
- What can be done to support agricultural producers, both male and female, to adjust to new conditions?
- What are practical solutions that agricultural producers and others can put into practice?
- What types of changes will other stakeholders need to make in order to introduce climate-smart agriculture?
- How does a trainer structure a participatory capacity-development process?
- How can climate change can be effectively communicated to food producers?

However, it should be noted that agricultural production varies widely from place to place, and climate change affects each area and each farm in a different way. Climate-smart agricultural approaches are specific to site and context and there is no one solution, or even one set of solutions, that fits all situations. Nonetheless, we can define some general principles to follow, and we can give examples that readers could adapt to suit their particular circumstances.

OUTLINE OF THE COURSE

This manual is designed for a four-day training course on climate-smart agriculture that would take the learner from the basics of climate science to the impacts of climate change and the linkages among climate, agriculture and food security. It contains four modules, each addressing a particular aspect and consisting of several sessions that are held either in plenary, as one group, or in smaller work groups (Table 1). The content and structure of this manual has been developed and tested through fieldwork involving extension agents and agricultural producers in Zambia, Malawi and Viet Nam.

Table 1. Outline of the training course

Module A: Understanding climate change	
1. What is climate change? 2. What causes climate change?	Helps you understand what climate change is, what causes it, what the effects are, and what you can do about it.
Module B: Climate change impacts on agriculture and food security	
1. What are the effects of climate change on agriculture and how does agriculture contribute to climate change? 2. The link between climate change and food security	Focuses on how climate change is likely to affect agriculture: its effects on different types of farms, on men and women, and on food security.
Module C: Climate-smart agriculture	
1. What is climate-smart agriculture: definition and characteristics 2. Gender issues in climate-smart agriculture	Discusses the challenges of agricultural development in the context of climate change and introduces the concept of climate-smart agriculture, particularly looking at gender related issues.
Module D: Climate-smart agriculture solutions for your area	
1. Local climate-smart practices 2. Barriers to and opportunities for climate-smart agriculture	Looks for ways to make current practices more climate-smart, and presents some possible climate-smart practices that can be used in your area and their barriers and opportunities.

NOTES FOR THE FACILITATOR

Communicating climate change

Climate change is a complex topic. This complexity makes comprehension and knowledge pivotal for the broad concept of climate-smart agriculture to be fully understood and for its relevance to be accepted widely (FAO, 2013b). Moreover, agricultural producers are the key element for achieving the behavioural changes required to adopt climate-smart practices, so they should be adequately supported to get a full grasp of what climate change is and what implications it has for their livelihoods. In this sense, communicating climate change effectively to them, as well as to other stakeholders, is the initiating step in the transition to climate-smart agriculture. To start, there are some key points to keep in mind:

- When communicating about climate change with agricultural producers, participatory approaches should be adopted while accounting for different groups of stakeholders. Farmers, in fact, are the experts on practical solutions in their situation. If we get them involved by sharing clear information, then it is more likely to achieve engagement and promote change through the identification of climate change effects and appropriate solutions accordingly.
- It is paramount to adopt a language that is easily understood and based on concrete examples. In this sense, the use of diverse and culture-sensitive outreach tools is crucial, as well as the use of case studies and examples that the target audience can understand and relate to.
- Agricultural producers should be encouraged to report and exchange observations about local weather and climate, as well as the practices and technologies they adopt, to better connect the changes they witness to climate change effects in their area.

Structure of the training manual

This training manual is organized following a two-tiered approach. The first is to provide a sound theoretical background of information on different aspects of climate and agriculture. The second is to allow participants to apply this knowledge through practical examples, exercises and group work.

TIER 1. Background information that introduces the topic of the session: You can use this information in different ways. You may give a brief presentation to the participants, invite a guest speaker to give a talk on the background, or go straight to the examples or exercises. You may also choose to give the background text to the participants as a handout either before or after the session. Sessions will include examples or more elaborate case studies from Zambia, Malawi and/or Viet Nam. These countries are where the training was developed and tested by FAO. These examples can be replaced by examples from other countries, as appropriate.

TIER 2. Practical exercises in which individuals or groups of participants discuss the topic or try to solve a problem, before reporting back to the plenary: These exercises aim to draw on participants' own knowledge and experience. The workshop participants are likely to have a wealth of knowledge and experience about farming in their local area. You should draw on this knowledge as much as possible. Ask the participants to share their experiences and to explain or develop solutions to problems that they see in the field. Guide and coordinate the group and help them to come up with their own solutions.

This training manual is designed to be flexible, so it can be tailored for context:

- Adapt the content to suit the needs of the participants and the situation in your region and country. Where possible, examples should relate to local conditions. For instance, if you are working in a coastal area, you may want to find cases on lowland farming and fishing. If you are working in a pastoralist area, replace the crop examples with ones on livestock.
- Invite guest speakers to discuss particular topics. This is particularly useful for Module D, which focuses on farming in your area.
- Add, change or drop exercises. Discuss this within the group before reporting back to the plenary. The allotted time for the exercises is only an estimate. Feel free to adapt the exercises or to create your own and replace the examples with ones that are more relevant to your participants' experiences and circumstances.

- Add modules to deal with topics relating to the immediate situation. For example, you might want to spend more time discussing irrigation, credit, drought management, or other issues that are particularly important locally and currently.

Duration of the training

This manual has a flexible structure, so the duration of training components can be modified, ranging from one day for selected aspects and up to four days for the complete training course. The duration of each module is indicative and can be adjusted depending on the needs of the trainers and circumstances of participants.

Tailoring to local and country context

This training manual should help extension agents to develop specific instruction on climate-smart agriculture for practical applications. This means that the examples and exercises should be modified to reflect a country's specific circumstances, because climate-smart agriculture is highly specific to place and context. Where sources of data and information have not been provided, the trainer should consult country documents such as National Communications to the United Nations Framework Convention on Climate Change (UNFCCC) and other national and local planning documents, as well as national, regional and local climate-smart agricultural strategies.

Independent learning

While this manual was assembled to guide the design of group trainings in a workshop setting with around twenty people, it can also be utilized for independent learning on climate-smart agriculture. Readers can go through the introductory texts for each session, then run through the exercises independently. Try to think through each one as if you were in a group. Much of the value of the exercises comes from discussing and learning from people with a range of different experiences.

Note on terminology

The subject of climate change is full of technical terms. We have tried to avoid using them whenever possible and have explained the terms we do use. Even though the examples provided throughout the manual focus mainly on crops, the term agriculture encompasses all agricultural sectors including livestock as well as forestry, fisheries and aquaculture. Similarly, agricultural producers refers to farmers, pastoralists, fisher folk, foresters, etc. and include both women and men.

MODULE A

Understanding climate change

OVERVIEW

The first module of this manual is an introduction to the science of climate change needed to understand the broad concept of climate-smart agriculture. It aims to increase the participants' understanding and knowledge of climate change and its causes. The module also highlights how climate change affects agro-ecosystems and how agricultural sectors contribute to climate change through greenhouse gas emissions.

KEY QUESTIONS

- What is climate and climate change?
- What is the difference between climate change and natural climate variability?
- What are the causes of climate change?
- How does agriculture contribute to climate change?
- What are other sources of greenhouse gas emissions?

OBJECTIVES

After completing this module, participants will be able to:

- Explain the difference between weather and climate
- Distinguish between climate change and climate variability
- Describe the greenhouse effect and global warming
- List the main causes of climate change
- Describe the likely effects of climate change
- Explain the effects of climate change on agro-ecosystems: crops, livestock, fisheries and forestry
- Describe how different agricultural practices contribute to greenhouse gas emissions
- Describe the causes of global warming and how contributions to greenhouse gas emissions differ across world regions
- Analyse the gender dimensions of climate change.

DURATION

4 hours

SESSION A1. WHAT IS CLIMATE CHANGE?

SESSION OVERVIEW

This session introduces participants to the basics of climate change and distinguishes climate from weather and climate variability. The session encourages learners to consider climate trends and recent extreme weather events in their area.

WEATHER AND CLIMATE

To understand what climate change really means, it is important to first differentiate between weather and climate:

- **Weather** is the state of atmospheric conditions at a particular place and time. The most common aspects of weather are felt by everyone during the course of a day and include rain, humidity, wind, sunshine, cloudiness and temperature but also include extreme events such as tornadoes, droughts and tropical cyclones. Weather is dynamic and can change within a very short period of time, even within the same day.
- **Climate** is the set of weather conditions prevailing in an area over a long time, typically three consecutive decades (IPCC, 2007a). Several factors contribute to the definition of climate, including long term averages of temperature and precipitation, but also the type, frequency, duration, and intensity of weather events such as heat waves, cold spells, storms, floods and droughts.

CLIMATE VARIABILITY

Climate variability is the natural fluctuation within the climate, including swings above and below the mean state and other parameters. It reflects the different weather conditions over a day, month, season or year. For example, if we consider rainfall in a given period in a particular region of the world, the variability can be low, meaning that there is not much difference in quantity or timing of rains from one year to another. In another region, there may be high variability, meaning that rainfall quantity swings from far below average to far above average from year to year, and the timing is unpredictable. Climate variability affects weather conditions including cyclone activity and temperature, as well as rainfall. Climate variability results from natural internal processes within the climate system, such as the El Niño Southern Oscillation (Box A1), or from variations in natural external forces, such as volcanic eruptions.

Box A1. Example of climate variability - El Niño Southern Oscillation (ENSO)

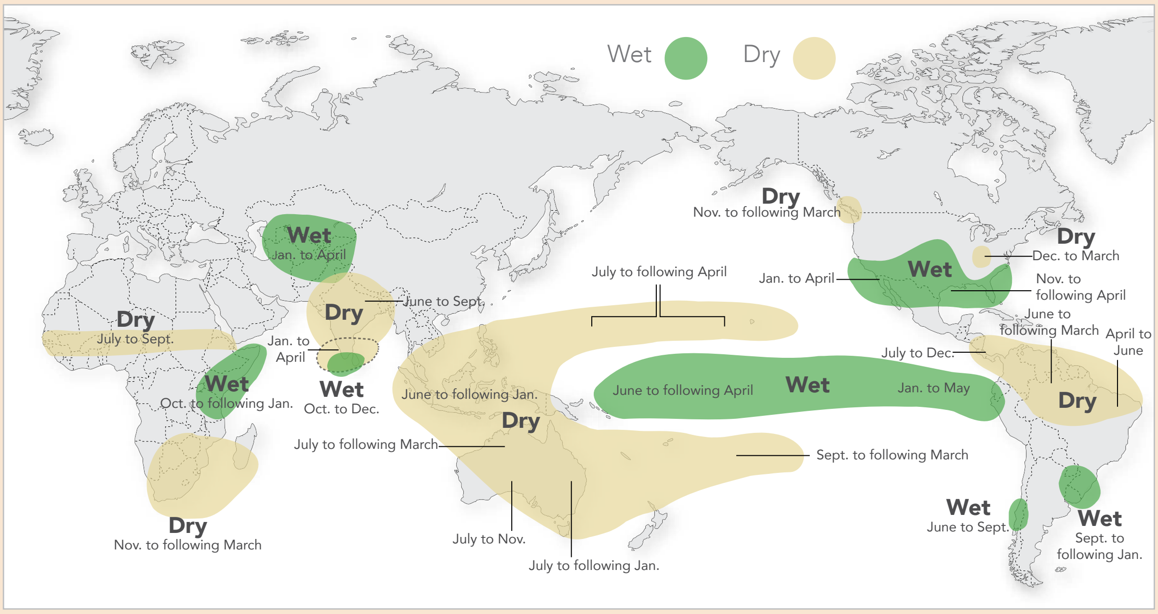
In some cases, patterns of weather conditions may vary in a natural cycle. These fluctuations or oscillations move between two main states and produce both local and distant repercussions. The El Niño Southern Oscillation (ENSO) is an example of a periodic variation, in which interactions between the atmosphere and ocean in the tropical Pacific ultimately affect climate variability in many parts of the world:

- When sea water surface temperature in the central and eastern equatorial Pacific Ocean is warmer than usual, it is known as El Niño.
- Conversely, when sea water surface temperature in the same area is cooler than usual, it is known as La Niña.

Both El Niño and La Niña can last for several years. They may cause big variations in the planet's weather, bringing rain or drought to different parts of the globe. Although every event is different, in El Niño years, the weather tends to be drier than usual in Southern Asia and Oceania, and wetter in Eastern Africa (see Figure below),while the opposite would happen in La Niña years. Both El Niño and La Niña help drive normal climate variability.

...

El Niño affects precipitation patterns globally



Source: International Research Institute for Climate and Society (IRI).

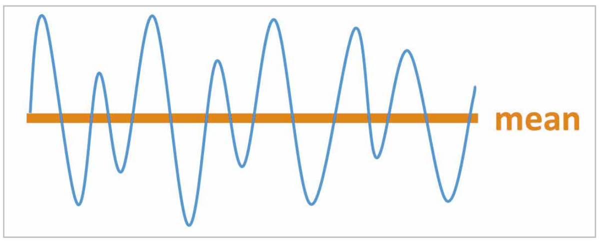
CLIMATE CHANGE

The main difference between climate variability and climate change is that a trend over a time scale indicates a change in climate. While fluctuations over shorter terms – days, seasons, years or several years – and in cycles is climate variability, a consistent linear trend will define climate change as patterns shift over decades.

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

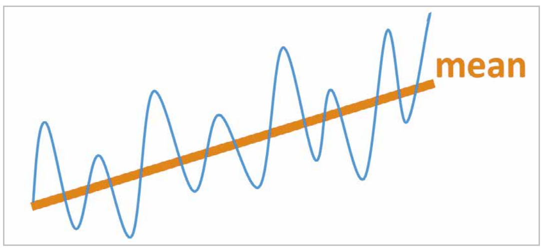
Climate variability averages out as climate over years in a steady state (Figure A1). Climate change averages out to a changing trend over decades (Figure A2).

Figure A1. Climate: Variability around a steady mean



Source: Authors' elaboration.

Figure A2. Climate change: Conditions trend and the mean changes



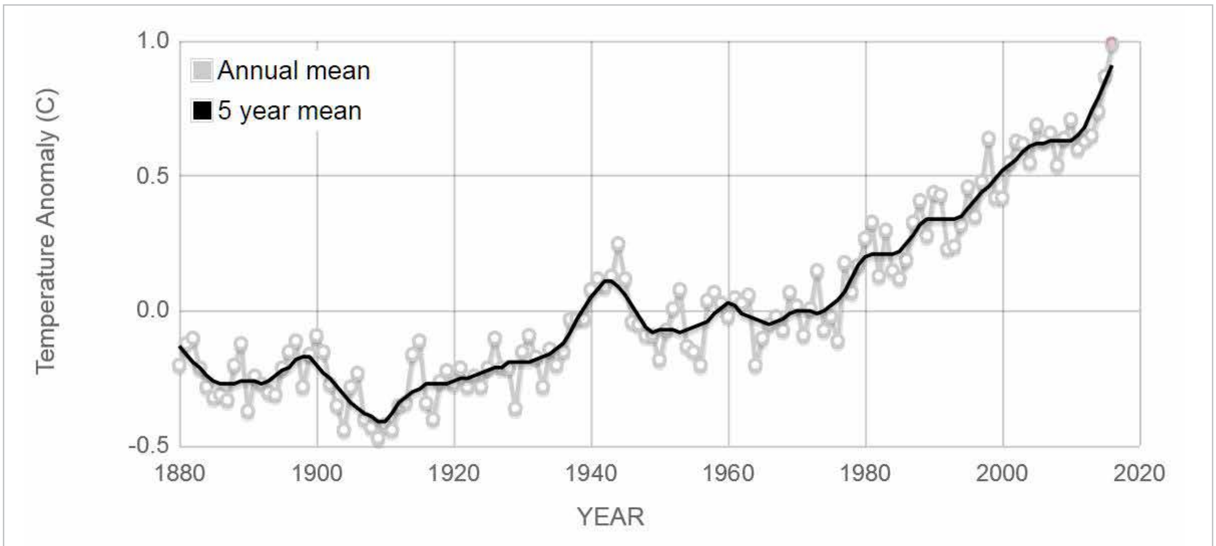
Source: Authors' elaboration.

CLIMATE CHANGE AND GLOBAL WARMING

The Earth's climate has always been changing due to natural causes that include widespread volcanic activity and oscillations in the planet's rotational and orbital cycles. However, scientists have been measuring trends to higher average global temperatures that are happening much faster than observed previously and that cannot be attributed to natural causes. Instead, scientists conclude this longer-term warming is anthropogenic, meaning it is caused by human activities. For this reason, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "change of climate that is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere, and that is in addition to natural climate variability observed over comparable time periods" (UNFCCC, 1992).

Studies show that concentrations of compounds that trap heat in the atmosphere, called greenhouse gases (GHGs), have increased substantially since the beginning of the industrial era. Around the year 1750, industrial-scale production began and led to a global increase in use of fossil fuels that emit greenhouse gases when burned. Over the period from 1880 to 2012, the planet warmed by an average of 0.85 °C. Temperatures are expected to continue rising by between 0.3 °C to 4.8 °C by 2100, depending on different possible conditions (IPCC, 2013). Each of the last three decades – 1981 to 1990, 1991 to 2000 and 2001 to 2010 – has been successively warmer at the Earth's surface than any decade since measurements began. The warmest decade ever measured was 2001 to 2010, and 2016 was the warmest year on record, with a 1.1 °C increase from pre-industrial level (WMO, 2017). Although these may seem to be small changes, seen against long term observations of stable conditions, the change is clear (Figure A3). This long term global warming produces climate changes at regional and smaller scales with important repercussions for the planet's ecosystems.

Figure A3. Global land-ocean temperature index 1880–2016



Source: NASA/Goddard Institute for Space Studies (GISS).

CLIMATE CHANGE ASSESSMENT TOOLS AND METHODS

Scientists use different tools to understand how climate is evolving over time and to forecast possible changes, including prediction models, emission scenarios and climate projections.

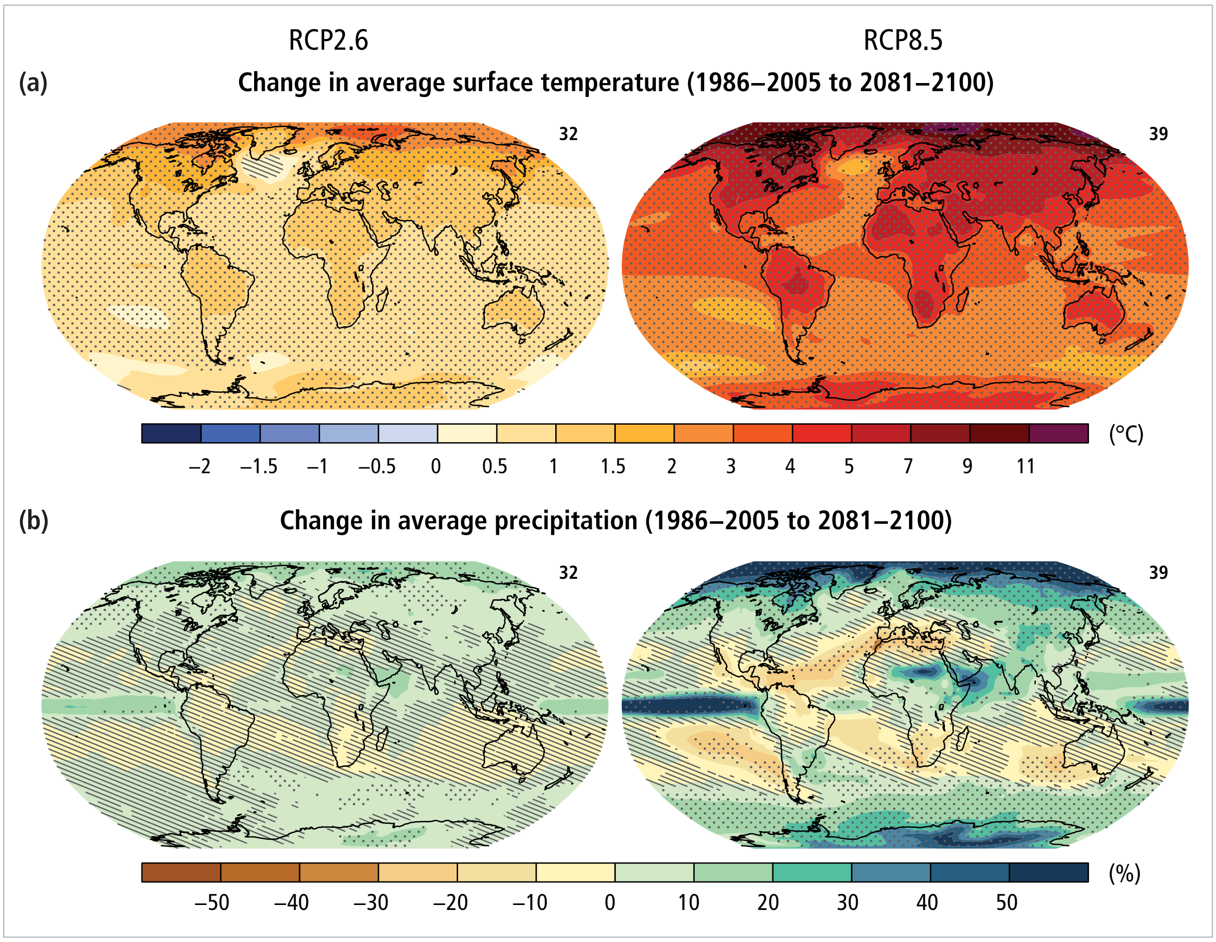
Scientists also use simulations to better understand the future effects of climate change. For example, they can simulate the possible effects of different future climate conditions on agricultural productivity and population health (Figure A4). Because future conditions are uncertain, scientists typically consider a set of alternative possible scenarios that are likely to occur in future years. For instance, in estimating the productivity of rice yields in 2050 in Sub-Saharan Africa, two scenarios could be considered:

- One characterized by high temperatures, but without the adoption of new technologies; and
- A second one characterized by the same high temperatures as well as the adoption of new efficient agricultural technologies in rice farmers' practices.

In these cases, simulations of how the scenarios evolve help to quantify the changes in expected rice production according to the two alternatives. This allows policymakers and other stakeholders to evaluate potential benefits of new farm technologies and practices against business-as-usual practices, in the context of changing climate.

Future effects of climate change include and depend on many factors – temperature and precipitation patterns, possible influence of CO_2 on plant growth, incidence of pests and diseases, among other things – that can challenge simulation of potential agricultural production. However, successful simulations of these conditions produce crucial information for the design and implementation of sustainable agricultural policies that minimize the detrimental effects of climate change on agricultural production and on peoples' lives.

Figure A4. Scenarios for temperature and precipitation changes



Source: IPCC, 2014.

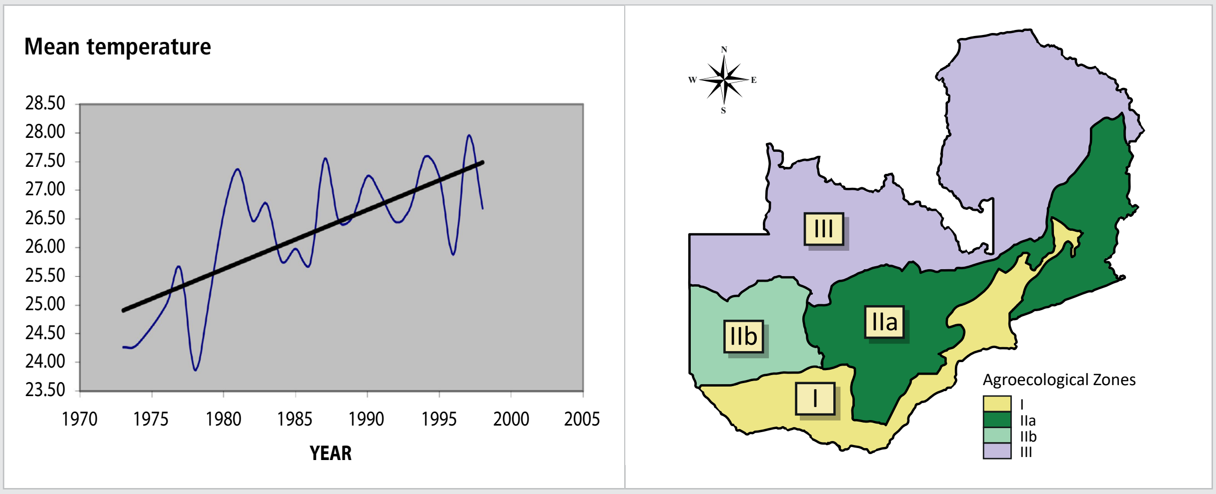
CASE STUDY ZAMBIA

Temperature and rainfall trends

TEMPERATURE

Zambia has four distinct Agro-Ecological Regions and the predicted impacts of climate change differ across each of them. Records show that the mean annual temperature in all agro-ecological zones has increased by 1.3 °C between 1960 and 2003 (Government of Zambia, 2010). This is approximately twice the increase in temperatures worldwide. In the western and southern part of the country alone agro-ecological zone (AER) I, the mean temperature in November–December, when seedlings germinate, rose by 2.5 °C between 1975 and 2000 (Figure AZ1) (Jain, 2007). The temperature increase is expected to continue across the country by a further 1.2 to 3.4°C by the 2060s, in particular in southern and western regions of the northern and eastern regions. (Government of Zambia, 2010; Kanyanga *et al.*, 2013).

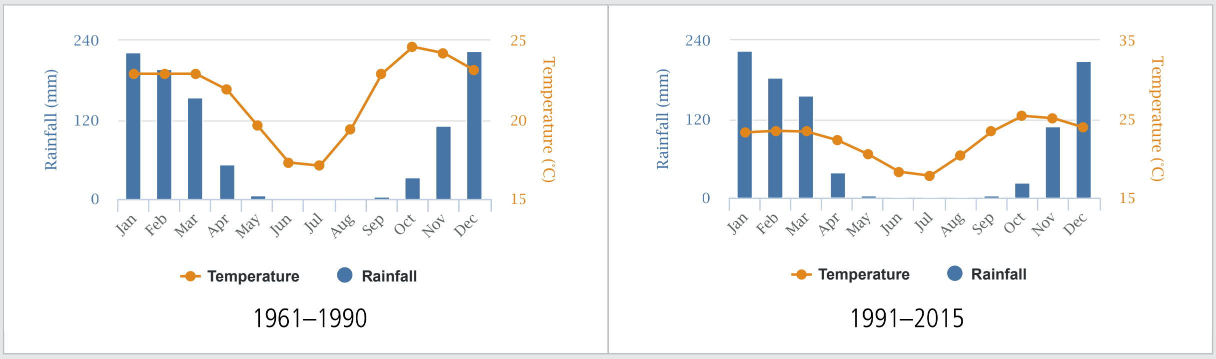
Figure AZ1. November–December mean temperature in Zone I



Source: Jain, 2007. Source: Dept. of Meteorology, FEWSNET.

The country experiences two main seasons: a rainy season (November to April) and a dry season (May to October). AER I is exposed to low, unpredictable and poorly distributed rainfall in general, whereas the central part of the country (AER IIa & b) has well-distributed rainfall (Jain 2007). Overall, changes between the periods 1961 to 1990 and 1991 to 2015 show a declining trend in normal rainfall in each of Zambia's agro-ecological zones (Figure AZ2). Zambia-specific climate models predict that rainfall will decrease increase in AER I and II, while it will increase in the northern parts of the country (AER III) (Kanyanga *et al*. 2013).

Figure AZ2. Average temperature and rainfall in Zambia from 1961–1990 and 1991–2015

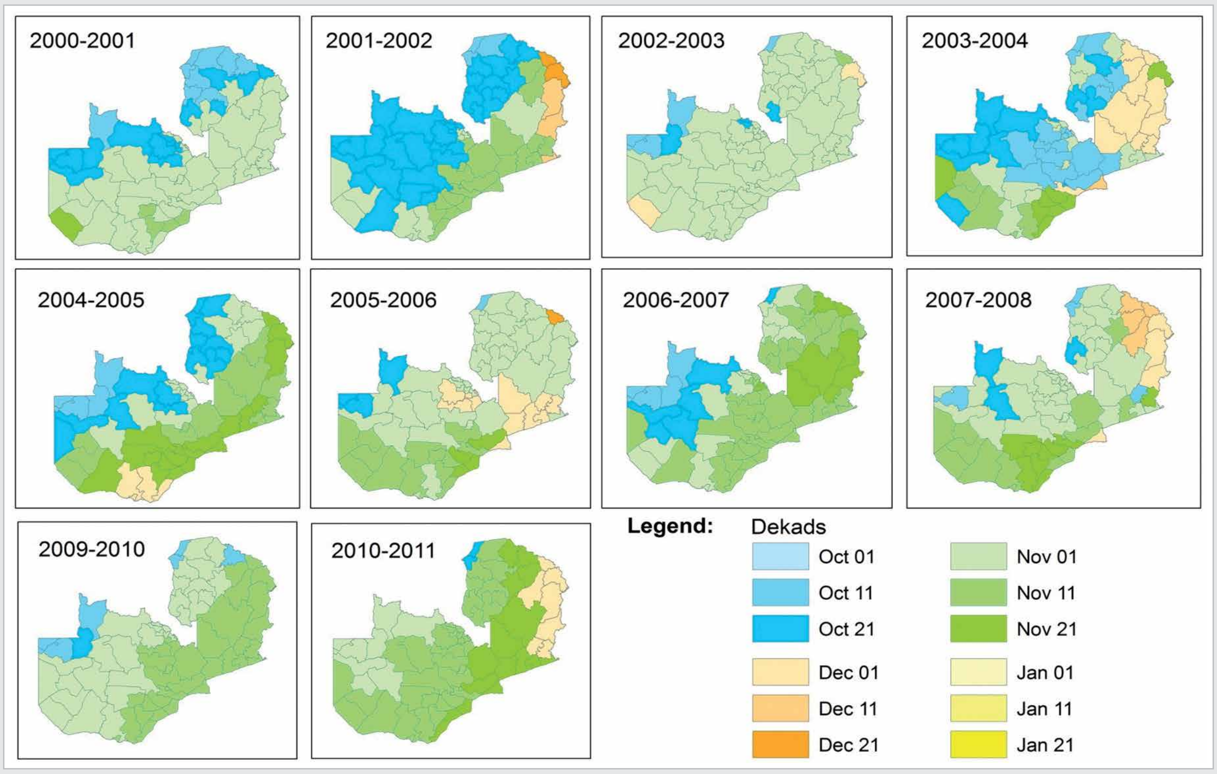


Source: Word Bank Climate Change Knowledge Portal.

The list below reflects the issues discussed by Zambian farmers and stakeholders during a series of consultations in the country.

- **When does the rainy season begin?** In Zambia, the rains generally begin in mid to late October. But a changing climate means this is becoming less predictable. Farmers need to have some idea when the rains will start so they can prepare the fields and sow on time (Figure AZ3).
- **How long does the rainy season last?** Rains generally continue through the end of March into early April. A late start to the rains may shorten the length of the rainy season. Climate change may also mean the rains stop earlier than usual. That may be a problem for crops that need water late in the season.
- **How much rain will fall?** Crops require a certain amount of water to grow and produce a good yield. The water is stored in the soil, where plant roots can reach it. If too little rain falls, there is not enough water to support the crops.
- **How heavy is the rain?** If the rain comes in a few heavy storms, most of the water will run off, causing erosion and flooding. Little water sinks into the soil, so the crop may go thirsty later in the season.
- **When will the rain fall?** Dry spells can cause problems with germination or flowering. Wet spells can make it difficult to harvest and dry the crop.

Figure AZ3. Changes in the onset of the rainy season in Zambia from 2000 to 2011



Source: Authors' elaboration using RFE Data.

CASE STUDY MALAWI

Temperature and rainfall trends

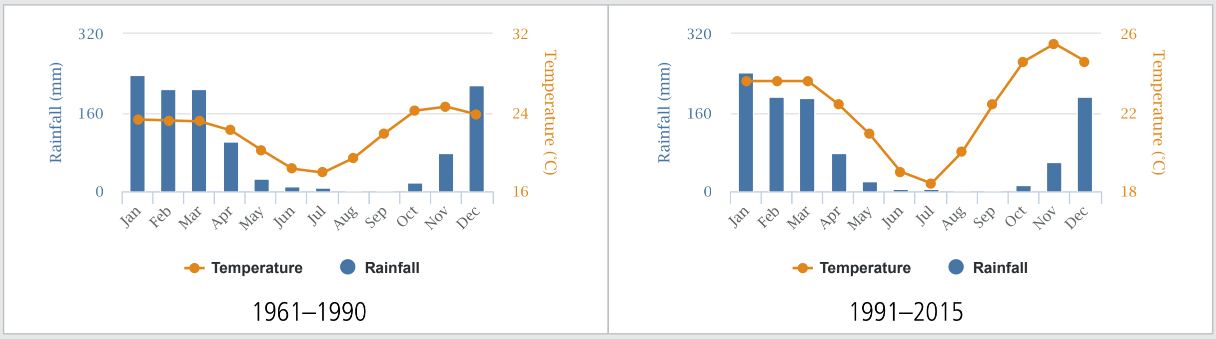
TEMPERATURE

If we look at some key indicators on temperature, it is possible to identify recent climate trends in Malawi (World Bank 2011). For example, the mean annual temperature rose by 0.9 °C between 1960 and 2006, an average of about 0.2 °C per decade, while the frequency of both hot days and nights, during which temperatures exceeded by 10 percent the current climate of that region and season, has increased substantially between 1960 and 2003:

- The average number of hot days per year increased by 30.5.
- The average number of hot nights increased by 41 a year, an additional 11.1 percent of nights.
- The average number of cold days per year fell by 16, 4.3 percent of days.
- The average number of cold nights per year fell by 33 days, 8.9 percent of nights.

The rainy season falls between November and April, while there is little rain during the rest of the year. Unlike temperatures, Malawi's inter-annual rainfalls show significant variability (mainly due to El Niño Southern Oscillation) and it is difficult to identify long-term trends. (World Bank 2011). This can be recognized in the record of the mean historical monthly temperature and rainfall for Malawi during the periods 1961-1990 and 1991-2015 (Figure AM1).

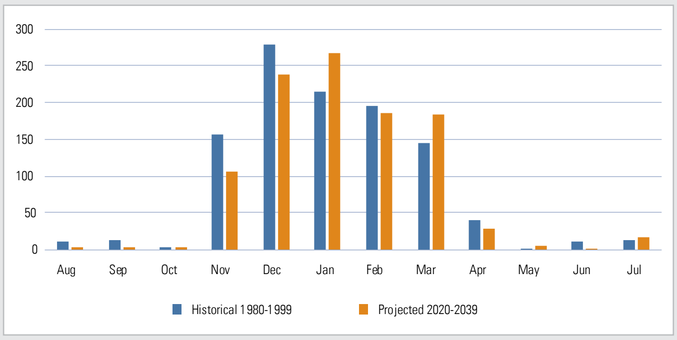
Figure AM1. Comparison of average temperature and rainfall in Malawi from 1961–1990 and 1991–2015



Source: World Bank Climate Change Knowledge Portal.

Malawi's climate projections indicate that the mean temperature will increase by 1.1 to 3.0 °C by the 2060s and by 1.5 to 5.0 °C by the 2090s. On the other hand, precipitation projections show little substantial change. Depending on the scenario used, some projections show a decrease of rainfall in dry season and an increase in wet season (Figure AM2).

Figure AM2. Historical and projected rainfall patterns in Malawi



Source: World Bank Climate Change Knowledge Portal. Note: Calculation of projected rainfall is based on the MIROC-ESM-CHEM model.

CASE STUDY VIET NAM
Temperature and rainfall trends

TEMPERATURE

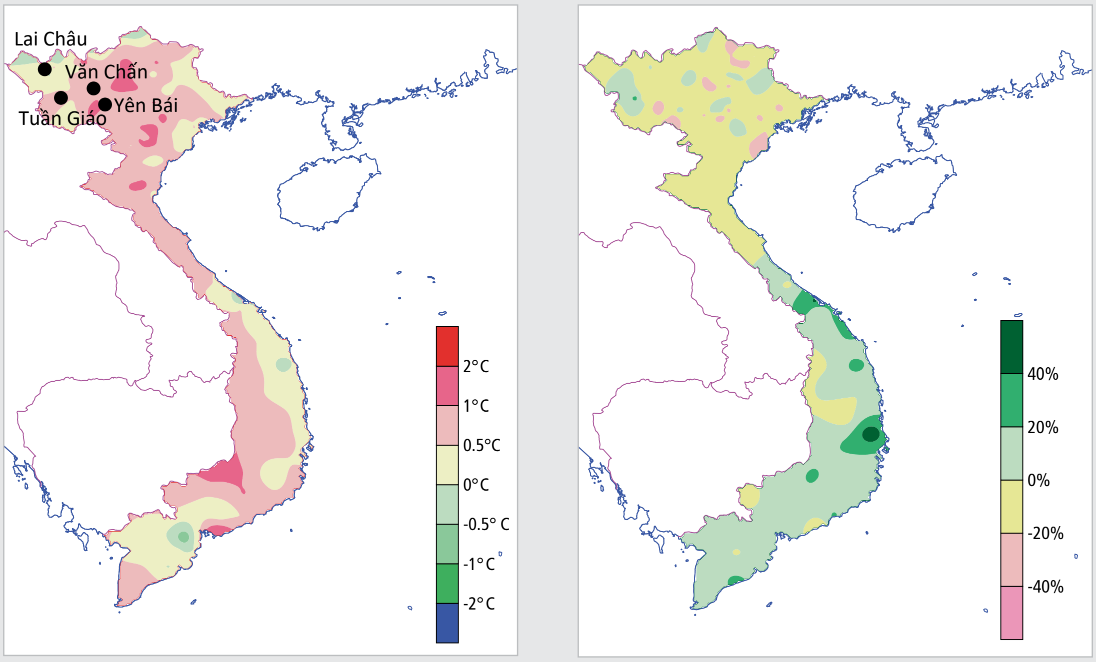
In Viet Nam, temperature increases have been recorded in many locations (Figure AV1). Only a few locations have become cooler. It has been reported that in the last fifty years, temperatures have increased by 0.62 °C for the whole country, an average of 0.10 °C per decade (MONRE, 2016).

Figure AV2 shows the changes from year to year in the mountainous region in northern Viet Nam. While there has been considerable variation from year to year, the overall trend in all locations is upwards.

RAINFALL

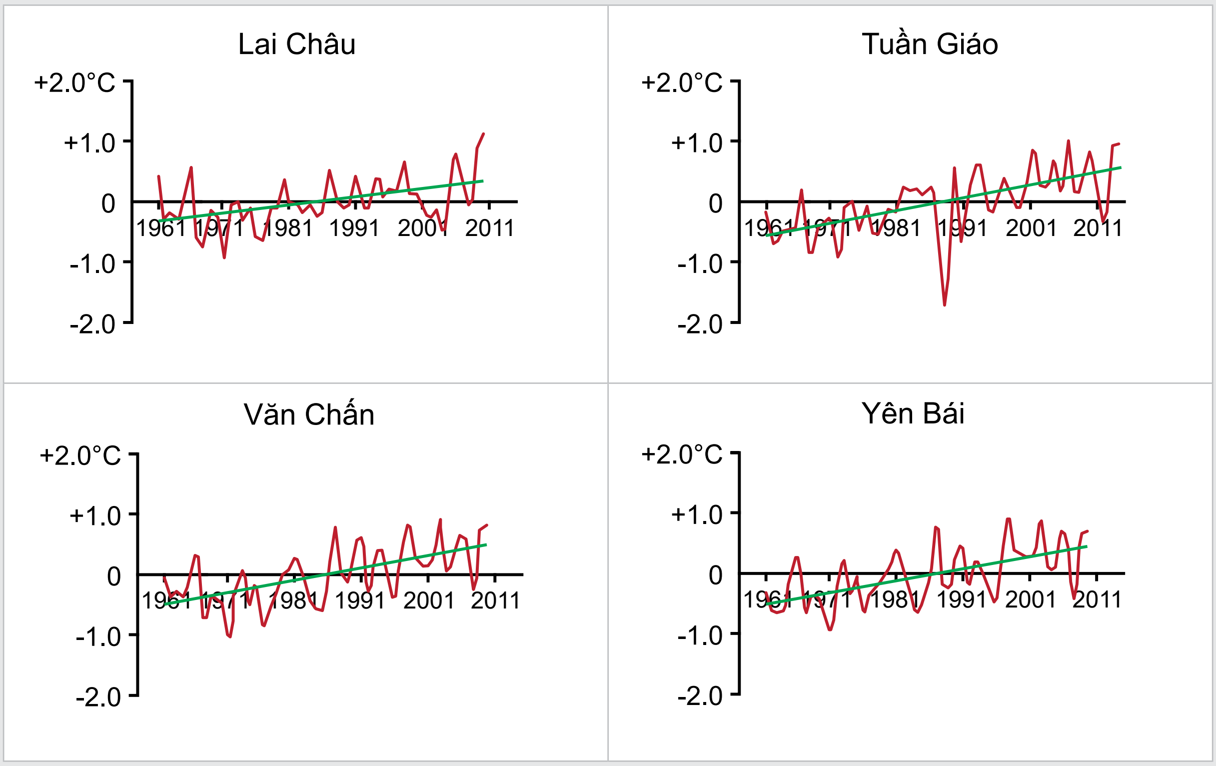
- **Onset of the rains.** The onset of rainfall in Viet Nam is variable but has become more unpredictable. The rainy season may begin or end earlier or later than average due to climate change.
- **Duration of the rainy season.** Generally, the rainy season has become shorter and rains are now more concentrated, while the dry period has become longer. This results in drought problems for crops in the dry season and increased flooding in the rainy season.
- **Total amount of rainfall.** The total rainfall in southern Viet Nam has generally increased, while in northern Viet Nam it has decreased. Even where there has been little change in the total rainfall, at some locations the totals from year to year have become more erratic, for instance in Lai Châu (Figure AV3).
- **Rainfall distribution.** The distribution of rainfall has changed in many places. It is distributed more unevenly throughout the year and across Viet Nam. Both the amount and timing of rains have become more difficult to predict.
- **Extreme weather.** Floods, drought, landslides and tropical cyclones have increased in terms of both frequency and severity.

Figure AV1. Changes in the average temperature and rainfall in Viet Nam during the past 50 years



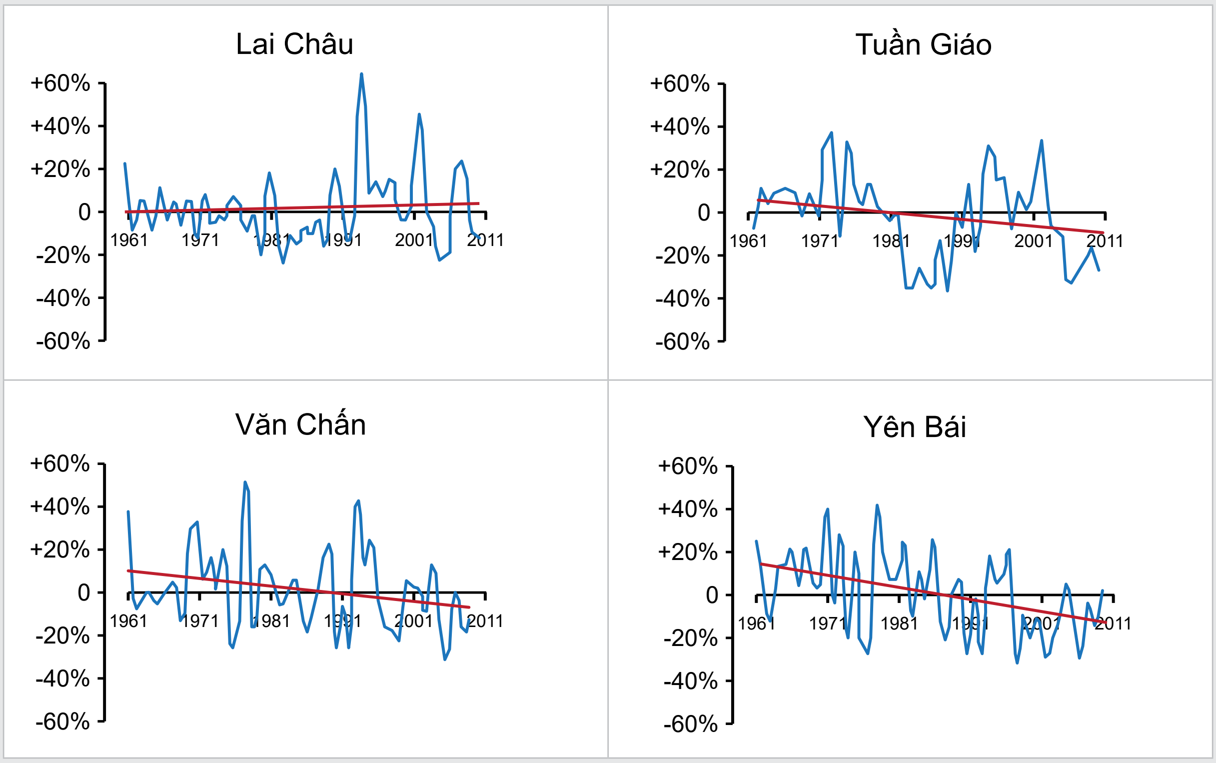
Source: Viet Nam Institute of Meteorology, Hydrology and Climate Change (IMHEN), no date.

Figure AV2. Changes in average annual temperature in northern Viet Nam, 1961–2011



Source: MCG, 2014 using DONRE data.

Figure AV3. Changes in average annual rainfall in northern Viet Nam, 1961–2011



Source: MCG, 2014 using DONRE data.

SESSION A2. **CAUSES OF CLIMATE CHANGE**

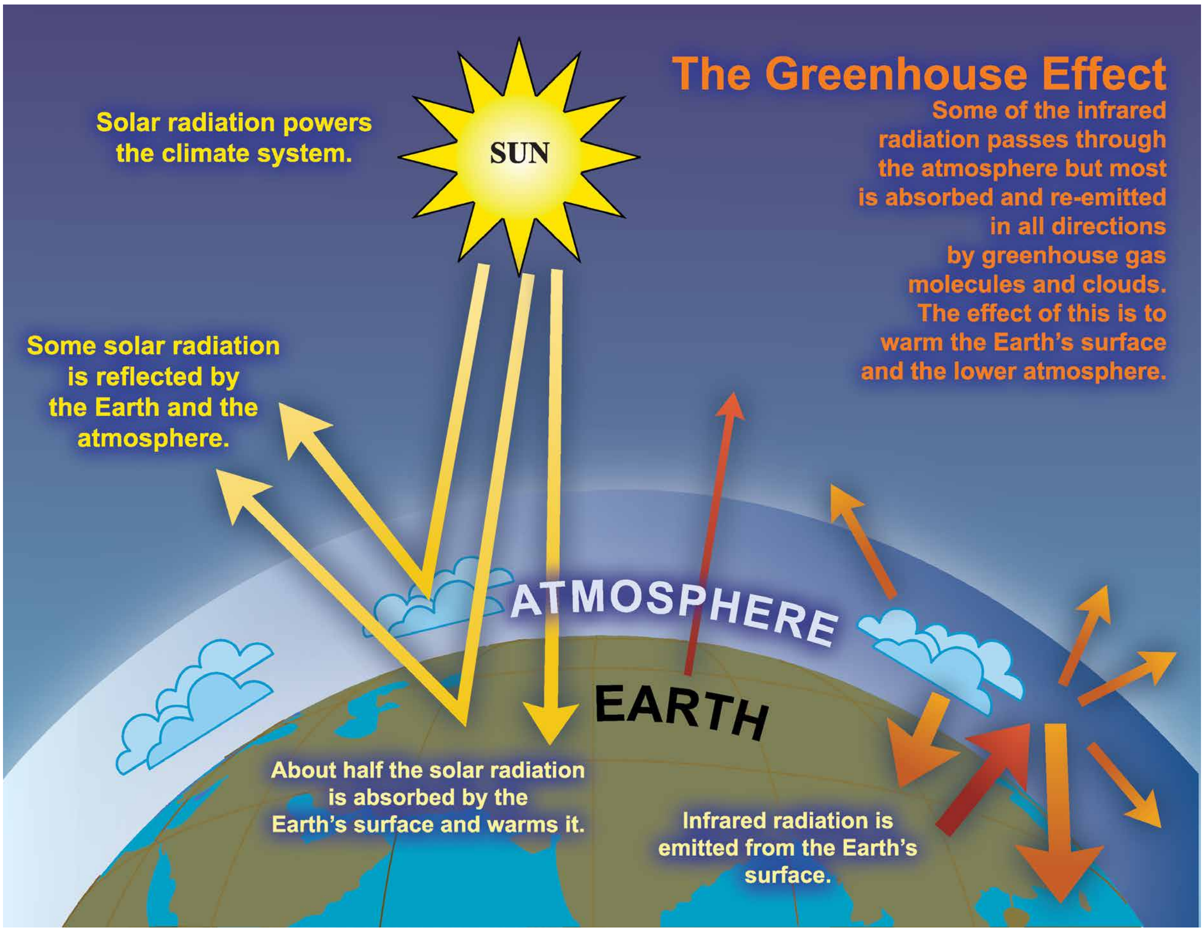
SESSION OVERVIEW

This session explores the causes of climate change. It examines the greenhouse effect and the main sources of greenhouse gases. The exercises help participants understand the greenhouse effect and to visualize how various human activities influence the emission of greenhouse gases.

THE GREENHOUSE EFFECT

Energy from the sun, arriving as ultraviolet radiation, drives the Earth's weather and climate. It heats the Earth's surface land and oceans, which in turn heat the atmosphere as infrared radiation. Most of that energy is radiated back into space, but some is trapped in the ground, the ocean and the atmosphere (Figure A5). The Earth's atmosphere consists mainly of nitrogen, oxygen and argon, which have no effect on climate. It also contains small amounts of other gases, including water vapor, carbon dioxide, methane and nitrous oxide, called greenhouse gases because they act like the glass in a greenhouse: they block heat from escaping, allowing the atmosphere to warm up. The atmosphere, in turn, further warms the ground and the oceans. This is known as the **greenhouse effect.** Earth's natural greenhouse effect makes life as we know it possible, otherwise it would be too cold for human life. As we have seen in the previous session, it has been observed that the Earth is getting warmer. This is due to an increasing concentration of greenhouse gases that trap heat in the atmosphere caused by human activities since the industrial revolution in the late 18th century.

Figure A5. The greenhouse effect



Source: IPCC, 2007a.

MAJOR GREENHOUSE GASES

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

- Water vapour (H_2O) is water that evaporates from the sea, lakes, rivers and the soil surface, and that is transpired by plants and often felt as humidity. Human activity makes little direct contribution to the large amount of water vapour or clouds in the atmosphere.
- Carbon dioxide (CO_2) can be found in nature produced by volcanoes and geysers. It is emitted by human activities including transport and energy production based on combustion engines burning fossil fuels such as coal, mineral oil, gas. All animals exhale it through respiration, as do plants at night when they are not photosynthesizing. It also enters the atmosphere through the decay of organic matter, deforestation, burning vegetation and certain industrial processes such as cement-making.
- Methane (CH_4) enters the atmosphere when produced by livestock, as well as by microbes in the soil and in water, such as in flooded rice fields. It is released when permanently frozen ground thaws in mountains and polar regions and when wetlands, marshes, swamps, bogs and peatlands are dried.
- Nitrous oxide (N_2O) is produced by farming, including organic and synthetic fertilizer applications, industrial processes and burning fossil fuels.
- Fluorinated gases (F-gases) are made by humans and used in refrigerators, air-conditioners, foams, cosmetics and fire extinguishers.

Note that nitrous oxide is different from other compounds of nitrogen and oxygen:

- Nitrous oxide (N_2O) is a greenhouse gas.
- Nitric oxide (NO) and nitrogen dioxide (NO_2) are pollutants emitted by motor vehicles. They cause respiratory problems but do not cause global warming. They are collectively known as NO_X.

Carbon dioxide equivalents

Different greenhouse gases have different effects, depending on their concentration in the atmosphere, their ability to alter the radiation balance, and the amount of time they remain in the atmosphere. To allow comparisons of the global warming impacts of different gases, the IPCC (IPCC, 2014a) uses global warming potential (GWP) as a measure to "represent the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing". The larger the GWP value, the higher the warming effect of a given gas compared to carbon dioxide over a time period, usually in terms of 100 years. For example, one tonne of methane is equivalent to 25 tonnes of carbon dioxide, while one tonne of nitrous oxide is equivalent to 298 tonnes of carbon dioxide (IPCC, 2007b).

- A molecule of carbon dioxide has the smallest effect on the climate, but it is by far the most common anthropogenic greenhouse gas, so it has the biggest overall effect. The GWP of carbon dioxide is 1 regardless of the time period and it is used as the reference that allows comparison with other gases. Carbon dioxide accounts for around three-fourths of total emissions and its overall contribution to radiative forcing continues to rise. It is difficult to provide a single lifetime of carbon dioxide because the gas is not destroyed over time, rather it moves through the Earth System: so far, most of the excess has been incorporated in the oceans over decades, while the rest will remain in the atmosphere for thousands of years.
- Methane is a more potent greenhouse gas than carbon dioxide, but sunlight converts methane molecules to carbon dioxide after about 12 years. Averaged out, the GWP over 100 years of methane is 28.
- Other gases are more powerful sources of warming and last much longer in the atmosphere. Nitrous oxide lasts 121 years and has a GWP over 100 years of 265, while some types of fluorinated gases may last thousands of years with a GWP over 100 years of more than 6500.

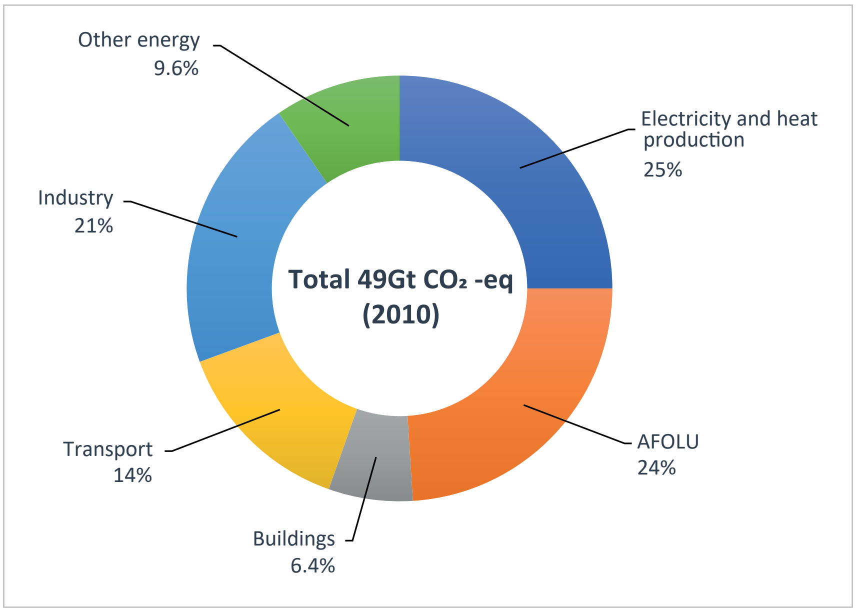
WHAT ARE THE MAIN SOURCES OF GREENHOUSE GASES?

Human activities play an important role in the emission of greenhouse gases. The amount of carbon dioxide released by each country depends on the type and share of its main economic activities. Therefore, the shares of carbon dioxide emissions are different across the regions of the world.

The latest estimates of emissions from human activities totalled more than 46 billion metric tonnes of greenhouse gases, expressed as carbon dioxide equivalents, representing a 35 percent increase over the previous decade

(IPCC, 2014a). Electricity and heat production represents the biggest source of greenhouse gases emissions globally, mainly due to the burning of coal, oil and natural gas (Figure A6). Agriculture, forestry and other land use (AFOLU) sectors are the second most important source of emissions, responsible globally for around 24 percent. Other sectors include industry that accounts for 21 percent of all emissions, transport – road vehicles, trains, ships and aircraft running on fossil fuels – accounting for 14 percent, other energy sources accounting for 9.6 percent and buildings accounting for 6.4 percent.

Figure A6. Global greenhouse gas emissions by economic sector



Source: IPCC, 2014a.

EXERCISE A.1 INTRODUCTION TO THE TRAINING COURSE

30 minutes

See the Introduction to this manual.

1. Welcome the participants and invite each one to introduce him- or herself in one minute (name, job or position, organization he/she works for), and to answer the question "Why are you here and what do you hope to learn?"
2. Make note of the expectations and keep them for reference during the session and the review at the end of the workshop.
3. Explain the purpose and outline of the training course, referring back to the participants' expectations where relevant.

EXERCISE A.2 WEATHER AND CLIMATE

60 minutes

1. Explain that studies show climate is indeed changing. Give examples from studies from your country or area. Emphasize that research from many sources, studying locations on every continent, have reached this conclusion and it is very widely agreed. Use video, if possible, for explaining the concept. (15 minutes).
2. Divide people in groups giving them questions that they have to answer during the discussion. Questions could be on two scenarios and participants discuss to identify what is weather and what is climate. (5 minutes).
3. Work in groups. (30 minutes).
4. Ask the groups to report back to the plenary. (10 minutes each).

EXERCISE A.3 GLOBAL WARMING

60 minutes

See Figure A3: Global land-ocean temperature index 1880-2016

1. Invite the participants to look at Figure A3. Draw their attention to the periods between 1880 and 1920, and between 1940 and 1980. During these times, the annual temperature (the lighter line) varied a lot, while the 5-year average (the darker line) varied somewhat but did not rise by the end of the period.
2. Now draw their attention to the periods between 1920 and 1940, and after 1980. During these times, the annual temperatures tended to rise, though there was still a lot of variation from year to year, and the 5-year average rose almost continuously. Explain global measurements indicate that the Earth's temperature in fact rose 0.6 to 0.9 °C (1.1 to 1.6 °F) between 1906 and 2005 and projections suggest it will rise further in the coming years.
3. Ask participants why the Earth's temperature is heating up and what would that could mean for their livelihoods. You might want to introduce Figure A5 to show how the sun heats the land and oceans, and the atmosphere.

EXERCISE A.4 CHANGES IN RAINFALL

60 minutes

See Figure AZ2: Average temperature and rainfall in Zambia from 1961–1990 and 1991–2015

1. Ask the groups to discuss how the patterns in Figure AZ2 relate to their own experience over the last 10–20 years.

2. Facilitate a discussion about what the rainfall differences mean to agricultural producers. How are they affected by an early or late onset of the rains? By a long or short rainy season? If it stops raining for a month during the wet season? See the Module A case study texts on Rainfall for some ideas.
3. Ask the participants how agricultural producers can tell when the rainy seasons will start? Where do they get such information? Do men and women have the same access to this information and if not, why? What can extension staff do to help producers, both men and women, get the information about the weather?

EXERCISE A.5 THE GREENHOUSE EFFECT

60 minutes

See Figures A5 and A6

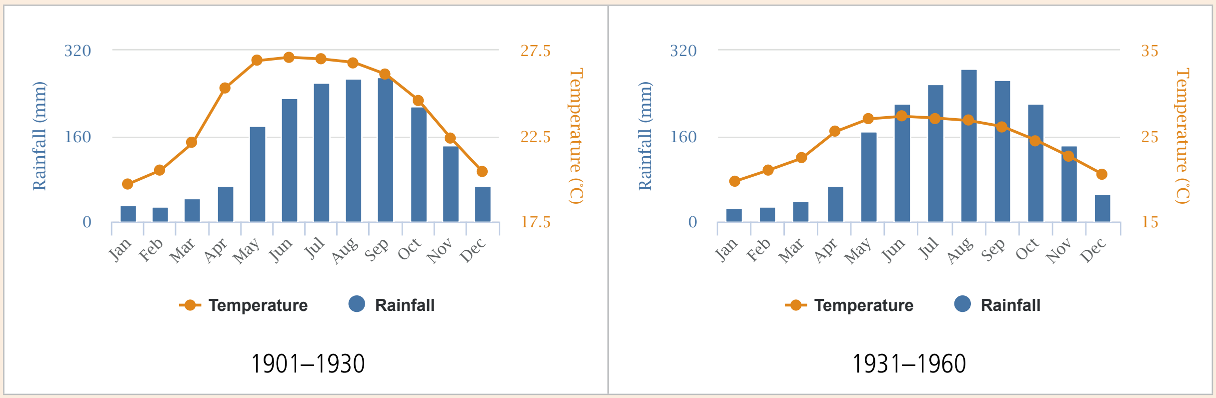
1. Ask the participants if they know why the climate is changing. Possible answers include: the climate is not changing; changes in the temperature of the oceans, such as El Niño and La Niña; volcanic eruptions; or human activity such as cutting down trees, urbanization and burning fossil fuels.
2. Explain that the climate is indeed changing, and that humans are the main cause. Draw their attention to Figure A5. Emphasize that research from many sources, studying locations on every continent, and very widely agreed have reached this conclusion. While cutting trees and urbanization are important, the biggest cause of climate change is the increased levels of greenhouse gases: carbon dioxide, methane and several other gases in the air. These gases trap heat, warming up the ground, the oceans and the atmosphere. The greenhouse gases come from a variety of sources, including burning fossil fuels – coal, oil, and gas; changes in land use, such as ploughing, draining swamps, burning off fields and cutting trees; and industry.
3. Give a presentation on the greenhouse effect as described at the beginning of Session A2. Discuss the sources of greenhouse gases and draw attention to Figure A6, providing further detail about the various sectors and inviting participants to give input on fuel use and emissions and to ask questions.

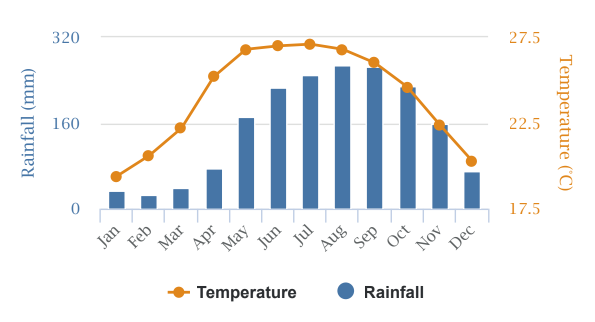
EXERCISE A.6 CLIMATE CHANGE IN YOUR AREA

60 minutes

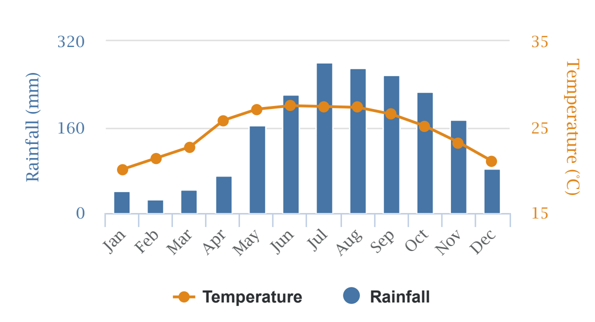
1. Before the session, visit the World Bank's Climate Change Knowledge Portal. Click on your region and country in the world map and download the graphs for rainfall and temperature in the different time frames: 1901–1930, 1931–1960, 1961–1990, and 1991–2012). Make sure you are aware of the different vertical scales used for both rainfall and temperature. Different vertical scales can skew the visual representations.
2. Print the graphs out as posters or handouts (or show them on a screen). See, for example, these graphs of data from Viet Nam:

Figure A7. Average monthly temperature and rainfall for Viet Nam, 1901–1930, 1931–1960, 1961–1990, 1991–2015





1961–1990



1991–2015

Source: World Bank Climate Change Knowledge Portal.

1. Explain to the participants that the red line shows the mean temperature, and the blue bars show the mean rainfall in each month. Note how using different scales distorts the impression of relationships between the two variables. Note the similarities of the graphs when the same scales are used for both variables. Stress that these are averages for up to 30 years – so there may be big differences from one year to another that are not reflected in the graphs.
2. Divide the participants into groups. Ask them to study the graphs and answer the following questions about the temperature and rainfall:
   - When are the warmest and wettest months?
   - When are the coolest and driest months?
   - Has the temperature and rainfall pattern changed since 1900?
3. Invite each group to report back to the plenary.
4. Lead a discussion about the changes they have noticed, and gently point out important things they may not have noticed. Point out that different parts of the world will experience different types of changes.

Ask them to relate their findings to their own experiences and the history of the area. For example, what do elderly people say about the climate in their youth?

MODULE B

Climate change impacts on agriculture and food security

OVERVIEW

The aim of this module is to understand the relationships among climate change, agriculture and food security. It does so by reviewing some possible effects that a changing climate could have on the agro-ecosystems and how ultimately this affects agricultural development and food security, putting vulnerable communities at risk, and taking into account that men and women are affected in different ways. In the first session, the module reviews some of the possible impacts of climate change on agricultural sectors. This is followed, in the second session, by a presentation of the concept of food security and an explanation of the reasons why, in absence of appropriate policy interventions, climate change can be harmful to the four dimensions of food security and nutrition in the short and long term. Participants are encouraged to debate how a changing climate is likely to affect a particular aspect of human activity in their area.

KEY QUESTIONS

- What are the effects of climate change on the agricultural sectors?
- How is agriculture contributing to climate change?
- What is food security and what are its dimensions?
- Why is it important to understand the relation between climate change and food security?
- What are the means through which extreme climate shocks can put food security and nutrition at risk?
- How are male and female agricultural producers affected by climate change in similar and different ways?

OBJECTIVES

After completing this module, participants will be able to:

- Identify key possible effects of climate change on agriculture
- Recognize agricultural producers' different vulnerabilities and capacities
- Explain the concept of food security and its four dimensions
- Explain the difference between short-term and long-term food security, the causes of food insecurity and measures to address it
- Describe the transmission mechanisms of climate shocks - from their occurrence to the risk of food insecurity
- Describe how different climate shocks affect the four dimensions of food security.

DURATION

5 hours

SESSION B1. CLIMATE CHANGE AND AGRICULTURE

SESSION OVERVIEW

This session introduces the importance of understanding the evolution of climatic conditions for agricultural production. It explains the effects of climate change on agricultural sectors – crops, livestock, forestry, fisheries and aquaculture – and livelihoods. It also examines the effects of agriculture on climate change, and it discusses how agriculture plays a role in both releasing emissions and sequestering carbon in soils and biomass. Finally, it examines the different greenhouse gas emissions across agricultural practices.

UNDERSTANDING THE EFFECTS

Climate change affects plants and animals in a variety of ways: directly or indirectly, by changing their natural equilibrium inside. Understanding the effects of climate change on ecosystems is important to the design of policies and adaptation strategies (Table B1).

Bearing in mind that climate impacts are highly site-specific, some of the possible effects of climate change on agro-ecosystems reported by agricultural producers include:

- Increased variability and unpredictability of weather and climate events: for example, changes in seasonal rainfall variability, high rainfall variations such as longer dry periods, higher or lower temperatures, heatwaves and others
- Changes in timing of seasons: for example, some areas are witnessing an earlier arrival of spring that affects the lives of migratory animals; but also planting periods and wet seasons start late or finish early
- Dry spells that affect crops at different points in the growing season
- Alteration in land suitability for agricultural production or grazing
- Increased intensity of extreme weather events such as sudden downpours and windstorms, droughts, floods, cyclones
- Increased pest and disease outbreaks

Table B1. Examples of effects of climate change on several aspects of human life and ecosystems

Oceans	**Sea level rise:** Melting ice sheets and glaciers are raising sea levels that flood low-lying areas during high tides and storms. Islands, coastal cities and farmland near the sea are particularly at risk; **Acidification:** Dissolved carbon dioxide makes seawater more acidic, harming marine life; **Marine oxygen concentration:** Less dissolved oxygen in sea water affects marine life and can lead to changes in the distribution of species; **Increase temperature:** The types of plants, corals and animals that can live in each location will change, aquatic species will migrate due to warmer water temperatures.

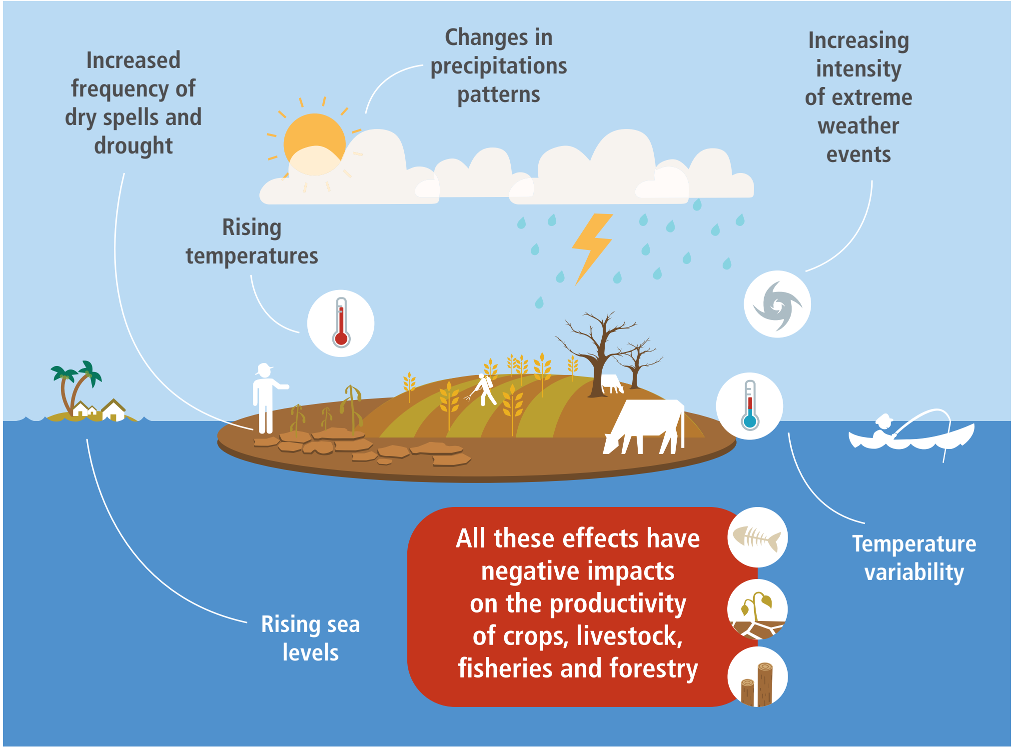
Natural Resources	**Freshwater:** Supplies of freshwater for drinking, domestic use and irrigation may decline. Rivers, springs and wells may dry up as air temperatures increase; **Vegetation:** Agro-ecological zones are shifting, tree and plant ranges are moving poleward and up mountain slopes; **Wildlife:** The areas in which animals live are changing: some animals and plants are moving towards cooler places or higher altitudes. The areas of some species may expand; others will shrink; **Biodiversity:** The diversity of animals and plants is likely to decline. That will affect the stability of ecosystems; **Forests, grasslands, deserts:** The area suited to forests and grasslands is changing. In some areas, deserts are expanding. Risks of forest fires are increasing. Other areas are getting wetter, encouraging the growth of some species; **Extinctions:** Up to one-quarter of the world's species may become extinct as their habitats decline; **Ice sheets:** Ongoing melt of the ice sheets in Antarctica and Greenland; **Glaciers:** They are receding and disappearing, disrupting the quantity and timing of river flows.
Human Health	**Disease:** Some types of diseases, such as malaria, diarrhoea and dengue fever, may become more widespread; **Heatwaves:** Periods of extreme high temperature are increasing in intensity and frequency putting increasing numbers of people at risk.
Society and Economy	**Migration:** Changes are forcing people to move from one place to another to support themselves. People may move within countries or across international boundaries. Those who have moved to coastal areas will likely be displaced again, by rising sea levels; **Conflict:** Competition for resources such as water and food fuel conflicts; **Poverty:** Some people are less able to adjust than others. Poverty levels are likely to increase; **Economy:** Climate change will affect businesses and the economy. It could cost between 5 and 20 percent of the annual gross domestic product.

Sources: FAO, 2016a; IPCC, 2014b.

THE IMPACTS OF CLIMATE CHANGE ON AGRICULTURE

The agricultural sectors – including crop, livestock, forestry, fisheries and aquaculture – are highly dependent on climate stability. Temperature increases lead to a number of consequences affecting the whole of ecosystems and human activities (Figure B1).

Figure B1. How climate change affects agriculture



Source: FAO, 2016c.

Higher temperatures not only melt ice that discharges water into the oceans, but warmer water expands: the resulting rising sea levels flood low-lying areas, especially at high tide and during storms. Islands, coastal cities and farmland close to the sea are particularly at risk. Moreover, as sea temperature gets warmer, many types of plants, corals and animals will be affected. Rainfall is becoming more variable and unpredictable. This may cause water shortages, shorter growth periods, and more frequent flooding and drought. Some areas may become unsuitable for farming while other areas, such as those at higher latitudes and altitudes but with more fragile soils, may become farmable. Key climate-related repercussions for each agricultural sub-sector can be explained (IPCC, 2014b; FAO, 2016b).

Crops. Changes in temperature and rain patterns, as well as the frequency and intensity of weather events, have significant consequences for crop production and will reduce yields of some staple crops such as wheat, rice and maize. In some regions, where cool temperatures are currently constraining crop growth, an increase in temperature and CO_2 levels may increase plants growth and yields. However, in temperate and tropical regions, excessive temperatures and precipitation could harm crops and reduce yields, posing serious challenges for farmers to ensure productivity. As well, these challenges could increase the work load of women responsible for household food provision and for water and fuel collection (Box B1). Increasing temperatures can damage the physical structure of soils, while increasing erosion and affecting soil fertility (FAO, 2013a).

It is estimated that in the medium to long term climate-related changes will lead to negative effects on yields, effects that are likely to accelerate (Table B2). These effects will be more severe in lower than at higher latitudes. The situation is particularly harmful for developing countries, whereas developed countries show a larger share of potential positive effects driven by climate change. Depending on the scenario used, researchers estimate that with no adoption, maize yields could decrease by up to 45 percent, wheat by 50 percent, rice by 30 percent and soybeans by 60 percent, compared with simulations that do not include climate change (FAO, 2016b).

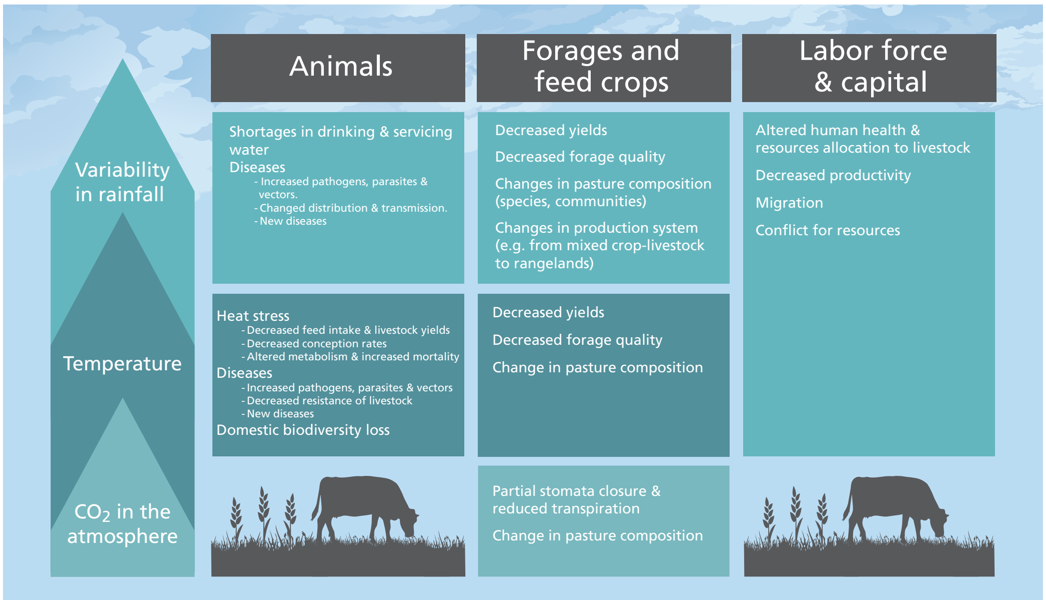
Table B2. Example of projected climate change effects on crop production

Event	Potential effect
Cold periods becoming warmer and shorter; over most land areas, days and nights becoming hotter (almost certain).	Increased yields in colder environments; decreased yields in warmer environments; increased outbreaks of new insect pests and pathogens; potential impacts on crop production.
Heavy precipitation events increasing in frequency over most areas (very likely).	Damage to crops; soil erosion; inability to cultivate land owing to waterlogging of soils.
Drought-affected area increases (likely).	Land degradation and soil erosion; lower yields from crop damage and failure; loss of arable land.
Intense tropical cyclone activity increases (likely).	Damage to crops.
Extremely high sea levels increase in incidence (excludes tsunamis) (likely).	Salinization of irrigation water, estuaries and freshwater systems; loss of arable land.

Source: FAO, 2013a.

Livestock. The effects of climate change on livestock combine direct effects on animal productivity and health and on the quantity and quality of pastures and animal feed. Increased variability in precipitation can lead to water-logged ground and to shortages of drinking water, increasing vulnerability to disease. Higher temperatures cause heat stress and make animals less resistant to pathogens. It translates into reduced feed intake, unhealthy states, lower rates of reproduction and productivity as well as higher mortality rates. It can also result in changes in the distribution of diseases (FAO, 2016a). Outbreaks of Rift Valley Fever in East Africa, for instance, are associated with the frequent rainfall and floods that arrive with El Niño (Box A1, Module A).

Figure B2. How does climate change affect livestock keepers and production?



Source: Adapted from FAO, 2016d.

Fisheries and aquaculture. Capture fisheries and aquaculture systems will suffer from higher water temperatures and oxygen deficiencies that lead to changes in productivity patterns. In the oceans, sharp variations in climate trends will change the habitats of aquatic animals as well as the composition of fish species. Some of them are already migrating poleward to higher latitudes, leading to a dramatic drop of fish species in the tropics projected for the next decades. Coral reef systems are at increased risk due to the combination of rising seawater temperatures and ocean acidification (FAO, 2016a).

Forestry. An estimated 1.6 billion people, 20 percent of the human population, depend on goods and environmental services from forests. Forests deliver clean and reliable water supplies, offering protection against landslides, soil erosion and land degradation, as well as providing habitats for plants and animals and goods for household use. Climate change impedes productivity of forests through drought and temperature stress; increased wind and water erosion; more frequent forest fires, pest and disease outbreaks, landslides and avalanches – as well as shifts in the ranges of forest plants and animals and in the timing of their biological rhythms (Braatz, 2012; FAO, 2016a).

Changes in precipitation patterns increase tree mortality and decrease productivity of orchards, plantations, and forests through heat and drought stress, pest outbreaks and fire disturbance (Allen *et al.*, 2010; Williams *et al.*, 2013; Settele *et al.*, 2015; FAO, 2016b). Models predict that most tree species will shift to higher altitude at rates faster than they occur naturally; this in turn can harm ecosystem communities as component plants and animals may be slower to shift range upslope. Additionally, elevated levels of carbon dioxide are an issue. Given sufficient levels of water and soil nutrients, CO_2 increases will make trees more productive but in the presence of poor-quality soil, a decline in plant growth will occur, influencing the complex forest ecosystem (Settele *et al.*, 2015).

Genetic resources. Climate change is one of the key drivers in the loss of genetic resources in food and agriculture – including plants, animals, forests, aquatic resources, invertebrates and micro-organisms: the raw materials that local communities and researchers rely on to improve the quality and output of food production. In particular, changing climate threatens the survival of the strategic reservoir of crop and livestock genetic resources needed to adapt production systems to future challenges. Some varieties of plants and animal breeds may be lost forever, if conservation steps are not taken (FAO, 2015a).

Box B1. Gender-differentiated impacts of climate

Climate change affects men and women, boys and girls, in different ways. Therefore, it is important to see how interventions can be better designed to address the needs of different actors along the value chain and to overcome existing gender-based discrimination and associated inequalities. Women agricultural producers tend to be more exposed to climate risk compared with men, for many of the same reasons that farm productivity is, on average, lower for female than male farmers: women have less access to, and control over, productive resources and services – including climate information – with fewer employment opportunities, and they are generally less mobile for cultural and economic reasons (FAO, 2011).

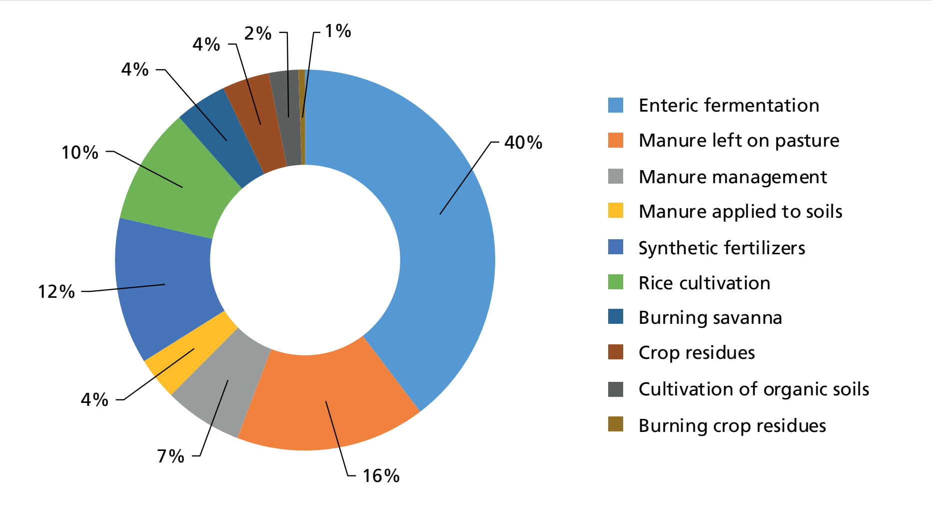
GREENHOUSE GAS EMISSIONS IN AGRICULTURE

As we have seen in Session A2, agriculture, forestry, other land use sectors are important sources of greenhouse gases, accounting for at least 20 percent of total emissions – mainly from the conversion of forests to farmland and from agricultural production. The greenhouse gases of particular relevance to these sectors include:

- **Carbon dioxide (CO2)** results from conversion of forests and grassland into agricultural land, soil degradation, fuel consumption for farm machinery, electricity consumption for irrigation systems and fertilizer production, among others.
- **Methane (CH4)** mainly results from enteric fermentation through the digestion process of ruminants such as cattle, sheep and goats and from rice cultivation practices, particularly flooded rice systems. Biomass burning, destruction of peatlands and manure management are further sources of methane emissions.
- **Nitrous oxide (N2O)** results mainly from the application of synthetic and organic fertilizers to soils. Biomass burning, manure management and soil carbon mineralization are further sources of nitrous oxide emissions.

A global picture of greenhouse gas emissions from the agricultural sectors (excluding forestry) shows the diversity of sources (Figure B3). If we look at the single agricultural activities, the most significant contribution of greenhouse gas emissions is enteric fermentation: the major source of methane emissions. Other important sources include manure left on the pasture at 16 percent, the use of chemical fertilizers at 12 percent and rice cultivation at 10 percent.

Figure B3. Share of agricultural emissions in CO_2 equivalent in 2014, by source and at global level



Source: FAO, 2016b. Annex table A.3.

Emissions are different according to different regions of the world. For instance, rice cultivation is the most important source of agricultural emissions in much of Eastern and South-East Asia with 26 percent, while in Oceania the cultivation of organic soils is the major source at 59 percent of total emissions (FAO, 2016b).

The various contributions can be further detailed according to specific agricultural practice (Table B3).

Table B3. Main sources of greenhouse gas emissions from agriculture

Enteric fermentation	▸ GHG emissions from enteric fermentation consist of methane ▸ gas produced in the digestive systems of ruminants and, to a lesser extent, of nonruminants. ▸ 40 percent of greenhouse gas emissions from agriculture
Manure left on pasture	▸ GHG emissions from manure left on pasture consist of nitrous oxide gas from nitrogen additions, made by grazing livestock, to managed soils. ▸ 16 percent of greenhouse gas emissions from agriculture
Synthetic fertilizers	▸ GHG emissions from synthetic fertilisers consist of nitrous oxide ▸ gas from synthetic nitrogen additions to managed soils. ▸ 12 percent of greenhouse gas emissions from agriculture
Rice cultivation	▸ GHG emissions from rice cultivation consist of methane gas from ▸ the anaerobic decomposition of organic matter in paddy fields. ▸ 10 percent of greenhouse gas emissions from agriculture
Manure management	▸ GHG emissions from manure management consist of methane and nitrous oxide gases from aerobic and anaerobic manure decomposition processes. ▸ 7 percent of greenhouse gas emissions from agriculture
Burning-Savanna	▸ GHG emissions from burning of savanna consist of methane and nitrous oxide gases from biomass combustion. ▸ 4 percent of greenhouse gas emissions from agriculture
Crop residues	▸ GHG emissions from crop residues consist of nitrous oxide gas deriving from the decomposition of nitrogen in crop residues, left on managed soils. ▸ 4 percent of greenhouse gas emissions from agriculture

Source: FAO, 2015b.

However, it is important to note that agriculture, forestry, other land use sectors also play a key role in removing greenhouse gases from the atmosphere and contributing to balance the global carbon cycle. When aiming to reduce the negative contribution of these sectors to climate change, it is essential to target greenhouse gas emission levels as well as to increase carbon sequestration in an integrated manner (Box B2).

Box B2. Removing carbon dioxide from the atmosphere through sequestration

Greenhouse gases like methane and nitrous oxide eventually break down: methane into carbon dioxide and nitrous oxide into the nitrogen that makes up most of the air we breathe, as well as into oxygen. Carbon dioxide does not break down in the atmosphere, but plants can lower the concentration of carbon dioxide in the atmosphere through the process of photosynthesis. This process uses sunlight to extract nutrients from carbon dioxide and stores the resulting compounds in plant material. The plant material can persist for long periods, acting as sinks and storing carbon in reservoirs, or carbon pools, such as below-ground biomass, litter, dead wood, soil organic matter and harvested wood products, as well as healthy vegetation. This storage is a form of carbon sequestration, in which the carbon is kept out of the atmosphere (FAO, 2013a; Goodland, 2016).

Vegetation: Forests, trees, shrubs, some grasses, and many products made from their materials store carbon into woody matter and can sequester it for months, years, decades and even centuries. When timber is harvested to produce building materials the process can be planned to maximize the long-term use of the material. Forest floor litter should be maintained: while it breaks down slowly, it will feed the underlying soil and interfere with erosion forces in the meantime.

How to increase the amount of carbon stored in woody vegetation? This is accomplished through sustainable forestry practices: Planting trees, allowing forest and trees to regrow, planting perennial crops, promoting agroforestry and silvo-pastoral systems. Managing sustainable woodlot operations and minimizing emissions if there is any use of wood as fuel.

Soil: Organic matter in the soil can store a lot of carbon. Soil's storage capacity depends on the balance between mineral or organic material, on ecosystem characteristics and on management practices. Globally and on average, the top one metre of soil contains about three times as much carbon as the above-ground biomass of plants, and twice as much as the atmosphere. Organic matter is important for soil life, helps keep water in the soil, allows soils to be productive and helps maintain healthy crops. A particular type of soil – histosols, found in peatlands, wetlands and bogs – stores large quantities of carbon. When peatlands are drained in hopes of cultivation, they release significant amounts of methane as the organic matter oxidizes when exposed to atmospheric oxygen.

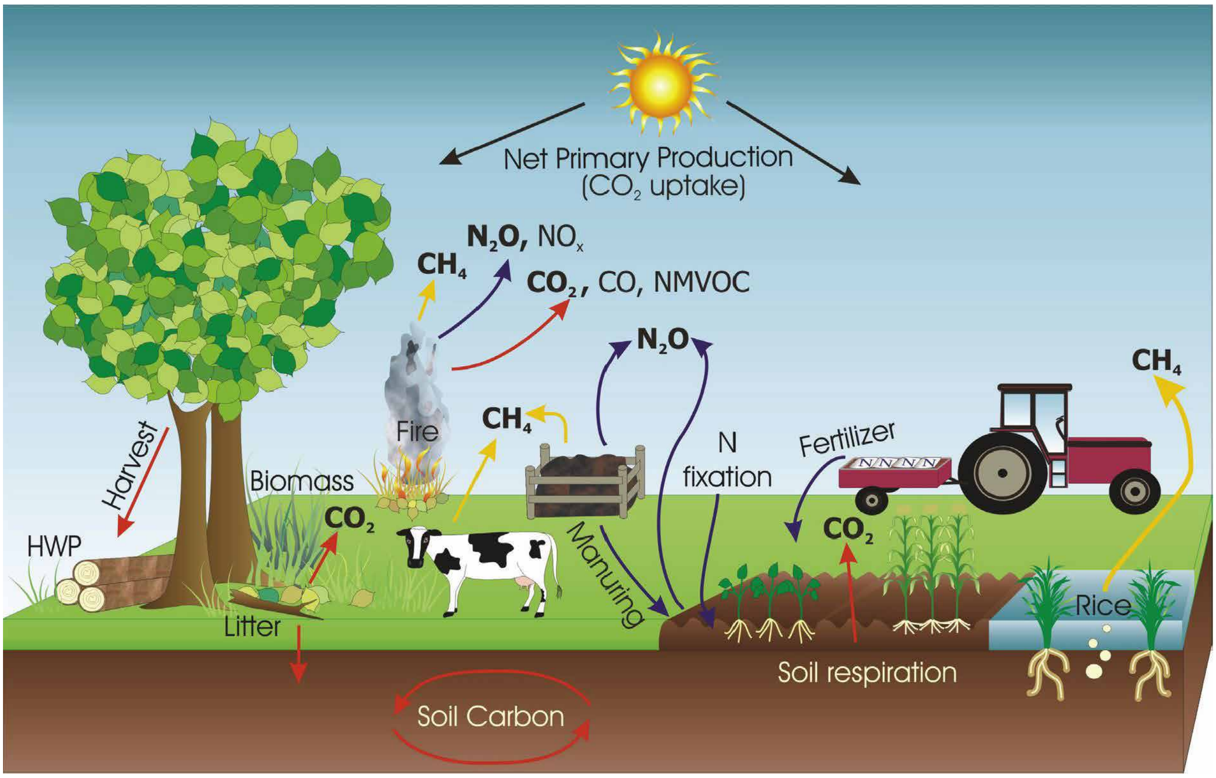
How to increase the amount of organic matter in the soil? Solutions include rewetting organic soils and adding mulch, compost and other soil amendments to mineral soils. Research into the formation of biochar, a type of charcoal produced through pyrolysis that removes oxygen by mild heating, suggests the possibility of thousand-year carbon sequestration in soils, with slow fertilization enriching the soil during that time span.

Processes and activities that emit and remove greenhouse gases from carbon pools are called sources and sinks, respectively. The Intergovernmental Panel on Climate Change (IPCC, 2013) defines them as:

- **Source:** Any process, activity or mechanism that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol into the atmosphere.
- **Sink:** Any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere.

Sources and sinks are inter-related in agricultural activities (Figure B4). Cattle digestion, fertilizers and animal wastes cause emissions to the atmosphere, mostly methane and nitrous oxide, while a growing forest or above ground biomass, benefiting from the associated nutrients, has the capacity to remove carbon dioxide from the atmosphere and store it in its organic matter.

Figure B4. Greenhouse gas sources and sinks in managed ecosystems



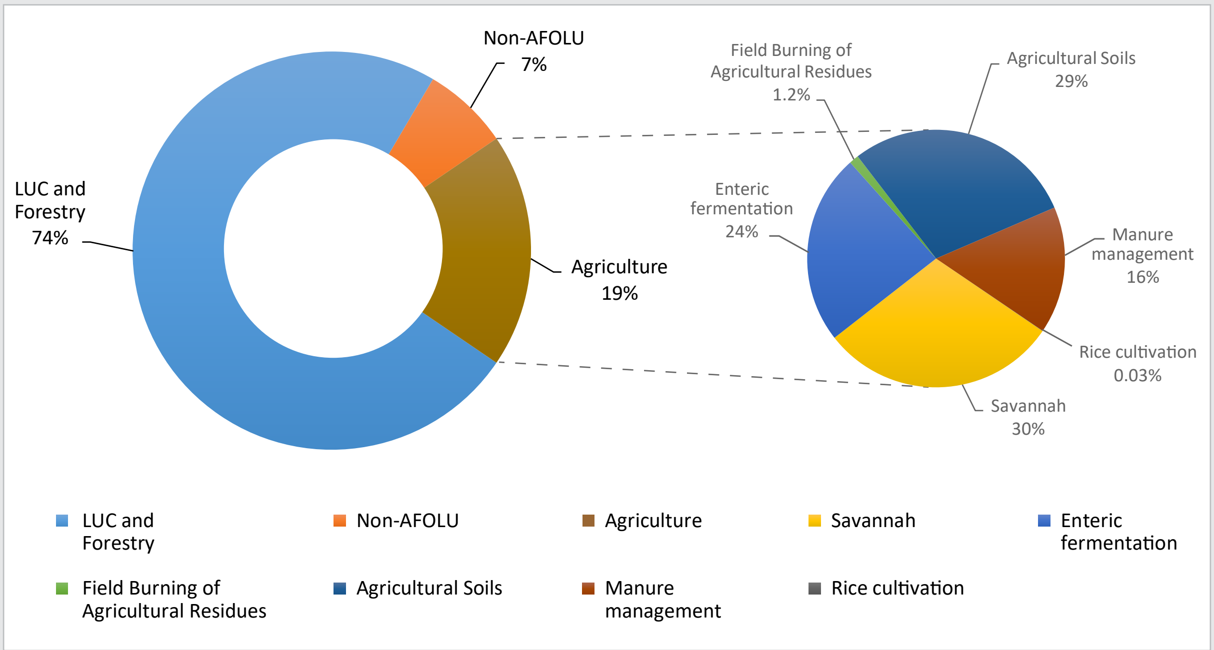
Source: IPCC, 2006.

CASE STUDY ZAMBIA

Greenhouse gas emissions

The Second National Communication of the Government of Zambia to the United Nations Framework Convention on Climate Change (Government of Zambia, 2014) reports that between 1994 and 2000 the country's total greenhouse gas emissions rose by 6.2 percent from 51.52 million tonnes CO_2 equivalent to 54.72 million tonnes. Zambia is a net emitter of greenhouse gases, producing more emissions than it can absorb through its forests and other vegetation. Furthermore, the report identifies the agriculture, forestry, other land use sectors together as the major contributor to national greenhouse gas emissions. Land-use change and forestry accounts for 74 percent of national emissions and the agriculture sector is responsible for 19 percent, while the rest of the economy only contributes 7 percent (Figure BZ1). Despite the smaller amount of emissions from agriculture, the sector also does represent the main driver of deforestation. When considering agriculture-related emissions only, the three largest contributions are reported as stemming from savannah burning at 30 percent, agricultural soils induced emissions with 29 percent and enteric fermentation at 24 percent.

Figure BZ1. National GHG emissions in Zambia by sector



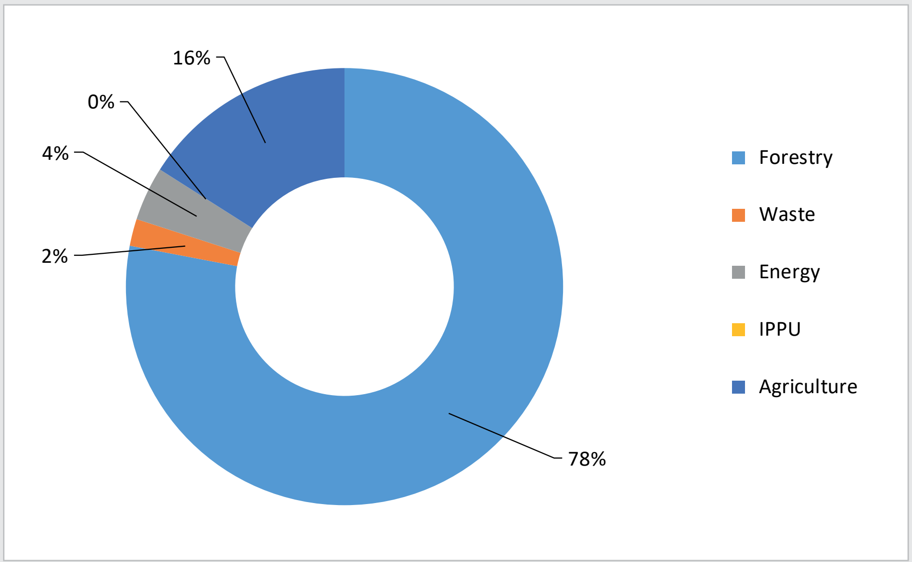
Source: Adapted from Government of Zambia, 2014.

CASE STUDY MALAWI

Greenhouse gas emissions

Malawi's Intended nationally determined contribution (Government of Malawi, 2015), which includes a GHG profile for the country, reports that around 78 percent of the emissions are produced by the forestry and other land use sectors and that agriculture produces 16 percent. The energy sector produces 4 percent and mostly accounts for combustion of fossil fuels. Overall emissions in Malawi in 2015 were reported approximately 29 million tonnes CO_2 equivalent and are expected to rise to 42 million by 2040, with a 38 percent rise mainly in the energy sector. For the agricultural sector, major sources of emissions result from farming activities that include enteric fermentation, manure management and the use of fertilizers.

Figure BM1. National GHG emissions in Malawi by sector



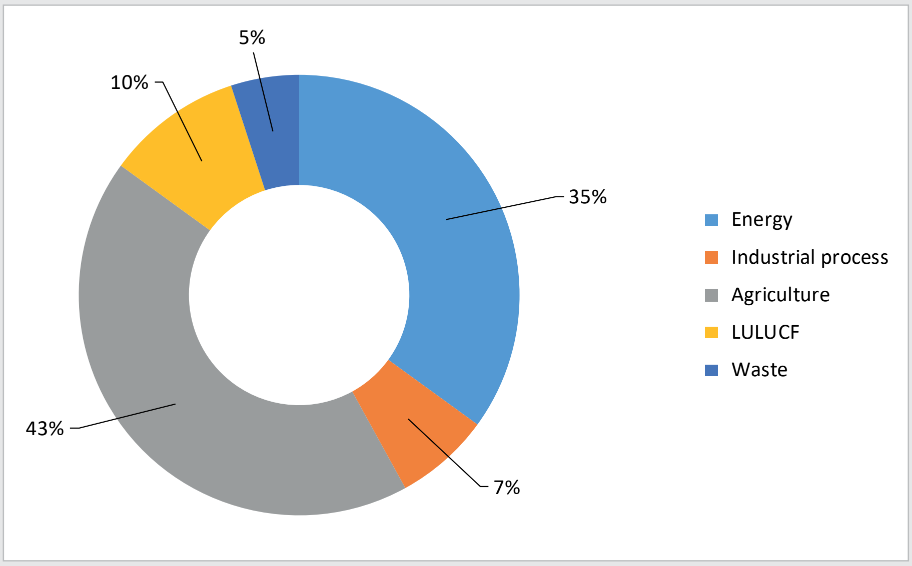
Source: Adapted from Government of Malawi, 2015.

CASE STUDY VIET NAM

Greenhouse gas emissions

In Viet Nam, agriculture contributes to 43 percent of overall national greenhouse gas emissions, as the main contributor to GHG emissions in the country with 65 million tCO_2 equivalent. The energy sector is the second largest contributing sector with 35 percent (Government of Viet Nam, 2010).

Figure BV1. Greenhouse gas emissions in Viet Nam by sector



Source: Adapted from Government of Viet Nam, 2010.

Projections foresee that emissions from the energy sector will increase radically in the future, establishing it as the main emitting sector in the country. The agriculture sector will remain a major contributor to national greenhouse gas emissions, with total net emissions still increasing moderately. Land use, land use change and forestry, referred to here as LULUCF, by contrast contributed only 10 percent of national greenhouse gas emissions in 2000, while they are foreseen to become a relevant mitigation source. The outlooks for greenhouse gas energy, agriculture and LULUCF until 2030 suggest that the land use and forestry mitigation efforts will begin to compensate for mild increases in the agricultural sector, while the emission increase expected from the energy sector far outweighs any mitigation achievements (Table BV1).

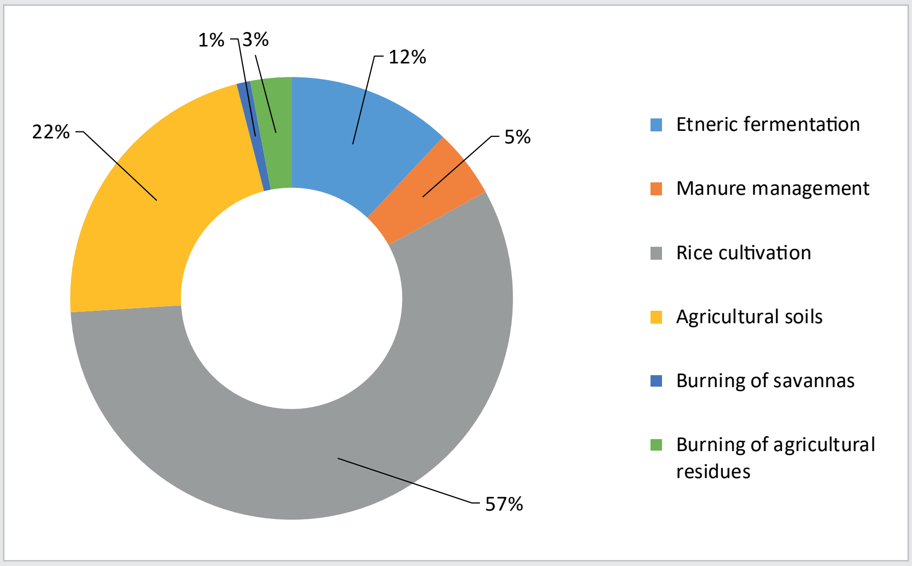
Table BV1. Greenhouse gas emission projection by sector (in million tonnes CO_2-eq)

	2000	2010	2020	2030
Energy sector	52.7	113.1	251	470.8
LULUCF	15.1	-9.7	-20.1	-27.9
Agriculture	65.1	65.8	69.5	72.9
Total	**132.9**	**169.2**	**300.4**	**515.8**

Source: Adapted from Government of Viet Nam, 2010.

In the agricultural sector of 2000, rice production systems are the dominant single emissions contributor at 58 percent. The relevant rice production process supports micro-organism activities in flooded fields that decompose organic matter and produce methane, a powerful greenhouse gas. Emissions from agricultural soils, 22 percent, and from enteric fermentation, 12 percent, are other significant emission sources (Figure BV2).

Figure BV2. Greenhouse gas emissions in the agricultural sectors in Viet Nam



Source: Adapted from Government of Viet Nam, 2010.

SESSION B2. CLIMATE CHANGE AND FOOD SECURITY

SESSION OVERVIEW

Ensuring food security for a growing global population is one of the greatest challenges of our time. After looking at the effects of climate change on ecosystems in previous sessions, this session focuses on the concept of food security and provides a definition of its four dimensions. Participants will also be exposed to a framework to understand how climate-related risks cause direct or indirect consequences to food security. Finally, the concept of vulnerability is introduced.

THE FOUR DIMENSIONS OF FOOD SECURITY

Food security is the result of an efficient food system including all the activities related to production, distribution and consumption of food that finally affect human nutrition and health. An efficient food system positively contributes to all the four dimensions of food security: availability, access, utilization and stability.

Box B3. What is food security?

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996).

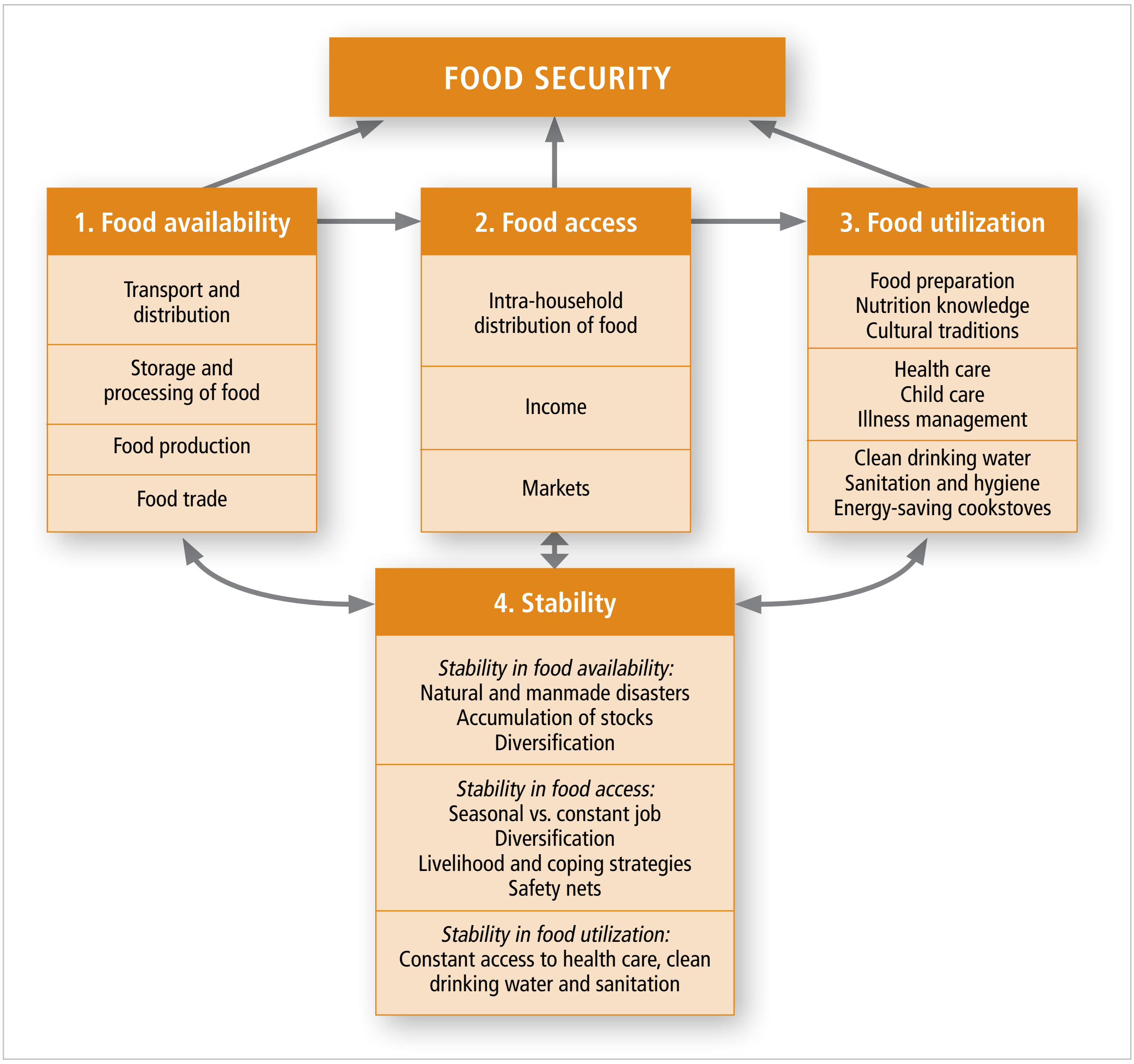
This definition of food security implicitly identifies availability, access, utilization and stability as four essential pillars, while the nutritional dimension is integral to the concept of food security (Table B4) (Figure B5).

Table B4. The four dimensions of food security

Pillar	Explanation	Example
The availability of food	The supply side of food security. Sufficient quantities of quality food must be present in a given area either supplied by domestic agricultural production or imported from abroad.	Food is available, and people can find it in markets or purchase it from producers and traders.
Economic and physical access to food	Whether the households or individuals have enough resources to access – through purchase, production, or other means – appropriate quantity of quality foods. Food access depends on several socio-economic factors including income and food prices.	A sharp increase in food prices may lead poor households, mainly net food buyers, to buy less food and/or low-quality food since their income availability has decreased. It is important to notice that men and women within the same household or community might have different access to markets and traders, which affects their access to available food.

Food utilization	How much food is eaten, and what and how people eat. General hygiene and sanitation, water quality, health care practices and food safety and quality are determinants of good food utilization by the body. Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, diet diversity and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.	The Mekong River has faced environmental degradation due to the multiple sources of pressure such as rapid population growth, industrialization and intensive agricultural development. Water quality is becoming dramatically degraded from upstream to downstream in many parts of the basin: this threatens animal, ecosystem and human health since this water source is intensively used for drinking, irrigation and domestic services.
The stability of food security	The stability of the other three pillars. People cannot be considered food secure until there is stability of availability, accessibility and proper food utilization conditions (Figure B5). This recognizes that people's food security situation may change. It emphasizes the importance of having to reduce the risk of adverse effects on the other three dimensions.	Adverse weather conditions can affect food security, such as El Niño-Southern Oscillation, which produces changes of surface temperature in the tropical Pacific Ocean leading to various extreme weather events. Depending on the phase of the oscillation, weather conditions may include increases in rainfall, tropical cyclones, drought, and flood. Food stability can be also threatened by political instability (social unrest), or economic factors (unemployment, rising food prices) which affect people's food security and nutrition status.

Figure B5. The four dimensions of food security



Source: Adapted from Burchi *at al*. 2011.

TIME DIMENSION OF FOOD SECURITY

The time dimension is also an important factor in relation to food security. In fact, there are important differences in how the duration and the severity of food insecurity affects livelihoods. Understanding these variations is important since various factors influence the choice of intervention to address food insecurity concerns.

Duration

Households suffer inadequate food consumption for different periods of time. This may vary from a short-term transitory experience to a long-term chronic condition (Table B5).

Table B5. The duration dimension: chronic versus transitory food insecurity

	Chronic food insecurity	Transitory food insecurity
Description	Long-term or persistent.	Short-term and temporary, unpredictable.
Occurrence	People are unable to meet their minimum food requirements over a sustained period of time.	Sudden inability to produce or access enough food to maintain a good nutritional status.

Causes	Extended periods of poverty, lack of assets and inadequate access to productive or financial resources, climate shocks.	Short-term shocks and fluctuations in food availability and access, including year-to-year variations in domestic food production, food prices and household incomes.
Response measures	Typical long-term development measures also used in addressing poverty, such as education or access to productive resources. Chronically food insecure people may need more direct access to food to enable them to raise their productive capacity.	Transitory food insecurity is often relatively unpredictable thus making planning and programming more difficult. It requires different capacities and types of intervention, including early warning capacity and safety net programmes.

Source: Adapted from FAO, 2008.

Another type of food insecurity recurs seasonally, when seasonal fluctuations in weather, cropping patterns, pest and disease breakouts and labour imbalances result in inadequate food availability and access (FAO, 2008). Seasonal food insecurity is intermediate between transitory and chronic food insecurity. It occurs commonly in the pre-harvest period, when on-farm stocks are depleted, and other sources of food are not available.

CASE STUDY MALAWI

The effects of climate change

Malawi's population has grown quickly from 3 million in 1950 to about 17 million in 2015, and it is projected to exceed 41 million by 2050 and 75 million by 2100 (UN, 2017). The rapid rate of population growth, which reached over 5 percent in the 1990s, has been exerting enormous pressure on land and other natural resources. This pressure has led to fragmentation of small land holdings and to overexploitation (Mutunga, Zulu and De Souza, 2012).

A World Bank study reports that about 50 percent of Malawians live below the poverty line, with the majority in rural areas. In Malawi, 85 percent of people rely on rain-fed subsistence farming to survive (World Bank, 2011). Evidence shows that increased droughts and floods exacerbate poverty levels, leaving many agricultural producers trapped in a cycle of poverty and vulnerability.

The impacts of climate change on agriculture and health include:

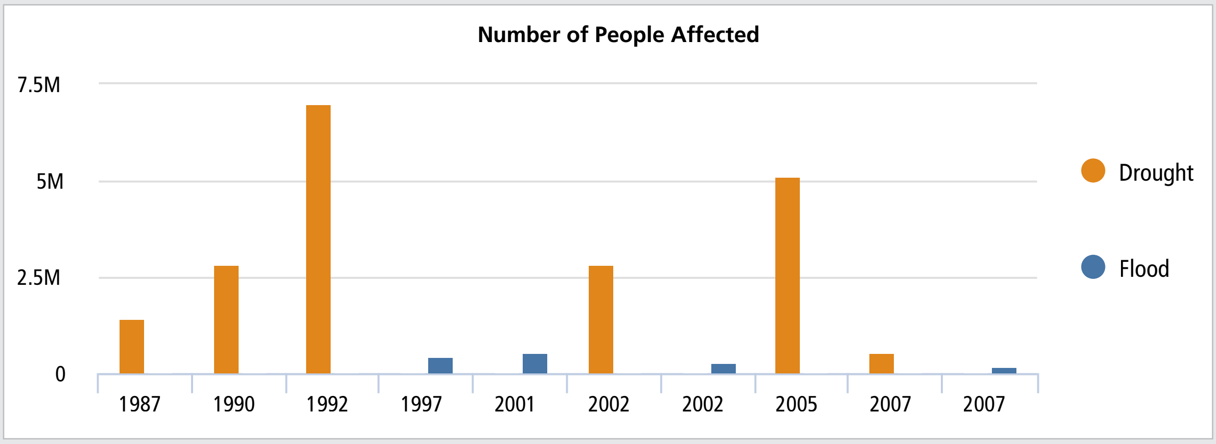
- Frequent droughts and floods pose a systematic risk to the economic viability of Malawi and seriously disrupt water availability, quantity and quality
- The increasing incidence of floods and droughts leads to infant malnutrition and chronic ailments associated with malaria, cholera and diarrhea
- Disrupted growing seasons prompt farmers to switch to more tolerant crops or varieties with unknown yield prospects

Smallholders adapt by changing the crops they grow and the timing of planting and harvesting. But they lack the knowledge, skills and money to cope fully with continually changing climate conditions (World Bank, 2011).

> *"Food availability has been an issue over the years since the disasters began. Much as we have experienced floods in those days, their impact was somehow not as severe. As time went by, there has been a drop in crop production due to frequent flooding and droughts."*
>
> – Farmer in Salima district, Malawi

A 1991-1992 drought across southern Africa affected 7 million people in Malawi only. In 2002, both drought and floods caused further crises. Another drought in 2005 affected more than 5 million people (see Figure BM2). The number of districts at risk has also increased sharply. Before 2001 only nine districts in Malawi were classified as flood-prone. In 2001, 16 were affected, and an additional 14 in 2002. By the end of January 2003, there was localized flooding in 22 districts (Coulibaly *et al.*, 2015).

Figure BM2. Numbers of people affected by droughts in Malawi, 1987–2007

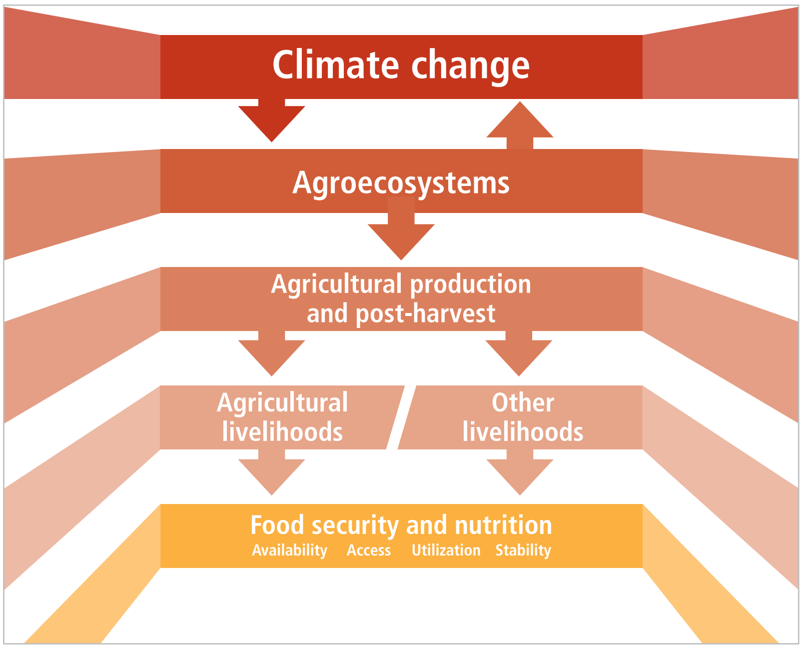


Source: World Bank Climate Change Knowledge Portal.

IMPACT OF CLIMATE CHANGE ON FOOD SECURITY AND NUTRITION

Climate change directly affects agricultural production in terms of both quantity, or lower crop yields, and quality, or poorer nutrients in harvested crops: either deficiency puts food security at risk. Lower crop yields mean less availability of primary food items in the markets resulting in higher food prices that are especially damaging for poor households. Higher prices are particularly negative for net-buyer agricultural producers households – those who buy more food on the market than they sell for a given season or year. Net-seller households, those that sell more food on the market than what they buy, will also be negatively affected by adverse climatic shocks. Since their livelihood strongly relies on agriculture and producing their own food, lower agricultural production means less quantity and quality of food and this will jeopardize their food security. Lower agricultural incomes will weaken sellers' livelihoods. For instance, they will spend all available income on food while non-food consumption will be dramatically reduced, increasing their vulnerability.

Figure B6. From climate change to food security: transmission mechanism



Source: FAO, 2016c.

Understanding the consequences of climate change for food security is a challenging task and further complicated because the vulnerabilities and capacities of male and female agricultural producers to respond to risks are unevenly distributed across families, communities and cultures. When designing climate-smart interventions it may be useful to assess how climate change can have direct or indirect effects on all four pillars of food security and nutrition:

Food availability

Climate change affects food production directly by adding additional stress to agro-ecosystems, as well as indirectly by driving social and economic changes that influence the demand for agriculture products. As a consequence of changes in climatic conditions, both crop yields and availability of arable land and water resources are often affected. For instance, agricultural production of some staple crops is already shifting, especially at tropical latitudes (IPCC, 2014b). Furthermore, changes in the suitability of land for crop production may undermine farmers' capacity to plant and ensure sufficient production for their own and their own family's consumption, with different outcomes for men and for women (FAO and CCAFS, 2012).

Food access

Climate change reduces access to food through hardships for rural incomes and livelihoods. More frequent and more intense storms will lead to more climate-related natural disasters in the absence of dedicated disaster reduction and recovery programmes. Natural disaster and climate shocks not only have short-term consequences by reducing current incomes but can also cause asset losses that erode future income-earning capacity. When the effects of climate change are particularly severe, households may decide to follow negative coping strategies that include selling their productive assets to buy food, taking children out of school or over-exploiting lands and forests. Productive assets that are commonly sold in these circumstances include livestock, farm equipment, vehicles, looms, and food processing utensils. All these negative coping actions leave the households even more vulnerable and prone to long-term poverty and might have different consequences for men and women and for specific types of households, such as those headed by females or with disabled family members.

Food utilization

Climate change will also have a detrimental effect on food utilization, thus diminishing the nutrition status of the poor and vulnerable groups. For instance, higher temperatures can foster the resilience and spread of pathogens, while water scarcity reduces water quality and inhibits good hygiene habits, leading to the spread of disease. Climate impacts could increase the burden of diarrhoea by up to 10 percent by 2030 in some regions (FAO, 2016b). The most severely affected would be poor children. Climate change will affect nutrition status in many other ways, from reductions in caregiving and the nutrient content of staple food crops, to higher risk of food contamination.

Food stability

Climate variability and a higher frequency and intensity of extreme weather events will affect the stability of food availability, access and utilization through changes in seasonality, more pronounced fluctuations in ecosystem productivity, increased supply risks and reduced supply predictability. This will be a major problem especially for landlocked countries and small island states, which are more vulnerable to both food supply disruptions and damages from extreme climate events. Climate change is just one of several drivers now shaping trends in poverty and food security. The prevalence of poverty and food insecurity, and the severity of climate change impacts on them, will be determined largely by future social and economic development.

Table B6. Types of climate-related risks and potential impacts on agricultural producers

Type of risk	Economic consequences	Food security consequences	Long-term consequences
Input price increase: seeds, etc.	Reduced income for farmers.	Reduced availability of food.	Only to the extent it affects investment.
Output price decrease.	Reduced income for farmers.	Reduced food access due to a decrease in farmers' incomes.	Reduced incentive for investment.
Weather shock.	Likely crop failure or yield reduction.	Reduced food availability.	Depending on type of shocks and productions – can lead to loss of productive assets.
Plant pests and diseases.	Reduced yield.	Reduced food availability; potential impacts on food safety (utilization).	Loss of productive capital (trees) and assets. Potential trade barriers.
Animal diseases.	Reduced production.	Reduced availability of food.	Disease could last. Loss of productive asset. Potential trade barriers.

Source: Adapted from FAO, 2012a.

Box B4. Understanding vulnerability to climate change

Vulnerability in the context of climate change can be described as the propensity or predisposition of a system, such as a farm, to be adversely affected by climate changes, including climate variability and extremes. Measuring vulnerability is a complex task, as it needs to be considered across various dimensions, including economic, social, geographic, temporal, demographic, cultural, institutional, governmental and environmental. To better understand what vulnerability is, it may be useful to break it down in its three main components (see Figure below).

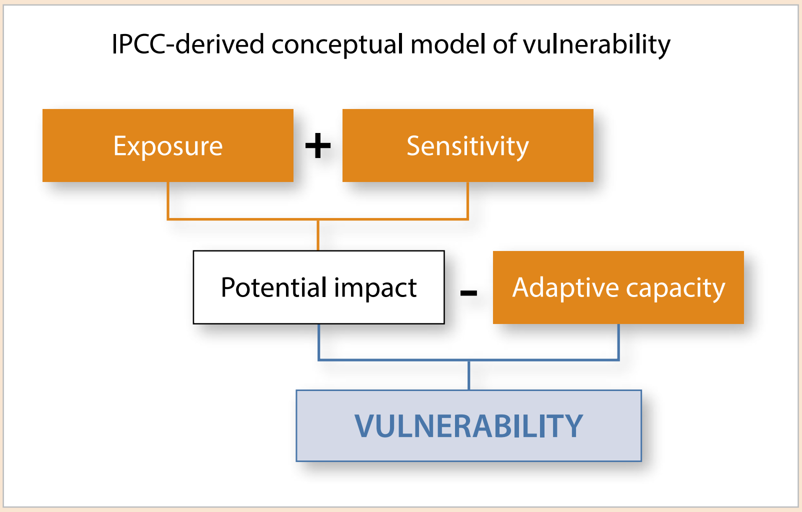
First, the vulnerability of a system depends on its exposure to the threat of a climate hazard. For example, people living on a farm situated on highlands are more exposed to landslides then farmers in the flood plain, who are more exposed to floods, unless the flood plain is below an unstable slope.

Second, sensitivity of a system reflects the degree to which the system is threatened by climate change. The more sensitive a system is, the more it reacts to climate and may be highly altered by small changes. For instance, an irrigated system is less sensitive to changes in precipitations than a rain-fed one. Saline sensitive crops are less sensitive to sea level rise.

The vulnerability and sensitivity of a system determines the potential impact. The potential of that impact is modified by the adaptive capacity of the system.

Finally, adaptive capacity indicates how well a system absorbs shocks and how quickly it responds to changing conditions. For example, diversified seed availability will enable farmers to access drought-tolerant varieties, increasing the adaptive capacity of the whole agricultural endeavour. The specific level of vulnerability of men and women of different ages and from different social groups and economic backgrounds needs to be considered when assessing the adaptive capacity of a system. For example, a farm with many young children may not have the adaptive capacity of one with adolescents and young adults when building sandbag levees is the chosen method of protecting cropland from floods.

High adaptive capacity will minimize the impact of a hazard to the system. Climate-smart agriculture is an approach that works to maximize the adaptive capacity of a food-producing system so its ultimate vulnerability to changing conditions is low (Steenwerth *et al.*, 2014).



Source: Adapted from McCarthy *et al.*, 2001.

CASE STUDY ZAMBIA

Climate and food security

Zambia has large reserves of uncultivated land, a favourable climate, and 40 percent of the water resources of southern Africa. Nevertheless, food security remains a problem due to barriers that include low agricultural productivity, inadequate management and inappropriate policies. Floods, flash floods, drought, extreme heat and even frost during the colder months of the year, all damage farming efforts. Nearly all smallholder farmers rely on rain for their farm production. If the rainy season arrives late, dry spells often follow, exacerbating moisture stress and causing crop failures. Pastures dry out and livestock go hungry. Drought lowers the water table and dries up rivers and streams, especially in wetlands that many farmers use to grow crops. Such extreme weather undermines household food security and forces people deeper into poverty.

The country is highly vulnerable to precipitation variability and historically has been suffering from both sudden heavy rainfall events, bringing flash floods to many regions, as well as drought. Prominent examples include the Kazungula floods and Kafue Gorge mudslide in 2005 that caused a countrywide electricity blackout. Flooding may drown people and livestock, destroy standing crops, and erode valuable soils and ground cover. It can damage buildings, roads, bridges and food storage facilities and consequently destabilizes markets and drives price increases. It also increase the spread of vector-borne diseases (i.e. malaria).

When poorer people can no longer afford to buy food, they shift to less nutritious alternatives, search out bush meat with inherent health risks or stay hungry. Table BZ1 shows some causes of food insecurity in Zambia resulting from heavy rainfall events.

Table BZ1. Examples of how heavy rain affects food security in Zambia

Heavy rain…	Causes flooding that destroys crops, kills livestock and/or damages food stored for consumption and sale.	→	Reducing food availability
	Damages roads, impeding the movement of commodities and people to markets. Food prices rise, forcing people to buy lower-quality food or import; Households cannot reach markets to buy meat or vegetables.	→	Reducing their access to food
	Causes floods that decrease the quality of water, lead people to buy less food and rely on less nutrient-dense diet.	→	Reducing their utilization of food
	Results in food shortages during and after the shock.	→	Reducing the stability of food security

EXERCISE B.1 UNDERSTANDING THE EFFECTS OF FUTURE CLIMATE CHANGE

60 minutes

See the beginning section of Module B on 'Understanding the effects'.

1. Explain how climate change is expected to affect agriculture and related aspects of human lives.
2. Invite groups of participants to discuss how higher and lower temperatures, as well as uncertain rainfall, will affect their area. Ask each group to focus on a particular aspect:
   - Agriculture and food supply
   - Human health and water supplies
   - Social and economic factors
   - Natural resources and the environment
3. Ask each group to report back to the plenary. Facilitate a discussion about their findings.

EXERCISE B.2 EFFECTS OF CLIMATE CHANGE

60 minutes

1. Divide the participants into groups of five with a senior person in each group, if possible. Ask them to reflect over the last 20 or 30 years. What have been the main shocks relating to agriculture and food security in their area during this time? Ask them to think of droughts, floods, wars, storms, big changes in prices, and other things that might affect farming. How many people were affected? What types of effects did the shock have? How were men and women affected by the shock?
2. Ask each group to report to the plenary. Map their responses on a graph like Figure BM2, with estimates of 'people affected' and what 'affected' might mean.
3. Facilitate a discussion of the causes and effects of the shocks. Explore the logic between cause and effect. Ask the participants what could be done to prevent the shocks. What can be done to alleviate their effects?

EXERCISE B.3 THE GREENHOUSE EFFECT

30 minutes

1. Present the causes of global warming.
2. Discuss the greenhouse gas emissions from agriculture, forestry and land use in your country using the case studies of Zambia, Malawi and Viet Nam as departure points. The statistics on greenhouse gas emissions for your country can be found at the UNFCCC GHG Profiles Page for Non-Annex 1 Countries: http://di.unfccc.int/ghg_profile_non_annex1

   If your country is an Annex 1 Country, you can locate that list from that site. You can find more details from your country's UNFCCC National Communications site: https://unfccc.int/process

   Other sources for information include FAOSTAT (www.fao.org/faostat/en) or the World Resources Institute's Climate Analysis Indicators Tool (http://cait.wri.org).

EXERCISE B.4 COMPARING COUNTRIES' GREENHOUSE GAS EMISSIONS

30 minutes

Find out the total greenhouse gas emissions for your country and add it to Table B7.

Table B7. Greenhouse gas emissions by country (including LULUCF)

Country/region	Greenhouse gas emissions (Gg CO_2 equivalent)
China	11 320 248 (2012)
United States of America	6 461 499 (2000)
European Union	4 851 379 (2000)
Viet Nam	150.9 (2000)
Zambia	54.7 (2000)
Malawi	24.6 (1994)
Your country	...

Source: UNFCCC http://di.unfccc.int/detailed_data_by_party.

If possible, get the figures for the different sources of greenhouse gas emissions for your country. If you cannot find such figures, use the figures for Malawi as an example.

1. Ask groups to compare the total greenhouse gas emissions from their country with the other countries. Why do some countries produce a lot of emissions, but others only a little?
2. Answers: population, level of development and industrialization, types of industry, crops grown, deforestation and others.
3. Ask them to compare the different agricultural sources of greenhouse gases in their country with the world total (Figure A6). What causes these differences?
4. Answer: the type and level of economic activity in each country, efforts to reduce emissions, large tracts of healthy forest. Note the scale change between Gg and Gt for measuring GHG emissions.
5. Point out that even if a country emits very little greenhouse gas, it should still try to keep its emission levels low. Also note that with economic development, emissions tend to increase. Every country will have to deal with the consequences of climate change, regardless of its own level of emissions. Also, countries participating in efforts to reduce emissions may receive benefits through different international funding mechanisms, so it is an overall benefit to stay engaged.

EXERCISE B.5 "VIRTUAL FIELD VISITS" TO OBSERVE ACTIVITIES THAT RELEASE GREENHOUSE GASES

60 minutes

1. Group participants imagine they are visiting one of the following locations, with one group per suggested location, if possible. They list (a) activities that may release carbon dioxide or other greenhouse gases, (b) activities that absorb greenhouse gases, and (c) ways to reduce the amount of greenhouse gases.
   - A farm growing crops
   - A forest or woodland
   - A farm with livestock
   - A house
   - A power station
   - A city

Ask each group to report back to the plenary. Facilitate a discussion about the findings. Which activities in each location release a lot of greenhouse gas into the atmosphere? Which absorb greenhouse gases? What are the most realistic ways of reducing the amount of greenhouse gases?

EXERCISE B.6 WHAT IS FOOD SECURITY?

60 minutes

1. Explain what is meant by food security and its four dimensions.
2. Divide the group into four subgroups, one for each dimension: availability, access, utilization, stability. Ask each group to identify the major problems affecting that dimension of food security. Who is worst affected: young, old, rich, poor, urban, rural, men, women? Why?
3. Ask the participants to discuss whether food security is a problem in their area. Which of the four dimensions of food security are more of a problem?
4. Ask the groups to briefly present their findings to the plenary. Facilitate a discussion of the findings.

EXERCISE B.7 WHAT CAUSES FOOD INSECURITY?

90 minutes

1. Divide the participants into two groups. Ask one group to think about the causes of food insecurity in their own area, and the second group to analyse the causes of food insecurity in the country as a whole.
2. Invite them to brainstorm about factors that reduce food security and to list them on a flipchart, trying to address also the gender dimensions.
3. Ask each group to present their list to the plenary. Facilitate a short discussion of their findings and point out any major factors that they missed. Point out that climate is only one of the many factors that affect food security. It is not necessarily the most important factor at any given time, but it could be.
4. Present a short talk about the impact of climate change in the participants' country or region.

EXERCISE B.8 CLIMATE CHANGE AND FOOD SECURITY

60 minutes

1. Divide the group into four subgroups. Ask each group to make a diagram of how various aspects of climate change – such as changing temperature and erratic rainfall and higher sea levels – will affect other factors such as crop yields, pests and diseases, food prices or getting to markets. Then identify how these factors will then influence the four dimensions of food security at the other end of the diagram. They should draw arrows to show how each aspect is likely to affect the others.
2. Ask the four groups to recall how climate change might affect their area. Ask them to discuss how these could threaten, or enhance, food security in their area or country, taking into account components that will affect women, unemployed youth, the elderly and other marginalized groups. Get each group to create a diagram and encourage them to explore possible links.
3. Invite the groups to present the results of their discussions to the plenary. Facilitate a discussion of their findings.

MODULE C

Climate-smart agriculture

OVERVIEW

The previous two modules explored the causes and impacts of climate change. This module introduces the concept of climate-smart agriculture as an approach that aims to overcome challenges posed by climate change: to maintain or improve food security, to help farmers adapt to climate change, and to reduce the amount of greenhouse gases in the atmosphere.

This module looks especially at current agricultural practices and their effect on the environment and on climate change. It then introduces the concept of climate-smart agriculture before identifying practices that fulfil one, two or all three of its aims. However, climate-smart agriculture is comprehensive: it is not limited to a single set of practices but must be tailored to the context. It requires comprehensive capacity-development at various levels with the objectives of promoting behavioural change, enhancing the institutional and political setting, strengthening organizations and institutions and building the individual capacities of various stakeholders.

KEY QUESTIONS

- What is climate-smart agriculture?
- How does climate-smart agriculture contribute to adaptation, mitigation and food security?
- What makes climate-smart agriculture different from current agricultural practices?
- What is the role of gender in climate-smart agriculture?

OBJECTIVES

After completing this module, participants will be able to:

- Explain why it is important to implement sustainable agricultural practices for long-term food security
- Explain the long-term perspective of the climate-smart approach
- Explain the strategies through which farmers can strengthen resilience to climate change
- Describe the concepts of adaptation and mitigation
- List examples of adaptation and mitigation practices

DURATION

5 hours

SESSION C1. CLIMATE-SMART AGRICULTURE DEFINITION AND CHARACTERISTICS

SESSION OVERVIEW

This session defines the concept of climate-smart agriculture and its main features. It further explains its three objectives: food security, adaptation and mitigation. In addition, this session gives participants the opportunity to look critically at common practices in their area and to evaluate their positive and negative effects.

DEFINITION AND CHARACTERISTICS

We need to find ways to produce more food, adapt to changing weather patterns and prevent further damage to the climate, while at the same time assuring the same opportunities for men and women involved in food production. To address these interlinked challenges, food systems have to become at the same time more efficient as well as more resilient to changes and shocks. Agriculture should transform in order make a better use of natural resources, producing more with less land, water, energy and other inputs.

In 2010, FAO introduced the concept of climate-smart agriculture, often abbreviated to CSA, at The Hague Conference on Agriculture, Food Security and Climate Change. The concept integrates the three dimensions of sustainable development – economy, society and environment – by jointly addressing food security and climate challenges. It is an approach aimed at developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change (FAO, 2013a). It is usually defined by its three main objectives:

1. Sustainably increasing agricultural productivity and incomes.
2. Adapting and building resilience to climate change.
3. Reducing and/or removing greenhouse gases emissions, where possible.

Figure C1. The three objectives of climate-smart agriculture

Source: FAO, 2017.

This does not mean that every agricultural practice should achieve all the three objectives. Rather, climate-smart agriculture seeks to re-orient agriculture by taking these objectives into consideration and informing farmers' decisions. It is an interdisciplinary approach that is not limited to a single set of practices. Its application is tailored to specific situations using information from many sources. It requires comprehensive capacity-development efforts at various levels to promote behavioural changes and to enhance institutional and political settings, while strengthening organizations and institutions and building the individual capacities of various stakeholders. Since it focuses on broader social and ecological outcomes it requires the participation of both farming communities and decision-makers and an understanding of the synergies and trade-offs. National priorities need to be set according to each country's social and economic characteristics, on-going development processes and natural resource availability.

Climate-smart agriculture is site-specific rather than a universal approach. What can be defined as 'climate-smart' in one location may not be smart in other context. Climate-smart agriculture therefore is strongly evidence-based with the aim to identify practices that are appropriate to the local context. This base is rooted in a process of building knowledge and dialogue on the technologies and practices that a specific country has prioritized in its agricultural planning. In this framework, information on projected climate change trends is collected to assess food security in future years as well as to customize according to the adaptation potential of selected technologies and practices under changing climatic conditions.

To be effective and sustainable, climate-smart interventions need to consider local social differences, particularly gender and economic inequalities, to ensure equal benefits for men, women, and marginalized groups and to avoid exacerbating existing discriminations. Finally, climate-smart agriculture evaluates which strategies can be adopted to ensure food security.

Box C1. Different ways to achieve food security

Both current agricultural practices and climate-smart agriculture are context-specific. What is practiced in Zambia may not be practiced in the United States, for example. We need to look at specific farming systems in order to identify the climate-smart alternatives. Remember that farming practices have various effects on the natural resource base, on the environment and on climate. Some conserve the environment and enable farmers to adapt to a changing climate; others do the opposite. Can current agricultural practices be climate-smart? Yes! As we see in this session, what makes a practice climate-smart, rather than another one, is its final outcomes. For example:

- Current agriculture. Governments, extension services and agricultural development projects increase agricultural output and productivity by expanding the cultivated area, introducing new farming technologies, and encouraging farmers to specialize in certain crops or livestock breeds.
- Climate-smart agriculture. Interventions aimed at increase output and productivity, thus improving food security, but it with two additional aims: to help farmers adapt to climate change and to reduce the level of greenhouse gases in the atmosphere.

Table C1. Comparing current agricultural practices and climate-smart agriculture

	Current agricultural practices	Climate-smart agriculture
Land	Expand agricultural area through deforestation and converting grasslands to cropland.	Intensify use of existing areas rather than expanding to new areas. Expand the area cultivated by restoring degraded land rather than deforesting new areas.
Natural resources	Make the most use out of natural resources - the land, water, forests, and soils used in production - without paying much attention to their sustainability over the long term.	Restore, conserve and use natural resources sustainably.
Varieties and breeds	Rely on a few crops and/or few high-yielding varieties and breeds.	Use a mix of traditional and modern, locally adapted varieties and breeds to maintain output, increase yields and ensure their stability in the face of climate change.
Inputs	Increase use of fertilizer, pesticides and herbicides.	Improve efficiency of agrochemical use. Control pests and weeds using integrated management approaches. Apply compost, manure and green manure. Rotate crops with legumes to fix nitrogen and reduce use of artificial fertilizers.
Energy use	Use farm machinery that usually relies on fossil fuels – such as tractors and diesel pumps.	Use energy-efficient methods, such as solar power and biofuels.
Production and marketing	Specialize production and marketing to achieve greater efficiency.	Diversify production and marketing to add stability and reduce risk.

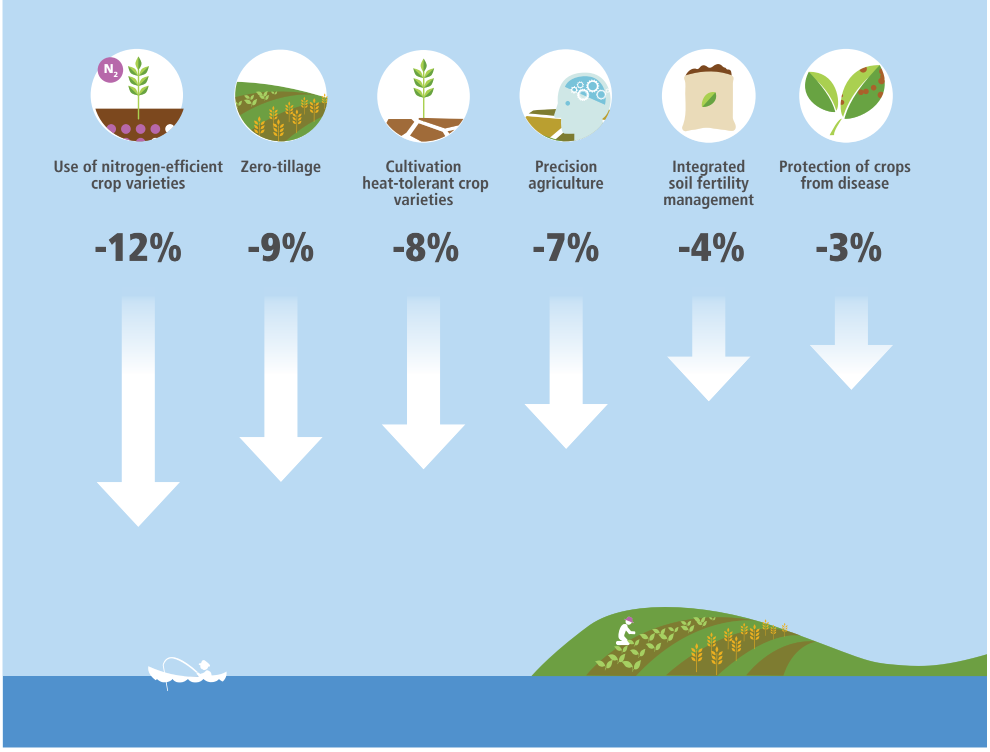
Source: Adapted from FAO, 2013a.

OBJECTIVE 1: SUSTAINABLE AGRICULTURAL PRODUCTIVITY FOR FOOD SECURITY

As we have seen in Module B, climate change has direct and indirect impacts on the whole food system and all the four components of food security. Ensuring food security is a primary objective for climate-smart agriculture, as it aims to sustainably increase agricultural productivity and incomes from crops, livestock and fisheries without damaging the environment or marginalized social and economic groups. The perceptions and types of climate-related risks faced by male and female farmers can differ, which might affect their incentives to adopt certain agricultural practices and technologies on their plots. For example, female farmers in Africa might not adopt soil management measures because their long-term access to land is at risk, so they hesitate to invest extra material or work in the short term that will reap rewards only at a later date (Doss, 2001).

However, research shows that climate-smart agricultural practices can make a real difference in productivity. Simulations undertaken by the International Food Policy Research Institute, comparing conditions with and without adoption of improved agricultural technologies, show that by 2050 their use would substantially decrease food insecurity (Rosegrant *et al.*, 2014; FAO, 2016b). For instance, adopting nitrogen-efficient crop varieties would reduce the percentage of undernourished populations by 12 percent globally, whereas the use of zero-tillage and heat tolerant crop varieties would decrease people at risk of hunger by 9 percent and 8 percent, respectively (Figure C2).

Figure C2. Change in the number of people at risk of hunger in 2050 with improved sustainable agricultural technologies



Source: Adapted from FAO, 2016c.

Agricultural innovations can increase farmers' resilience to climate change and ensure sustainable food production by efficiently using available resources and services. They can also guarantee a stability of returns from production and a reduction of damage to environmental resources. Successful innovation occurs when individuals and groups adopt new ideas, technologies or processes that spread through communities and societies and improve conditions. The most successful innovations often build on and adapt local knowledge and traditional systems in combination with new sources of knowledge from formal research systems (FAO, 2009).

Innovations that strengthen the resilience of smallholder farming systems to climate change include enhanced resource-use efficiency through sustainable intensification of production and the adoption of agro-ecological production systems. Agro-ecological principles are particularly relevant to climate change adaptation (Box C2) (Table C2). Improving water resource management is another area where innovation can be effective in addressing climate change impacts. All of these approaches improve carbon and nitrogen management.

Box C2. Agro-ecological principles

- Enhance the recycling of biomass, with a view to optimizing organic matter decomposition and nutrient cycling.
- Strengthen the resilience of agricultural systems through enhancement of functional biodiversity, by creating habitats for natural enemies of pests.
- Provide the most favourable soil conditions for plant growth, particularly by managing organic matter and by enhancing soil biological activity.
- Minimize losses of energy, water, nutrients and genetic resources by enhancing conservation and regeneration of soil and water resources and agrobiodiversity.
- Diversify species and genetic resources in the agro-ecosystem over time and space, at the field and landscape level.
- Enhance biological interactions and synergies among the components of agrobiodiversity, thereby promoting key ecological processes and services.

Source: Nicholls *et al.*, 2016.

Table C2. Description of some sustainable agricultural practices

Zero-tillage or no-tillage	Exposing the soil only where the seeds are placed, with minimal soil disturbance and retention of plant residues on surface.
Adoption of nitrogen-efficient crop varieties	Increases agricultural productivity and minimizes nitrogen losses from the soil. Example: varieties that use nitrogen more efficiently will produce global yield increase for rice.
Adoption of drought and heat-tolerant crop variety cultivation	Specifically designed to resist specific climate related challenges, like droughts, floods, saline or acidic soils, and pests. Example: adopting varieties resistant to heat and drought can produce global yield increase for maize.
Improved feed management	Storing fodder such as stover, legumes, grass and, grain and making better use of feed by combining types, growing grass varieties specifically suited to the agro-ecological zone.
Livestock manure management	The collection and storage of livestock manure for future application to producers' fields. It dries and composts during storage.
Water harvesting irrigation	Collects water from a surface area for irrigation or for improved filtration. These systems can be small or large, ranging from individual farms and plots to a much more considerable area. Structures can include open water ditches and water pans that must be managed well to avoid insects' proliferation, as well as closed tanks and cisterns.
Drip irrigation	A form of irrigation that allows water to drip slowly to the roots of many different plants thanks to a network of pipes, tubing and emitters. Narrow tubes deliver water directly to the base of the plant. It saves water and fertilizers.

Source: Adapted from World Bank, FAO and IFAD, 2015.

OBJECTIVE 2: STRENGTHEN RESILIENCE TO CLIMATE CHANGE THROUGH ADAPTATION

Agricultural producers and systems have always had to cope with variable weather conditions. The season may be hot or cool, or wet or dry, in general. But agricultural producers adapt, and usually they still produce enough food to eat and a surplus to sell. Sometimes, though, conditions are very unusual: it is much hotter, wetter or drier than normal. In such cases, crops may fail, and animals may die.

In some places, the mean amount of rainfall is declining and the rains are becoming more erratic. In other places, rain arrives more frequently and with greater intensity than before. With climate change, we can track that such shocks are getting more and more intense and unpredictable. Adapting to climate change means enabling agricultural producers to deal with such shocks. Adaptive capacity is the ability for farmers to adopt strategies that help them maximize their agricultural productivity even in the presence of adverse climate events (Box B4). As presented in Module B, there are three variables that can be modified at local levels and within communities to reduce vulnerability of farm systems:

- Reduce the farm system's exposure. Planting healthy windbreaks and hedgerows and following no-tillage planting practices help soil to stay put and resist erosion. Storing feed off the ground helps keep it safe from floods and vermin
- Reduce the sensitivity of the farm systems to these shocks. Using drought-resistant varieties or keeping adequate stocks of hay can reduce sensitivity to drought. Water harvesting, storage and conservation apply management techniques to reduce runoff and balance supply against demand.
- Increasing adaptive capacity involves learning new skills and trying innovative solutions. This includes considering the modifications of a system and taking into account all the potential shocks and changes together as possible compensating, exacerbating and cumulative effects.

Agricultural producers need to build their own adaptive capacity to succeed in the face of increasing climate risk. Decades of sharing experiences and refining approaches have produced many innovative solutions and traditional practices as potential responses to adopt for context and site-specific circumstances (Table C3).

Table C3. Sample options for adaptation to climate change at farm level

Risk	Response
Changing climate conditions and climate variability and seasonality	• Optimize planting schedules such as sowing dates (including for feedstocks and forage). • Plant different varieties, species or cultivars of crops. • Use short duration cultivars. • Varieties or breeds with different environmental advantages may be required, or those with broader environmental tolerances: use of currently neglected or rare crops and breeds should be considered. • Early sowing can be enabled by improvements in sowing machinery or dry sowing techniques. • Increased diversification of varieties or crops can hedge against risk of individual crop failure. • Use intercropping. • Make use of integrated systems involving livestock and/or aquaculture to improve resilience. • Change post-harvest practices, for example the extent to which grain may require drying and how products are stored after harvest. • Consider the effect of new weather patterns on the health and well-being of agricultural workers.
Change in rainfall and water availability	• Change irrigation practices. • Adopt enhanced soil water conservation measures. • Use marginal and waste water resources. • Make more use of rainwater harvesting and capture. • In some areas, increased precipitation may allow irrigated or rain-fed agriculture in places where previously it was not possible. • Alter agronomic practices. • Reduce tillage to reduce water loss. • Incorporate manures and compost, and other practices such as cover cropping to increase soil organic matter and hence improve water retention.
Increased frequencies of droughts, storms, floods, wildfire events, sea level rise	• General water conservation measures are particularly valuable at times of drought. • Use flood, drought and/or saline resistant varieties. • Improve drainage, improve soil organic matter content and farm design to avoid soil loss and gullying. • Consider (where possible) increasing insurance cover against extreme events.
Pest, weed and diseases, disruption of pollinator ecosystem services	• Use expertise in coping with existing pests and diseases. • Build on natural regulation and strengthen ecosystem services.

Source: FAO, 2016a.

The FAO details four interrelated adaptation strategy categories for smallholder farmers' consideration to reduce their vulnerability and to improve their sustainable development: agricultural and livelihood diversification, support to farmers in managing agricultural risk, reducing gender inequalities and migration (FAO, 2016b).

Agricultural and livelihood diversification: Agricultural diversification occurs when agricultural producers increase the number of crops or breeds on their farm, or decide to integrate production of crops, livestock and trees through agroforestry systems, for example. Different crops can also be raised at the same time in intercropped plantings or the same field can be cultivated with different crops in sequence. Livelihood diversification occurs when farmer households engage in farm and non-farm activities to spread their income sources over different economic sectors and along value chains. It enables farmers to be less dependent on income derived from their farm harvest alone.

Support to manage agricultural risk: A variety of social protection programmes, designed for poverty alleviation, are useful for managing climate risks. Social protection takes various forms, from cash transfers to school meals and public works. Agricultural extension services can alleviate climate risk by building the capacity of agricultural producers, by suggesting adaptive techniques and technologies and by educating them on the long-term positive effects of climate-smart practices. Managing agricultural risk is especially dependent on access to information about weather conditions that facilitate optimal planting dates or decisions about timely livestock sheltering. Usually, farmers that are able to access seasonal forecasts are able to make informed management decisions and to reduce harvest losses.

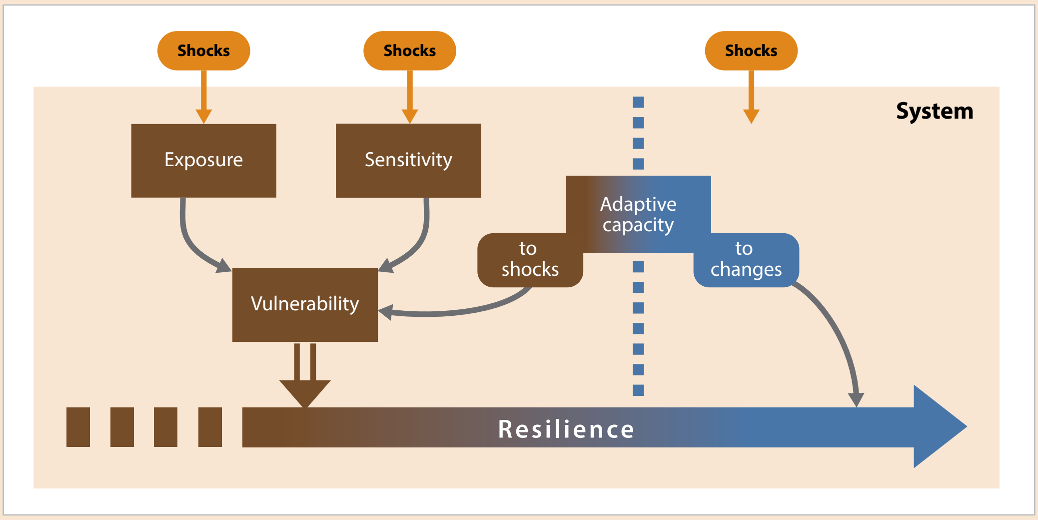
Reducing gender inequalities: Often, women have fewer entitlements and endowments than men, are less mobile and have limited access to information, making them more vulnerable to climatic shocks and low farming productivity. Possible interventions aimed at reducing this gender gap include: have a clear understanding of the local productive roles of men and women; analyse their different access to and control over productive and financial resources; increase women's access to productive land, services, inputs, markets, weather and climate information, knowledge and training; increase women's participation in decision-making processes by establishing community-level bodies with their adequate representation; and analyse the effects of climate change on labour requirements of men and women in terms of household and hired labourers.

Migration: Temporary, seasonal, circular and permanent migration can serve livelihood diversification, providing significant benefits to many rural households. It is a key source of income diversification that boosts household resilience and provides the means for productivity-enhancing investments. For farm households with limited options for on-farm and non-farm rural employment, migration to cities may be an option to improve their livelihoods. When the strategy works well, urban or migrant workers can support their family's livelihoods through remittances, while rural farmer branches can supply urban family members with farm products to supplement diets or to supply local markets. As various strategies and diversified approaches increase adaptive capacity, a farm system's vulnerability to climate risk declines: This is how resilience grows (Box C3).

Box C3. What is resilience?

Resilience can be defined as "the capacity of systems, communities, households or individuals to prevent, mitigate or cope with risk, and recover from shocks"(FAO, 2016a). It adds a time dimension to the concept of vulnerability: a system is resilient when it is less vulnerable to shocks across time and can recover from them in a timely manner. Resilience is achieved through exposure and sensitivity reduction and increased adaptive capacity. These can be undertaken across biophysical, economic or social domains. An example would be the transport of feed in case of drought or safety nets to compensate for bad harvests. Resilience puts great emphasis on the capacity of a system to recover and transform itself in the long term. In order to adapt to the changing environment, the system itself needs to take action at multiple scales, in various dimensions: ecological, technical, economic and social as well as involving various categories of actors and enabling governance environments. Additionally, different time frames need to be integrated for specific actions to produce positive effects.

Vulnerability and resilience



Source: Gitz and Meybeck, 2012.

OBJECTIVE 3: REDUCE GREENHOUSE GAS EMISSIONS THROUGH MITIGATION

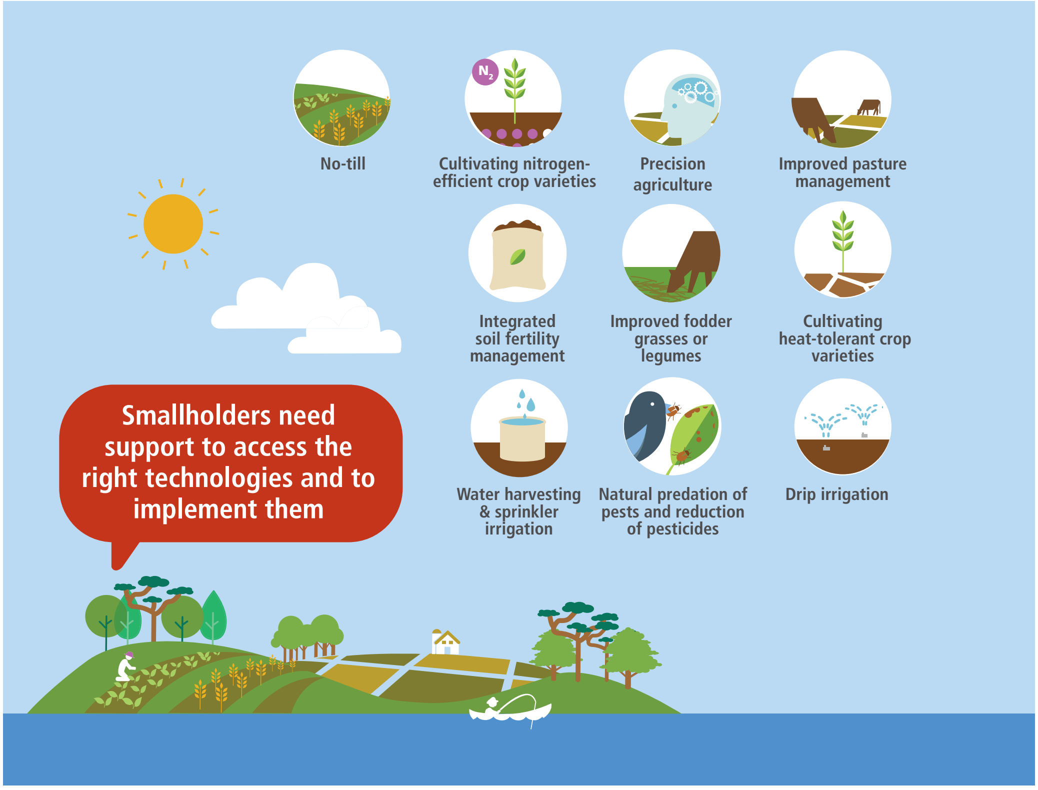
The IPCC defines mitigation as "an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases" (IPCC, 2001). It is human action to permanently remove or reduce greenhouse gas emissions and the long-term risks they pose to ecosystems and human life.

The two main ways to achieve climate change mitigation benefits are:

- Reduce and avoid emitting greenhouse gases into the atmosphere
- Enhancing carbon storage through sequestration by increasing the woody vegetation that absorbs carbon dioxide from the atmosphere, for instance, planting trees or by storing carbon-rich organic matter in soils.

In agriculture, most GHG emissions are driven by the use of natural resources: conversion of forests into farm land, use of agricultural inputs, energy consumption and other activities. A key aspect of climate-smart agricultural practices, therefore, is about increasing efficiency of the food systems. Producing more outputs using less inputs is key in reducing the emissions in agriculture. Many farming techniques exist to reduce emissions, enhance carbon storage, and also increase resource efficiency in food production. Some of them, depending on the context, have additional benefits and help build resilience in a farm system and increase food security (Table C4) (Figure C3). Some challenges arise when implementing the mitigation strategies. Tools used to measure emissions are often limited to one-time measurements and are generally incapable of capturing temporal and spatial emissions variability. For example, greenhouse gas emissions from agricultural soils are incredibly variable over time and space and are difficult to measure. Some mitigation practices may also increase soil carbon more than others and the magnitude of these effects may change across regions.

Figure C3. Some examples of sustainable agricultural practices



Source: adapted from FAO, 2016c.

Table C4. Examples of food security, adaptation and mitigation synergies

	Examples of possible climate-smart agricultural practices	Expected impact on food security	Possible impact on adaptation	Possible impact on mitigation
Crops	• Improved land management practices such as reduced or zero tillage. • Improved agronomic practices. • Soil and water conservation measures. • Integrated nutrient management such as efficient fertilizer application based on crop and site, specific nutrient balance analysis, split application, adaptable timing. • Proper management of organic soils avoiding deep drainage and deep ploughing, row crops and tubers and maintaining a shallower water table.	• Better plant nutrient content, increased water retention capacity and better soil structure generate tangible on-site production benefits in the form of higher crop yields.	• Increased system viability and resilience of crops and livestock. • Reduced vulnerability of farm system.	• Farming practices that restore soil health and fertility can increase biomass and carbon sequestration. • Conservation tillage minimizes soil disturbance and related soil carbon losses. • Integrated nutrient management reduces leaching and volatile losses. Proper management of organic soils reduces N2O and CH4 emissions. Reducing post-harvest food losses contributes to lower emissions per unit of food consumed.

Livestock	• Improved feeding practices such as introducing highly digestible forages. • Improved genetics and reproduction, and animal health control as well as general improvements in animal husbandry. • Improved manure management. • More efficient crop and grazing land management such as rotational grazing.	• Increased animal productivity and production. • Increased nutrient cycling and plant productivity. • Improved fodder production.	• Increased system resilience and reduced vulnerability.	• GHG emissions in livestock sector can be reduced substantially through improvement of feed quality, animal health and husbandry, more efficient energy use and manure management. • Reducing post-harvest food losses reduces emissions per unit of food consumed.
Fishery and aquaculture	• Use of fishing practices that adhere to the principles of the Code of Conduct for Responsible Fisheries. • Adoption of improved aquaculture management approaches such as selection of suitable stock, improved energy efficiency, increasing feeding efficiency, reduce losses from diseases. • Integration of aquaculture with other production systems such as aquaponics. • Improved management of ecosystems such as mangrove systems and seaweed farms.	• Increased fish productivity in a sustainable way. • More nutritional diets.	• Increased aquaculture resilience. • Increased resilience of natural ecosystems, increased biodiversity.	• More efficient energy use such as better use of fuel in capture fishing would reduce GHG emissions. • Increase the efficiency of feed and fertilizers. • Reducing post-harvest food losses reduces emissions per unit of food consumed.
Agroforestry	• Use of trees and shrubs in agricultural farming systems: improved fallows, growing multipurpose trees and shrubs, boundary planting, farm woodlots, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture and tree apiculture.	• Increased farm incomes and diversified production with food security benefits.	• Reduced erosion, increased soil stabilization and H2O infiltration rates, land degradation halts, reduced vulnerability to shocks, increased resilience.	• Stores carbon in above and below the ground biomass and progressively increases organic matter and carbon stocks in the soil. • Agroforestry systems tend to sequester much greater quantities of carbon than agricultural systems without trees. • Agroforestry measures increase C storage and also reduce soil C losses stemming from erosion.

Source: Adapted from FAO, 2012b; FAO, 2013a; Branca *et al.*, 2012.

CASE STUDY ZAMBIA

Examples of Tillage systems and their effect on climate

Slash and burn

Main features: This system is common in the Eastern, Southern and Central provinces of Zambia. At the end of the dry season, farmers slash the shrubs and grass in an area they want to cultivate. They rake the material into piles and burn it. This leaves the ground bare, freeing it for ploughing and planting. It also forces mice and other wildlife out of their burrows. The ash is rich in potassium, which fertilizes the soil and raises yields. The farmers dig planting holes with hoes.

A similar system is *chitemene* cultivation, common in the high-rainfall Northern Province. Here, the farmers trim branches in the tree canopies, pile them up in several places and burn them. They plant crops in the burned areas. Trees regrow, and the process can be repeated year after year. Some farmers cut off all the branches, leaving only the trunks. The trees take longer to regrow.

Effects on the environment: This method leaves the soil bare at the start of the rainy season. This increases run-off and erosion, so lowers the soil fertility.

It also destroys plant residues that provide many advantages: protecting the soil from rain splash and the formation of surface crusts; preventing soil from being washed away during heavy rain; holding water and allowing it to sink into the soil and recharge the watertable; as well as reducing the soil temperature, which can reach around 40 °C in October.

Burning destroys organic matter, so it is not added to the soil. Instead, carbon dioxide and other greenhouse gases are released into the air. Digging holes does not disturb the soil much, so does not expose much organic matter to the air. Erosion lowers soil fertility and reduces the amount of carbon in the soil.

Ox-ploughing

Main features: Most farmers wait for the rains before starting land preparation. They slash and burn the crop residues. They wait for the rains to start and the ground to become soft, and then they plough the field using oxen. They can then plant the crop. Using oxen makes it possible to cultivate a large area of land.

Effects on the environment: Ploughing exposes the soil to rain, which may wash the topsoil away. Ploughing also turns over the soil, bringing the organic matter into contact with the air. That permits the organic matter to be converted into carbon dioxide, which is released into the air.

After several seasons of ploughing, the soil becomes compacted. This reduces its ability to hold water, harms crop growth, reduces the amount of organic matter, and increases the soil acidity.

Fundikila: ridging up with a hoe

Main features: This system is common in Eastern province. The farmers use hand hoes to gather trash and weeds into mounds or ridges, which they cover with soil. They then plant crops on top of the mounds or ridges. The residues decompose, releasing nitrogen that the crop roots can take up and use.

The ridges are fairly widely spaced, so there is a lot of uncultivated ground between them. This soil is infertile, and weeds may proliferate there. The wide gaps make it more likely that the crops will fall over in high winds.

Effects on the environment: The buried plant residues may decompose quickly, leaving little nitrogen for the crop growing on the ridge. The ridges often run up and down the slope, so they channel water, which washes away the topsoil and may cause gullying.

Overall digging with hoe

Main features: This method is not widespread in Zambia. It involves digging the whole field with a hoe, usually after the first rains when the soil is moist. This is very labour intense, so is practical only on small areas.

Effects on the environment: This method exposes the soil to rainstorms and also accelerates the breakdown of organic matter.

Minimum tillage with hand hoe

Main features: Farmers in Zambia have used this method for centuries. After the first good rains, they dig planting holes, or scratch planting lines into the soil surface, without ploughing. This takes a lot of labour but allows early planting. The farmers then sow cereals such as maize, and later sow cowpeas, pumpkins and okra in the gaps between the rows.

Effects on the environment: This method reduces soil erosion as it does not disturb most of the soil. It also conserves organic matter and the soil structure. Plant residues can remain in fields, where they provide many advantages when properly managed: Protecting the soil from rain splash and the formation of surface crusts; preventing soil from being washed away during heavy rain; holding water and allowing it to sink into the soil and recharge the water table; as well as reducing the soil temperature, which can reach around 40 °C in October.

SESSION C2. GENDER ISSUES IN CLIMATE-SMART AGRICULTURE

SESSION OVERVIEW

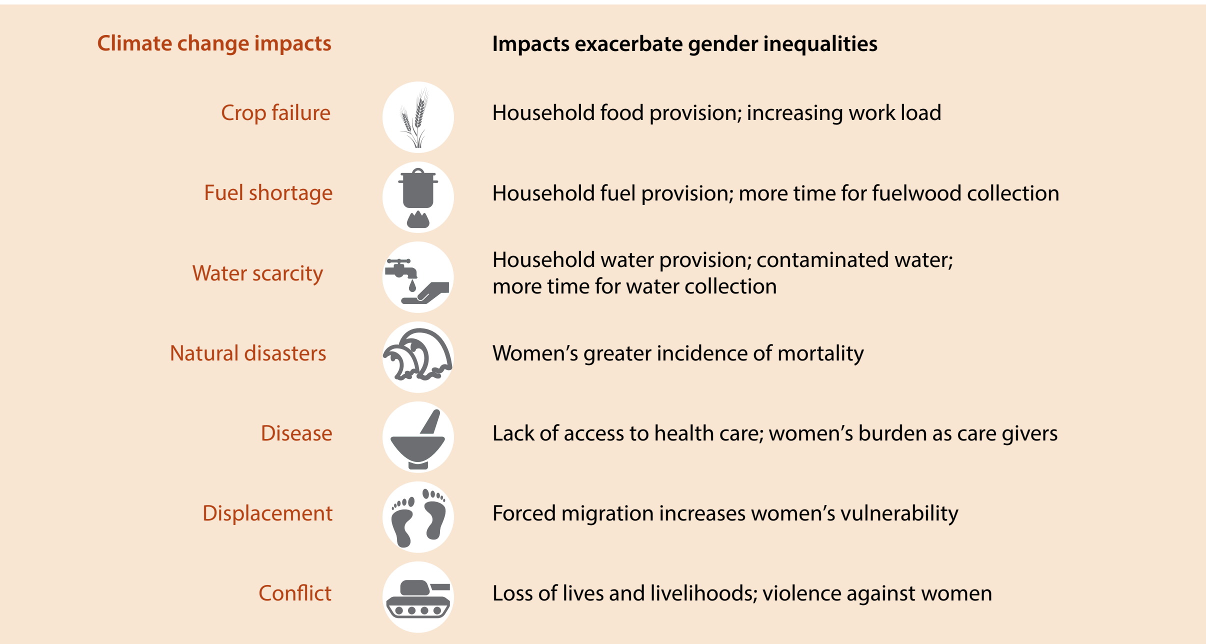
Developing adaptive capacity is extremely important to build resilience in farm systems that families, communities and countries need to assure food security in the face of changing climate. Adaptive capacity development cannot be contained within a particular part of society: instead, men and women should be fully informed and capable of practicing climate-smart agriculture.

Understanding gender issues is crucial to effectively deal with climate change and achieve climate-smart agriculture. Due to different gender roles and the related constraints, men and women may have different perspectives and knowledge about what climate risk is, how it may affect their livelihoods and how to respond to this challenge. They also have differential access to the resources and services needed to adopt climate-smart practices. This session examines the varying roles of men and women in agriculture and how climate change affects those roles; and it presents methods of identifying and addressing gender-related barriers to the adoption of climate-smart practices and interventions. It looks at gender-specific vulnerabilities and how to manage them through a gender-responsive approach in climate-smart agriculture.

THE GENDER GAP IN AGRICULTURE

Gender productivity gaps exist in agriculture. Due to traditional gender-based discrimination, women have fewer privileges, entitlements and endowments. Women face more challenges than men in accessing, using and controlling productive resources and services, such as land, water, credit, inputs, technologies, information, knowledge, education, extension and other rural advisory services, markets and weather and climate information. This affects their vulnerability and adaptive capacity to climate threats. Gender-specific consequences in the context of climate-smart agriculture vary by the degree to which women can equally access resources such as land or livestock, services, employment and business opportunities (World Bank, FAO and IFAD, 2015). It has been estimated that closing the gender gap in agriculture would reduce the number of hungry people by 100–150 million (FAO, 2011). However, climate change exacerbates the existing barriers that women face. Gender inequality and climate change consequences intersect in multiple dimensions (Figure C4).

Figure C4. The intersection of climate change and gender inequality with food security



Source: FAO and World Bank, 2017.

A GENDER-RESPONSIVE APPROACH TO CLIMATE-SMART AGRICULTURE

The accepted procedure for addressing the gender gap in agriculture is adopting a gender-responsive approach. In practice, this means that the differentiated needs, priorities, and realities of men and women are recognized and adequately addressed in the design and application of climate-smart agriculture so that both men and women can equally benefit (World Bank, FAO and IFAD, 2015). The ultimate goal of a gender-responsive approach to climate-smart agriculture is to give women and men the same incentives and opportunities to invest in or adopt climate-smart practices.

The fundamental component of a gender-responsive approach is to carry out gender analyses, aimed at developing understanding of specific social and economic contexts and gender-related inequalities. As part of a gender analysis, an assessment is made of women's and men's control of assets such as land, water and other productive resources; income; of the labour involved and the time required until benefits are realized; and of access to information, credit and markets – as well as gender-related vulnerabilities to climate change. The results of such an analysis can reveal the underlying causes of gender inequalities, social and economic barriers and other challenges, including cultural facets that could offer insights that inform solutions. All this information is crucial to understand the factors that influence adoption of climate-smart agriculture.

During the gender analysis phase and the subsequent design of gender-responsive, climate-smart, and adaptive capacity-developing interventions, several approaches can be applied. These could include:

- Context analysis to understand broad social and economic patterns and their role in gender relations
- Stakeholder analysis devised to identify the female and male stakeholders and their converging and diverging interests
- Gender-sensitive needs-assessment to understand the specific needs and priorities of men and women
- Livelihood analysis that looks at women's and men's access to resources.

In designing capacity development interventions for climate-smart agriculture, it is important to identify which approaches will address immediate needs of men and women and which approaches can promote a shift toward lasting equality between women and men. The more immediate needs are referred to as men and women's practical gender needs, such as employment and food for the family, and these can generally be addressed through extension services. On the other hand, strategic gender needs – equal access to resources, elimination of discrimination and adequate participation in decision-making mechanisms – require long term commitment and changes at different levels in the society. Meeting these strategic needs is fundamental to advancing toward gender equality. Possible actions to address practical and strategic gender needs can blend into each other as they determine the path for developing adaptive capacities (Table C5).

Table C5. Examples of actions to address practical and strategic needs

Example of actions to address practical needs:	*Example of actions to address strategic needs:*
• Provide training on ecosystem service opportunities of agroforestry for women and men. • Organize training on fishing gear maintenance skills for men and women. • Introduce improved stoves and other household labour-saving practices. • Provide vaccines for small livestock handled by women as well as for larger animals.	• Introduce incentives and land renting agreements for landless women. • Organize informal education activities for illiterate women, including both technical and soft skills development. • Involve women and men in decision-making roles on farming committees. • Encourage cooperation with neighbouring communities for larger ecosystem service projects that involve support from both women and men.

Gender analysis is a tool used when adopting a gender-responsive approach to design interventions that foster equality. The questions explored in the analysis require serious consideration from participants about which current agricultural practices are entrenched, how they are practiced, and why they are used (Box C4). The answers can provide rich sources of information about assumptions that underlie current practices and can offer insights into how traditional systems could integrate climate-smart practices. Successful integration provides a basis for innovative climate-smart solutions that fit the context of local circumstances.

Box C4. Conducting a gender analysis for climate-smart agriculture

Gender analysis is the study of the different roles of women and men in order to understand what they do, what resources they have, and what their needs and priorities are. Although no blueprint exists for conducting a gender analysis, and several approaches can be adopted to carry it out, some initial general questions aimed at understanding gender relations in the context of climate change can include:

Climate vulnerabilities and coping strategies

- Which hazards occur in the area and what is their frequency?
- Who is most affected by each climate-related hazard? Where? When? Why?
- Do men and women respond to a climate hazard in different ways? How? Why?
- Do men and women share the same views on climate change patterns?

Gender roles and relations:

- Who does what? How? Where? When? Why?
- Who benefits from decisions over resources? How? Where? When? Why?
- Who is included in planning at household, community and national scales? How? Where? When? Why?
- How much time do women spend on a certain agricultural activity? How much time do men spend on each activity? Are climate changes affecting that?

Access to resources:

- Who owns what? How? Where? When? Why?
- Who learns and knows what? How? Where? When? Why?
- Do weather and climate influence access to resources? How? Where? When? Why?
- Does climate change influence access to resource?
- How could households diversify their production and livelihood strategies?

Source materials for detailed guidance on conducting a gender analysis in the context of climate-smart practices in agriculture can be found at:

- Training guide: Gender and climate change research in agriculture and food security for rural development. FAO and the CGIAR Research Program on Climate Change, Agriculture and Food Security: www.fao.org/docrep/018/i3385e/i3385e.pdf
- Training Module How to integrate gender issues in climate-smart agriculture projects. FAO and World Bank: http://www.fao.org/3/a-i6097e.pdf

Sources: FAO and World Bank, 2017; FAO and CCAFS, 2012.

SELECTING CLIMATE-SMART PRACTICES

The information gathered during a gender analysis is valuable when selecting and promoting climate-smart agriculture practices. To ensure that the gender analysis findings are utilized in climate-smart interventions, the important question is: How can CSA-sensitive practices be identified, designed and implemented in a way that takes into account the local, existing differences and inequalities between men and women, and contribute to the promotion of gender equality? Special measures must be designed and implemented to give men and women the same incentives and opportunities to invest in or adopt climate-smart practices (FAO and CCAFS, 2016). To adopt climate-smart agricultural practices in particular, a potential intervention's relative contribution to the three objectives of food security, adaptation and mitigation needs consideration as well as its gender impact. Important field research in Africa and South Asia, achieved through programme experience and expert opinion, produced a framework that serves as a model for further work (Table C6). Such a framework can be used to evaluate possible climate-smart practices according to key gender-sensitive criteria. Using information from the gender analysis to fill in the table, a local team will have a summary of selected possible climate-smart options and their gender-related attributes relevant to their context and site. In this way, options and practices can be evaluated based on criteria such as control of income from a practice or amount of time until the benefits are realized. It should be kept in mind that, in general, women have more control over the income produced by home gardens, fodder shrubs, herbaceous legumes, and improved grasses, each of which require different amounts of time to yield benefits (World Bank, FAO and IFAD, 2015; FAO and World Bank, 2017).

Table C6. Relative contribution of agricultural practices to climate smart goals, gender impact, and requirements for adoption of the practice

	Contribution to CSA goals relating to			Gender impact		Requirements for adoption of practice				
Climate-smart agricultural practice or intervention	Adapt	Mitigate	Food and nutrient security	Women's control of derived income	Length of time until benefits realized	Potential women will benefit	Female and youth labour availability	Female access to and control of land	Female access to water for agriculture	Female access to cash and ability to spend
Stress-tolerant varieties	High	Low	High	Low	Low	Medium	Medium	High	Low	High
High-yielding varieties	Low	Low	High	Low	Low	High	Medium	High	High	High
Conservation agriculture	High	Medium	High	Low	High	High	Low to Medium	High	Low	Low
Improved home gardens	High	Medium	High	High	Low	High	High	High	High	High
On-farm tree planting	High	High	Low to Medium	Low	High	Medium	High initially Low later	High	High	Medium
Composting	Medium	Medium	Medium	Medium	Low	Medium	High	Medium	Low	Low
Small-scale irrigation	High	Low	High	Low to Medium	Low	High	Medium	High	High	Medium
Fodder shrubs	High	Medium to High	High	High	Medium	Medium	High	High	Medium	Low to Medium

Herbaceous legumes	High	Medium	High	High	Medium	High	High	High	Medium	Low to Medium
Improved grasses	High	Medium	High	High	Low	High	High	High	Medium	Low
Livestock genetic improvement	High	Medium	Medium to High	Low to High	High	High	Low to High	Low	High	Medium
Restoration of degraded rangeland	High	High	Medium	Low	High	High	Low to High	High	Low	Low

Source: Adapted from World Bank, FAO and IFAD, 2015; FAO and World Bank, 2017.

MONITORING CLIMATE-SMART AGRICULTURAL PRACTICES

Additionally, the monitoring and assessment of climate-smart interventions need to include gender-sensitive indicators that help track progress in closing the gender gap in agriculture. Achieved by assessing the differentiated effects on women and men from any intervention, the resulting information offers various advantages to:

- Highlight gender issues for consideration in climate-smart agricultural policy-making
- Build an evidence base on gender in climate-smart agriculture by collecting and analysing sex-disaggregated data
- Develop financial instruments that respond to the specific needs of women as well as men
- Introduce institutional changes to develop the capacity and build the commitment of decision-makers towards gender equality and women's empowerment
- Design climate-smart projects and investments that integrate gender issues throughout the cycle to ensure specific needs and priorities of both men and women are adequately addressed.

PRACTICAL CONSIDERATIONS

To ensure that both women and men benefit equally from climate-smart interventions, special attention must be given by extension staff so that women can equally participate in the design, testing and implementation stages of the intervention. Demonstrations and study tours are usually an effective way to expose men and women agricultural producers to new climate-smart practices; but enabling women's participation may require special arrangements according to the specific social and cultural context. This includes ensuring that both male and female extension agents are present to interact with male and female producers, and that they organize separate groups if women are not allowed in mixed groups or if they are reluctant to contribute in mixed groups. In addition, practical choices such as the timing and location for organizing extension events and the availability of childcare should be considered to maximize attendance by all actors in the community.

During the implementation of a climate-smart intervention, additional practical gender considerations must be taken into account, beyond those that can be arranged during direct contact with communities considering climate-smart practices. If the adoption of a practice requires access to credit based on land ownership, women's lower levels of land ownership and consequential inability to access credit must be addressed from the outset. In addition, differences in literacy levels and in access to and use of various information sources - newspapers, internet, radio, informal groups, organized events or shows - should be considered when planning for dissemination of information related to climate-smart agriculture.

In conclusion, a gender-responsive approach to climate-smart agriculture involves multiple actions, both during analytical phases and practical implementation of an intervention. To determine whether a climate-smart intervention is successfully following a gender-responsive approach, five criteria can be evaluated and used as a checklist (Table C7).

Table C7. Evaluation criteria: Was a gender-responsive approach used in a climate-smart intervention?

Criteria	Explanation of criteria
1. Both development and application of the climate-smart practice have been informed by gender analysis	Gender analysis: To better understand the site-specific gender, cultural, social and economic context we must analyse who has what and why, who does what and why, who makes decisions and why, and who needs what and why, right at the start of developing a climate-smart intervention or introducing a practice. This analysis explores the differential vulnerability of men and women to risk, their opportunities and benefits, the existing power relations within the household and the community, their willingness to take on risk, and available modes of access to sources of information. Findings of this analysis inform the application of the practice.
2. All practice- related work involves equal participation and engagement of men and women, particularly those who implement the climate-smart practice	Participation and engagement: Female and male farmers must be equally involved in developing, adapting, testing and adjusting climate-smart practices to meet their needs, preferences, and opportunities. Communities and experts work together to understand local problems, climate projections and available assets and services and to identify and test potential solutions by reducing existing gender inequalities and discrimination. Institutions must also be strengthened to continue fostering stakeholder engagement and raise their commitment towards gender equality and women's empowerment. It is also essential to involve both women and men from the first identification of the intervention through to implementation, as well as in monitoring and evaluation, to assess the gender-related consequences and to introduce corrective actions if required. This helps avoid exacerbating existing inequalities and discrimination against certain social and economic groups.
3. Efforts to reduce constraints to uptake of the climate-smart practice	Constraints to adoption of climate-smart practices are adequately addressed: Analysis findings are used to understand constraints to women's adoption of the practice, such as the unequal roles in decision-making, uneven access to information or credit, limited land ownership or other restrictions to resources and services needed for the practice or technology. By promoting equal access to resources and participation in household decision-making, all potential end-users can benefit from information and capacity development related to the climate-smart practice.
4. The practice results in short-term benefits for men and women	Short-term benefits: The climate-smart practice is designed to produce benefits for both women and men. These benefits include improvements in agricultural yields; reduction in time, energy and labour spent by food producers, particularly women, on their agricultural activities; and increases in women's access to and control of agricultural inputs and income.
5. The practice results in long-term benefits for men and women	Long-term benefits: The climate-smart practice itself contributes to longer-term changes in equality between men and women. It may enhance their specific resilience and agricultural productivity; increase women's control of resources and participation rates of women, youth and other marginalized groups in decision-making at household and community levels.

Source: Adapted from FAO and CCAFS, 2016.

EXERCISE C.1 ADAPTATION AND MITIGATION

90 minutes

See Module C. Session C1. Objective 2 on adaptation and Objective 3 on mitigation.

1. Divide the participants into groups. Ask each group to imagine they are in one of these hazardous situations:
   - The soil on your main farming field is degrading every year a bit more. Your crop yield is declining.
   - A pest is attacking your crop. You are afraid that as much as 80 percent of the harvest will be lost if you do not intervene.
   - It's been raining heavily for days. Your maize field is flooded, and you estimate that it will remain submerged for at least two weeks.
   - You planted all your cropland with rice this year. When the harvest season comes the price for rice has fallen by 60 percent and your household income is at risk.
2. Ask each group to discuss:
   - What could you have done to avoid the situation in the first place?
   - What can you do now to prevent the problem from getting worse?
   - If the problem does get worse, what can you do to reduce the damage caused?
3. Ask each group to report back to plenary.
4. Explain the meanings of adaptation and mitigation.
5. Remind the participants of the virtual field visits they made in Session B2. Ask them to classify their responses to that exercise as adaptation or mitigation.
6. Ask the participants to think of ways that agricultural producers, and others involved in agriculture, can adapt to climate change and what the governments can do to encourage adaptation and mitigation. What can the extension service and extension agents do?

EXERCISE C.2 CLIMATE-SMART AGRICULTURE

60 minutes

1. Remind the participants of the earlier discussions on adapting to and mitigating climate change. While adaptation challenges may seem challenging, it is important to note that mitigation strategies also face obstacles to actual achievement. Tools used to measure emissions are often limited to one-time measurements and are generally incapable of capturing temporal and spatial emissions variability. Some mitigation practices may also increase soil carbon more than others and the magnitude of these effects may fluctuate across regions and seasons.
2. Explain the concept of climate-smart agriculture and its three objectives:
   - Food security
   - Adaptation
   - Mitigation
3. Ask the participants to think of examples from their own experience of the three approaches to adaptation: reduce exposure, reduce sensitivity and increase adaptive capacity.
4. Ask them to think of examples of the two approaches to mitigation: reduce greenhouse gas emissions and increase sequestration of carbon in above ground vegetation and in below ground soil.
5. Ask them what practices have proved useful in increasing food quality and quantity despite climate change.

EXERCISE C.3 CURRENT AGRICULTURAL PRACTICES

90 minutes

1. Ask the participants to identify several major types of farming that are common in the region, such as extensive livestock grazing, intensive dairying, slash-and-burn cultivation, cultivation of cash crops using machinery, cultivation using hand hoes, and others.
2. Organize the participants into different groups. Assign one of the farming types to each group.
3. Ask each group to briefly describe the main features of their assigned farming system.
4. Ask them to identify how it affects the environment and natural resources, such as the soil and water. Does it cause erosion, deforestation, pollution, water table deterioration? How?
5. Ask them to identify their assigned system's effects on climate change. In what ways does it emit greenhouse gases? In what ways does it absorb carbon from the air?
6. Finally, ask them how the farming practice could be improved.

EXERCISE C.4 ARE CURRENT PRACTICES CLIMATE-SMART?

60 minutes

See Exercise C.2 and Figure C1.

1. Remind participants of the list they drew up on current farming systems for Exercise C.3.
2. For each system, ask them to identify whether it:
   - Contributes to improving food security
   - Helps agricultural producers adapt to climate change
   - Contributes to mitigating climate change.

   Ask the participants to justify the reasons for their identifications.
3. On a flip chart, draw a three-circle diagram like Figure C1. Ask the participants to indicate in which circle of the diagram each of the current agricultural practices could go.
4. Facilitate a discussion on which is the best practice from a climate-smart point of view.
5. Ask the participants to suggest how each of the practices might be changed to help it meet two or even three of the climate-smart objectives.

EXERCISE C.5 MAKING AGRICULTURAL PRACTICES MORE CLIMATE-SMART

60 minutes

See Exercises C.2 and C.3.

1. Remind the participants of the list of current farming systems they drew up in Exercise C.3 and discussed again in C.4
2. Ask them to think of ways that each practice might be improved to make it more climate-smart. For example, by replacing some of the artificial fertilizer with farmyard manure, or by planting trees on the edges of fields.
3. Ask them to think of other practices that they would regard as climate-smart. The practices may be either individual techniques such as mulching or more general approaches such as agroforestry or integrated pest management. Make a list of these practices on a flip chart: we will use the list in the next session.

EXERCISE C.6 PRIORITIZING OPTIONS

60 minutes

1. Divide the participants into three groups. Ask each group to take on one of the roles of the extension staff in the scenarios presented in the following scenarios. If convenient, replace the roles with other examples that are more relevant to your situation or that of the participants.

> **Scenarios: Deciding on priorities**
>
> Ibrahim is an extension agent working with villagers in a hilly area of the country. Over the years, the farmers have ploughed the soil on the slopes, causing severe erosion. Food is now scarce, and people have started abandoning their fields.
>
> Carol is an extension agent working in a low-lying, coastal area. The mangroves along the coast have been cleared to make charcoal, and now the groundwater and water in canals are becoming salty as sea water forces its way inland. Newly introduced high-yielding rice varieties do not grow well, and yields are declining.
>
> Michael is an extension agent working in an area with large, mechanized farms. These are productive, but continuous cultivation is causing the soil to lose organic matter and fertility. Furthermore, the tractors and other machinery use a lot of fuel.

2. Ask each group to discuss what they would do to solve the problems described for their chosen extension staff member. What aspects of climate-smart agriculture should they try to promote? What should the priority be: food security, adaptation or mitigation?
3. Invite each group to present the results of their discussion to the plenary. Facilitate a discussion of each presentation.

EXERCISE C.7 GENDER AND CLIMATE CHANGE

90 minutes

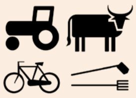
1. Ask the participants to list the tasks needed to produce a crop or livestock type in the area. For crops, this will include everything from obtaining seed and other inputs and preparing the land to sowing, weeding, controlling pests and disease, harvesting, threshing, drying, storage and sale. For livestock, it might include purchasing or breeding animals, care of pregnant and young animals, feeding, watering, herding, maintaining fences and hygienic shelter, milking, sale of milk and other livestock-derived products and sale of animals.
2. Ask who generally performs each task: men, women, or both. Fill in a table like Table C8 below to show this.

Table C8. Analysing who does what: an example

Task	Who?		
	Men	Both	Women
Obtaining seed			
Ploughing			
Sowing			
Weeding			
…			

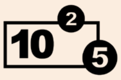
3. Now divide the participants into six small groups, and ask each one to discuss one of these topics:

Land and water



Productive resources: farm equipment, tools, livestock

Knowledge and technology



Financial resources

Access to decision-making

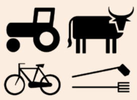
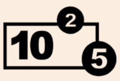
Services and markets

Each group should identify:

- Whether men or women or both have access to the resource/service or can use it? Who makes the decisions? For example, under financial resources, who can obtain credit? Who decides how to spend money?
- How will climate change affect the resource? Will it affect men and women differently? For example, under land and water, climate change may make the water table fall. Men may be affected because they are responsible for watering the crops. Women may be affected because they will have to go further to fetch water for domestic use. If they travel further do they face dangers? Will the additional time they take for daily water fetching have consequences for other household members, such as girls taken out of school to fill in on domestic duties?
- Given existing levels of access to resources and services, as well as possible impacts of climate change, what is the potential that men and women will adopt a climate-smart practice? An example of a specific practice could be given to the group for the purposes of discussion. For example, do women and men have access to the water resources needed to use this practice, and are those water resources likely to remain available under shifting climate conditions? If not, what would need to change for women and men to be able to adopt the practice?

4. Ask them to report back to the plenary. Based on their responses, fill in Table C9 on a series of flip chart sheets.

Table C9. Effect of climate change on women and men

	Access and control		Effect of climate change		Potential for adopting climate-smart practice
	Who has access to the resource?	Who makes the decisions?	…on women	…on men	Men / Women
 Land and water					
 Productive resources					
 Knowledge and technology					
 Financial resources					
 Access to decision-making					
 Services and markets					

MODULE D

Climate-smart agriculture solutions for your area

OVERVIEW

This final module presents some possible climate-smart practices that have been identified through participatory consultations with agricultural producers and policy makers. The module will then explore what are some of the opportunities of adopting climate-smart practices as well as possible barriers producers may encounter when transitioning towards climate-smart agriculture.

KEY QUESTIONS

- Which local agricultural practices are climate-smart?
- How do these practices contribute to each of the objectives of climate-smart agriculture?
- What are the benefits of adopting climate-smart practices?
- What are the barriers that agricultural producers can encounter in adopting the climate-smart approach?
- What are the specific differentiated barriers faced by male and female producers?

OBJECTIVES

After completing this module, participants will be able to:

- Provide examples of climate-smart agricultural practices in different production systems.
- Describe various local agricultural practices that are climate-smart.
- Identify what barriers may prevent the adoption of climate-smart practices
- Analyse the gender implications of transitioning to climate-smart agriculture.

DURATION

4-6 hours

SESSION D1. LOCAL CLIMATE-SMART PRACTICES

SESSION OVERVIEW

This session goes into detail on climate-smart agricultural practices that are or could be used locally. It illustrates some examples of these practices that participants can replace with examples from their own areas. Rather than presenting a comprehensive list of climate-smart practices, the purpose of this session is to familiarize participants with ways these practices can be applied to field activities. The benefits of the climate-smart practices presented here depend on local soil, slope, and water characteristics, among other variables. This focus should encourage participants to think about how the practices can be applied or replicated in their own areas.

INTEGRATED SYSTEMS

Integrated farming systems demonstrate diverse features and include elements from crops, livestock or forestry that can be integrated at various scales, on-farm and area-wide, to enhance the efficiency and environmental sustainability of the different production methods. In the case of integrated livestock systems – crops, livestock, sylvopastoralism, rice-fish farming – animals play a key role in providing additional adaptation options for the agricultural producers by providing meat, milk products, eggs or fibre, but also manure and energy that are useful for crop production. Agroforestry systems include both traditional and modern land-use systems where trees are managed together with crops and/or animal production systems in agricultural settings. They are dynamic, ecologically based, natural resource management systems that diversify and sustain production in order to optimize social, economic and environmental benefits for land users at all scales.

Why is it climate-smart?

Various combinations of timber, fuelwood, fruit, cash crops, nuts, edible oils, medicines and livestock fodder production diversify income sources, so risks are distributed. Soil shading, wind breaks and erosion prevention reduce exposure. Leguminous trees fix nitrogen from the air, enriching the soil and reducing sensitivity to shocks. Nutrient recycling from deep in the soil by roots, returning them to the topsoil in the form of leaf litter builds capacity and resilience. Leaves act as mulch and help build up organic matter, reducing exposure to erosion and evaporation. Removal of atmospheric carbon dioxide and storage in the form of wood or soil organic matter, sequesters carbon. Crop residues can be used for animal feed. Properly processed manure can fertilize crops and tree production (FAO, 2016b; OECD 2015; Soussana, Dumont and Lecomte, 2015).

CASE STUDY MALAWI

Agroforestry with *Faidherbia albida*

Faidherbia albida or winterthorn, known as *msangu* in Malawi, is a common tree in Malawi, often found in agroforestry systems along the lakeshore. It thrives in almost all soil types and climates in the country. It becomes dormant and sheds its leaves early in the rainy season and grows new ones at the start of the dry season. This makes it compatible with growing crops because it does not compete for light, nutrients or water. Farmers in Salima district, in the central region, say that fields with *Faidherbia* trees produce higher yields of maize and cotton. Like many other tree species used in agroforestry, *Faidherbia* improves the soil's ability to hold water, and it is also a legume that fixes nitrogen and increases the amount of carbon stored both above ground and in the soil (Kaczan, Arsland and Lipper, 2013).

***Faidherbia albida* trees with a crop of maize.**

CONSERVATION AGRICULTURE

Conservation agriculture is an approach to agricultural management based on three core principles:

- Minimum soil disturbance: no till or minimum tillage.
- Keeping the soil surface covered with mulch or cover crops.
- Use of crop rotations.

Conservation agricultural approaches:

- Manual. Instead of burning or clearing the previous season's crop residue, farmers leave it on the surface to act as mulch. They may grow a cover crop to avoid leaving the surface bare in the off season. Before planting, they slash the cover crop and any weeds, and leave them to cover the surface. Between rows, they weed or plant an intercrop. The next season they rotate crops to maintain soil fertility. A dibble-stick or special hand-planters can be used to sow seed.
- Animal draught. As with manual cultivation, except that farmers use animals to pull a chisel plough or ripper to open up a narrow furrow for sowing seed.
- Mechanized. Farmers use special equipment that can handle large amounts of residue on the surface. They may use a tractor-drawn ripper and planter to sow seed. They may control weeds using herbicides.

Why is it climate-smart?

Conservation agriculture can reduce carbon losses caused by ploughing, add to the organic matter in the soil and reduce erosion. It also reduces the use of fossil fuels since avoiding ploughing saves fuel. It can offer several benefits, including provision of stable yields, drought buffering, reduced field preparation costs, reduction of soil erosion and contributions to climate change mitigation (FAO, CYMMYT and CCAFS, 2014).

Table D1. Comparing current farming and conservation agriculture

	Current farming	Conservation agriculture
Soil structure	Repeated ploughing and disc-harrowing reduces soil organic matter and destroys the soil structure Very fine, unstable particles result. A hardpan – a hard layer that water cannot pass through – forms at ploughing depth.	Deep ripping may be necessary to break up a hardpan. Deep-rooted crops can also break it up. The soil is disturbed very little, so its structure stays intact. Organic matter builds up because crop residues and cover crops stay on the soil.
Soil moisture	Ploughing turns the soil over, allowing much of the moisture to evaporate in the air. On flat land, water forms pools on the surface, or is trapped above the hardpan, causing waterlogging and killing crops. It also destroys many of the pores and cracks in the soil, making it hard for water to seep in. With a slope, much of the rain runs off and is lost, instead of being stored in the soil or recharging the water table.	In a well-structured soil, water can soak into the soil easily through pores. It is stored in the soil, so is available for crops if there are active roots. There is no hardpan, so water can percolate deep into the ground and recharge the water table. Mulch and cover crops shade the soil surface, so less water evaporates.
Erosion	Heavy rainfall pounds the soil, breaking up lumps of soil into fine particles and creating a crust that seals the surface and prevents water from seeping in. On slopes, water runs downhill, carrying precious topsoil with it. Rills form and develop into gullies that carry the soil into rivers. The silt clogs reservoirs and irrigation canals and causes flooding when the next rains come.	Cover crops and mulch protect the soil surface from heavy rain and interfere with erosive overland flow. Roots bind the soil together, so it is less easily eroded. Less water runs off, so there is less water loss.

	Current farming	Conservation agriculture
Soil fertility	Ploughing buries organic matter and exposes the soil to the sun and rain. It breaks organic matter into smaller fragments, which are easily washed away. Removing or burning crop residues depletes the soil fertility. Planting a single crop year after year removes valuable nutrients from the soil. There are few earthworms, burrowing beetles, microbes, and other soil life that are vital for a healthy soil.	Crop residues and cover crops stay on the soil, adding to the organic matter. Adding compost, manure or mulch from other sources further improves fertility. There are many earthworms and other forms of soil life. Legumes improve fertility by fixing nitrogen.
Weeds and pests	Keeping the soil bare allows weeds to grow unhindered. Planting the same crop year after year encourages certain weeds, pests and diseases.	The cover crop or mulch smothers weeds and prevents them from growing quickly. Careful use of herbicides can also control weeds. Companion planting and mixed cropping can create mutually beneficial conditions that discourage weeds and pests. Rotating crops breaks the life cycle of pests and disease organisms. A healthy soil helps control pests and diseases.
Costs and labour	Ploughing and weeding are hard work, take a lot of time, and are expensive if it is necessary to hire workers. Fuel costs are high, and there is a lot of wear and tear on expensive equipment. Herbicides can save time and labour, but may harm the environment, especially if mismanaged in dosage and timing. Many herbicides and pesticides damage human and ecosystem health.	It is not necessary to plough, so there is no need to buy expensive mouldboard ploughs, disks and harrows, though farmers may have to invest in new equipment such as planters. Digging planting basins, used in one type of conservation agriculture, takes a lot of work in the first year, but less work is needed in the following years. Planting basins help with dosing of seeds and fertilizers, reducing costs. The costs of fuel or of hiring animal traction are lower, and there is less wear on equipment.

Source: IIRR and ACT, 2005.

SOIL AND WATER CONSERVATION

Soil and water conservation techniques are used to prevent erosion, to conserve soil moisture and to maintain and improve soil fertility:

- Physical measures that involve moving stones and earth: terraces, bunds, contour ditches, check dams, reservoirs, grassed waterways, diversion drains and others to discourage erosion and encourage water infiltration
- Biological measures that involve using trees and grass to prevent erosion, such as reforestation, hedgerows and vegetative strips. Leguminous trees and crops fix nitrogen for soil health.
- Agronomic measures that involve managing the crop itself: contour planting, strip cropping, intercropping, mixed cropping, fallowing, mulching, grazing management and agroforestry.

Why is it climate-smart?

Preventing erosion reduces the amount of carbon released into the air. Conserving soil fertility reduces the need for artificial fertilizers. Boosting the amount of organic matter in the soil reduces the amount of carbon dioxide in the air. Trees, grass, hedgerows and vegetative strips produce forage that can be used to feed livestock, as well as preventing soil erosion by wind and water.

LAND CLEARANCE

Land clearance should be reduced as much as possible. Some climate-smart land-clearance methods may include the following:

- Not burning vegetation
- Leaving as many trees standing as possible
- Cutting vegetation and leaving it on the surface as mulch
- Making compost with the residues

Why is it climate smart?

These practices seek to reduce the amount of greenhouse gases into the air and retain or build up the organic matter in the soil, boosting its fertility and water-holding capacity.

AGRONOMIC PRACTICES

Climate-smart agronomic practices include:

- Planting early to adapt to changing rain patterns
- Intercropping
- Crop rotation
- Crop diversification

Why are these agronomic practices climate-smart?

These practices help farmers adapt to climate change. Planting early reduces the risk of crop failure due to drought if the rainy season ends early. It is possible if land-preparation is done early, or if conservation agriculture techniques are used: not ploughing saves time because the farmer does not have to wait until the soil is moist and soft enough for ploughing. Growing several types of crops spreads the risk of one crop failing. Rotating crops maintains soil fertility and reduces the risk of pests and diseases.

FERTILIZER DEEP PLACEMENT FOR WETLAND RICE

The technology consists in placing particles, also called fertilizer pellets, of chemical or organic fertilizer directly in the root zone of the rice crop. The pellets add concentrations of phosphorous, nitrogen and potassium, the three primary nutrients that all plants require. Rather than broadcasting fertilizer over the surface in rice fields, deep placement allows less dispersion in the environment and more efficient fertilizer use (CODESPA, 2011).

Why is it climate-smart?

Deep placement reduces fertilizer losses resulting in cost savings and increasing rice yields, as well as reducing greenhouse gas emissions both for fertilizer production and in the field. It also improves soil and water quality due to reduced use of fertilizers. As well, effective delivery of required nutrients enables crops to utilize water and minerals more efficiently.

INTERCROPPING WITH LEGUMES

Farmers can grow two annual crops together in the same field either in alternating rows or in alternating strips of each crop. The main crop may be a cereal such as maize, dryland rice, cassava or a perennial crop such as fruit trees, coffee, or tea. The intercrop is often a legume such as black bean, mung bean, rice bean, soybean or groundnut. The density of the main crop may be the same as usual, or slightly reduced. The intercrops should be dense enough to cover the soil between the main crops.

Why is it climate-smart?

Farmers can harvest two crops rather than one from the field. They spread their risk: if one crop fails because of drought or pests, the other one may still produce a harvest. Legume intercrops fix nitrogen in their roots, enriching the soil and reducing the need for nitrogen fertilizer. The intercrop covers the soil and protects it from the sun, heat and heavy rains as it discourages weeds.

SWITCHING SPECIES, VARIETIES AND BREEDS

Climate-smart agriculture uses a combination of traditional and adapted modern varieties of crops and breeds of livestock. It may involve a shift in species, such as from water-hungry maize to drought-tolerant sorghum; in variety, such as one that tolerates heat better or matures faster; or in breed, such as from a sensitive cattle breed to one that is hardier.

Why is it climate-smart?

As the climate changes, high-yielding varieties and breeds that are suited to specific conditions may fail to perform well. Specially developed crop varieties and livestock breeds, or ones commonly used outside the region, can withstand the new conditions. For example, rice varieties that tolerate salt or flooding can grow in areas with rising salinity – river deltas, low-lying coastal land, or small islands – as the sea level rises. Crops that are tolerant of drought and heat are useful in areas that are becoming drier or with erratic rainfall.

CASE STUDY MALAWI

A local gene bank

A gene bank in Dowa district, Malawi, comprises a small brick building with a corrugated roof. One room serves as an office while the other room is used to store seeds in special containers. The building is designed so that the room temperature is maintained, and the seeds are protected from pests and temperature extremes.

A plant's or an animal's genetic make-up determines how well is can survive temperature extremes, drought, flooding, and pests and diseases. It determines the time to maturity, cycle of production, resistance to pests and adverse conditions and response to inputs such as fertilizer, water and feed.

The Dowa gene bank preserves seeds of local crop varieties. It was built by Malawi's Lilongwe University of Agriculture and Natural Resources. The conserved seeds include varieties that are tolerant to drought and resistant to pests and diseases. The gene bank stores seeds so they can be used to respond to problems and improve yields in the future.

SYSTEM OF RICE INTENSIFICATION

The system of rice intensification is a set of farming practices that aims to increase the productivity of irrigated rice by changing the management of plants, soil, water and nutrients (FAO, 2013a). It uses widely spaced seedlings, organic matter and minimal irrigation to promote the growth of the plant's root system and to increase soil organisms. The main principles of rice intensification include:

- Soil should be kept moist, not flooded, and enhanced with organic matter content, to ensure good structure and water and nutrient retention capacity.
- Young seedlings should be transplanted carefully, to avoid disturbance to the roots and preserve their growth potential, and should be spaced widely in a square grid pattern.
- Apply organic matter as appropriate.
- Less irrigation water means more weeds will grow. Remove weeds by hand or using mechanical equipment, such as a rotating hoe or cono weeder that contributes to soil aeration.

Why is it climate-smart?

Early transplanting helps the young plants avoid shock and allows them more time to grow vigorously. Reducing the supply of irrigation water stimulates aerobic micro-organisms and root growth. Applying organic matter increases the level of carbon in the soil and avoids excessive use of chemical fertilizers. Because rice intensification reduces the amount of flooding of irrigated rice, it is also likely to reduce methane emissions. The system also saves water and may possibly reduce nitrous oxide emissions (HLPE, 2012). In some countries, it has been estimated that application of this rice intensification system has resulted in an increased income of around 26 percent, yields increased by 17 to 105 percent and decreased water requirement between 24 and 50 percent (FAO, 2013a).

IRRIGATION

Irrigation methods have been used for millennia in different forms and at different scales. The most commonly used methods in household-oriented farm systems include:

- Sprinkler and drip irrigation.
- The use of unglazed clay pots for individual plants such as fruit trees and vegetables.
- Restricted irrigation in wetland rice.
- Systems that automatically control the amount of water reaching the crop.

Why is it climate-smart?

Irrigation helps farmers grow crops even if the rains fail. But water is scarce. Current practices such as basin or furrow irrigation waste a lot of water. Drip irrigation or sprinklers need more investment but are more economical in terms of water use.

Restricting the flooding in wetland rice-fields reduces the amount of methane emitted into the air.

Water management is the key to climate-smart irrigation schemes. Taking too much water from ground water or from rivers and reservoirs can lower the water table and deprive areas downstream. Reducing the amount of water used in the first place can reduce these problems. Optimizing efficiency is often the most climate-smart practice for irrigation systems, especially when combined with water harvesting.

WATER HARVESTING

Water harvesting is the collection of rainwater or runoff, so it can be used for irrigation, watering livestock, domestic purposes and other uses. The water may be stored in an open pit or depression, in a cistern, or even in the soil and water table. The many different types of water harvesting include:

Micro catchments. The rainwater is held in the field where it is to be used:

- Planting basins for individual plants such as a tree, or groups of plants such as maize.
- Half-moon, trapezoidal or diamond-shaped basins.
- Terraces and contour bunds on slopes.
- Tied ridging.

Macro catchments. The rainwater is captured and diverted directly into an irrigation system or into a storage tank or pond:

- Dams, weirs and channels to divert river water, or to collect and divert floodwater.
- Subsurface dams and sand dams, which trap water underground where it can be reached with a well or borehole.
- Rooftops and impermeable areas such as roads, drying floors or rock outcrops.
- Natural catchment areas where the water flow can be diverted easily.

Other storage options range from aquifers to holding tanks:

- The water table or an aquifer: larger water-harvesting systems may aim to replenish an aquifer that feeds wells and boreholes.

- Open farm ponds, open tanks, water pans, and lined ponds that may be built in rock or lined with cement or clay.
- Closed tanks, or cisterns, made from fired clay, plastic, metal, cement or brick.

Why is it climate-smart?

Much water runs off and is wasted, especially during heavy rain. Excess water can cause erosion and flooding. Slowing the flow so the water permeates through the soil and recharges the water table, as well as collecting in reservoirs of any type, means there is less flooding downstream. Capturing water for later use reduces the risk of dehydrated populations, animals and crops during dry seasons and drought. Also, conserving surface water and recharging soil moisture and the water table means there is reduced need to pump water from an underlying aquifer, a practice that often requires fossil fuelled power.

CASE STUDY MALAWI

Water-harvesting

PIT PLANTING

Across Africa, including Malawi, smallholder farmers plant maize and other crops in pits so they can maximize the use of limited water and survive dry spells. Planting in pits, called *zai* pits, is a water-harvesting technology suited to areas with low or unpredictable rainfalls and degraded soils with low permeability.

A typical pit is around 20–30 cm square and 10–20 cm deep (although dimensions can change) and can contain several plants. The topsoil is taken out, mixed with manure and crop residue, and put back in the pit during the dry season in order to harvest rainwater and improve soil fertility. The amount of manure can be reduced if fertilizers are used. One study, have reported that farmers using zai pits in Malawi have gained 79 percent higher yields (Lynch and Mkoka, 2017).

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Example of pit planting in areas with unpredictable rains.

SWALES

Swales are trenches dug along the contour at a depth of 1 m and width of 1 m. These are used to collect rainwater and allow it to seep gradually into the ground. The trenches are dug at regular intervals: the steeper the slope, the closer the trenches.

Trees or grasses can be planted along the swales to stabilize them and to produce fodder.

© FAO/Daniel Hayduk

A trench with pineapple planted along the ridge to improve land and water conservation.

WATER TANKS

Various types of dams, tanks and reservoirs can be used to harvest and store rainwater and runoff. Dams can be built across watercourses and used to store water or divert it into fields.

Tanks may be above ground or underground. They may be lined with bricks, cement, clay or plastic, or left unlined if the soil is impermeable.

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A sunken tank with land beside it ready for planting.

© FAO/Olivier Asselin

Vegetables grown using harvested rainwater.

LIVESTOCK FEEDING PRACTICES

Improving the quality of livestock feed can be done by simple adjustments, including introducing by-products such as molasses or bran; fodder crops or legume tree and shrub cuttings; chopping or urea treatment of crop residues to process feed; or improving pasture quality and productivity through fertilization, optimized grazing and introduction of legumes.

Why is it climate-smart?

Improving feed quality is climate-smart in three ways. First, more digestible feed results in less enteric methane emitted by ruminants. Second, better nutrition increases productivity at animal level through higher milk production and carcass weights. Finally, it can increase productivity at herd level, due to the effect of better nutrition on fertility and the decreased proportion of unproductive animals in the herd. Overall efficiency of resource use is improved, contributing to higher resilience. In addition, diversifying feed materials can make farmers less vulnerable should some crop fail.

Recent studies (Gerber *et al.*, 2013) have shown that in South America improving feed quality in beef production by 3 percent in digestibility could result in a direct reduction of 9 percent of greenhouse gas emissions and a 16 percent increase in productivity when coupled with improved husbandry.

ANIMAL HUSBANDRY AND HEALTH

Improving animal husbandry can be done by breeding for productivity and improving fertility through better nutrition, better care of animals, better timing of reproduction and sometimes through artificial insemination. Improving animal health is not only about vaccination for the eradication of infectious diseases but also anti-parasitic treatments, better care to avoid calving or lambing issues, mastitis or injuries.

Why is it climate-smart?

Reducing the number of unproductive animals in the herd results in better efficiency in production and use of resources, which contributes to both reduced greenhouse gas emissions per unit of product and reduced vulnerability to scarcer resources.

GRAZING MANAGEMENT

Globally, about 20 percent of grasslands throughout the world are degraded, resulting in decreased productivity, soil carbon deficiencies and biodiversity losses, and damage to water retention capability in soils and to water quality. Degradation also reduces the capacity of land and livestock keepers to adapt to climate change. Overgrazing reduces vegetation cover, exposing soil to water and wind erosion that decreases fields' and pasture land's capacity to retain moisture. This leads to declining vegetation yields.

Solutions to revert land degradation are available. Today, much more information is produced and advanced tools, such as remote sensing, can support landscape management at both regional and local scales. Improving grazing management can be achieved by adjusting grazing pressure and balancing spatial and temporal presence of livestock. New technologies like solar powered electrical fences can help fine tune grazing pressure at low cost. Fast growing species have become available that quickly establish vegetative cover to restore degraded grassland. At parcel level, a variety of choices offer specific remedies: Carefully selected fertilizers and nutrient management can help improve productivity of grassland with specific deficiencies. Also, the introduction of beneficial plants species, such as nitrogen fixing legumes, and the inoculation of plants with beneficial symbiotic microbes can focus solutions to the problems. Nitrification inhibitors can be used to limit nitrogen losses to ground water. At animal level, the ability to use feed additives and to optimize animal nutrition also exists in extensive grazing systems.

Why is it climate-smart?

Sustainable pasture management can sequester a substantial amount of carbon and have positive feedback on soil fertility, as well as on animal productivity. Silvopastoral systems provide further carbon sequestration in trees but also provide shade and shelter from weather extremes for livestock, as well as a diversity of goods and services for pastoralists, to build resilience against risks from a changing climate.

MANURE MANAGEMENT

Globally, the nitrogen contained in animal manure exceeds the amount of synthetic nitrogen used for fertilisation (Bouwman *et al*., 2013). However, it is estimated that livestock manure supplies up to 12 percent of gross nitrogen input for cropping globally and up to 23 percent in mixed crop–livestock systems in developing countries (Liu *et al*., 2010). Though part of the gap is explained by the deposition of manure on pastures and rangeland, this means that more livestock manure could potentially be used for crop fertilization. Efficiency gaps also exist due to different levels of nutrient retention. The difference between the retention of nutrients in animal products varies indeed across species and production systems. For example, Gerber *et al*., 2015 estimate that nutrient efficiency hardly exceeds 30 percent in the dairy herd and 15 percent in the beef herd.

In addition, emissions from manure management account for about 10 percent of global livestock emissions. Improving manure management can be done by improving its storage and application, for example, by composting, covering pits, collecting and applying to crop fields, but also by recycling nutrient and energy from manure through anaerobic digestion.

Why is it climate-smart?

Improving manure management contributes to improve nutrient efficiency at farm level. Crop and pasture lands can benefit over longer periods from the slow leaching of nutrients from composted manure and productivity increases. Fewer applications of artificial fertilizers are needed, so emissions are reduced from their manufacture, transport, and distribution, as well as their quick release of available nutrients with subsequent wastage and contaminating discharge into water bodies. In addition, proper manure management can reduce nitrous oxide and methane emissions during storage and application.

RICE-FISH CULTURE

Rice-fish culture involves raising fish in flooded rice fields. The fish are raised in the surrounding irrigation canals, and then released into the paddies when the rice plants are big enough and can no longer be damaged by the fish. The fish are harvested by reducing the water level, forcing them to swim to the lowest-lying part of the fields, where they can be caught easily.

Why is it climate-smart?

The agricultural producers gets two harvests – rice and fish – from the same land, improving income and food security. The fish fertilize the fields, reducing the need to apply artificial fertilizer. Pesticides cannot be used on the rice because they would harm the fish; but, with the fish in residence, pesticide is not needed as much.

SESSION D2. BARRIERS AND OPPORTUNITIES

SESSION OVERVIEW

Many factors hinder the adoption of climate-smart practices. This session explores these barriers and gets participants to think of ways to overcome them. It also enables participants to explore the opportunities for promoting climate-smart approaches.

CLIMATE-SMART AGRICULTURE

Climate-smart agriculture is attractive to agricultural producers because it maintains or increases their production and food security, increases the fertility of their soil and the long-term productivity of the land, and helps them adapt to a changing climate.

However, a number of obstacles may prevent its adoption. This session looks at several barriers, along with possible opportunities, in each area. Barriers may involve:

- Extra costs and labour
- Short-term fall in production
- Risk and vulnerability
- Tenure insecurity
- Cultural factors
- Lack of information, knowledge and skills
- Lack of access to inputs
- Lack of suitable finance
- Lack of effective supporting organizations and institutions
- Lack of supportive policies and political will

EXTRA COSTS AND LABOUR

Barriers

Some climate-smart practices require significant investments. Costs fall into three main categories:

Table D2. Cost barriers

Cost	Example
One-off investment costs: These pay for equipment, stock, machinery and farm structures. The farmer must bear many of these costs up front, while the benefits will take several seasons, or years, to materialize. It may be possible to offset these costs by subsidies for the initial investment or by offering loans that farmers can repay over several years.	The effort and expense to build terraces. Specialist equipment for conservation agriculture, such as rippers, jab-planters and cono weeders. The cost of raising and planting tree seedlings for reforestation. Risk of trying unfamiliar crop species, seed varieties, or livestock breeds.

Maintenance costs: The recurrent expenses needed to maintain climate-smart practices. Farmers may not be able to afford these costs and may not have foreseen them.	The regular maintenance needed for rainwater harvesting, irrigation and terraces. The recurring costs of finding suitable seeds and other farm inputs. The extra work needed for field operations such as weeding in conservation agriculture and harvesting in intercropping.
Opportunity costs: The income that farmers forego in order to adopt the practice.	Some climate-smart practices are time-consuming or need work at certain times of the year. That means the farmer cannot spend the time earning money somewhere else. A shift to conservation agriculture means that some types of equipment, such as ploughs, are not needed. A farmer who owns one will have wasted the investment.

Source: authors elaboration.

Opportunities

Climate-smart agriculture offers attractive opportunities to save both money and labour. For example, eliminating ploughing through conservation agriculture saves labour at a critical time of year, and allows farmers to plant and harvest earlier.

SHORT-TERM FALL IN PRODUCTION

Barriers

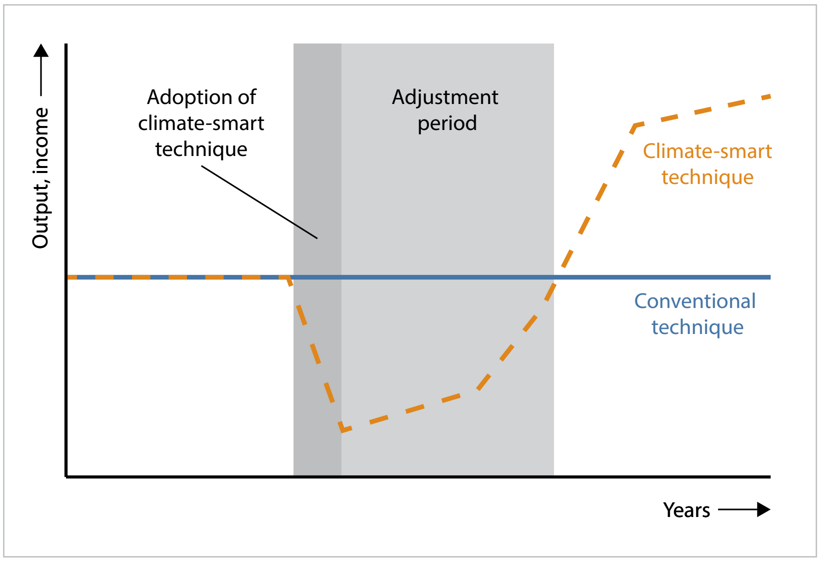
In some cases, adopting new practices may bring a decline in total output for a few seasons, until the practice is mastered and production recovers. That is income and food security foregone.

Table D3. Production barriers

CSA Practice	Potential short-term productivity issue
Building terraces	Takes land out of production while the terraces are being built. And it may take several years before the terraces reach their full yield potential. Even then, land on the terrace risers will stay permanently out of production.
Planting trees	Takes land out of production, and the farmer has to wait several years before harvesting any fruit or wood.
Conservation agriculture	It may take several years before the yields have recovered and exceeded their previous levels. Weeds are a significant cause: it may take several seasons to reduce the number of weeds to a manageable level.
Land restoration	Reducing the number of animals in a herd in order to restore rangelands reduces output in the short term, before the rangeland has recovered enough to produce more fodder.

Source: authors elaboration.

Figure D1. A dip in output in the first few years may deter agricultural producers from adopting some climate-smart techniques



Source: Adapted from FAO, 2013a.

Opportunities

Many climate-smart practices do not entail a short-term dip in output. A significant proportion of easily implemented changes can bring immediate benefits:

- Mulching, composting and planting leguminous cover crops revive soil fertility in the first planting
- Better water management can cut waste, saving time on fetching water, and improve yields
- Better-managed fertilizer use can cut costs and boost output with first planting
- Improved varieties can boost yields and reduce the risks of diseases and drought with first crop
- Diversifying crops and livestock can spread risk, raise output and improve diets in first season.

RISKS AND VULNERABILITY

Barriers

Smallholder farmers are highly exposed to weather-related risks as they are very dependent on weather for sun, rain and advantageous planting, growing, and harvesting. Weather-related risk is largely uninsured and, as such, it discourages investment and innovation by agricultural producers. Farmers who might benefit most from adopting climate-smart practices may be those that are most deterred by the risks involved. Any unfamiliar practice brings risks. And many farmers are vulnerable: they are already affected by changing climate and they cannot afford to take extra risks. They don't have enough capital, they control too little land or surplus to carry them through a poor season, or they lack the skills and knowledge to apply new methods.

Opportunities

The opposite of vulnerability is resilience. Agricultural producers who can invest capital, absorb setbacks, and apply skills are in a better position to try out new things. This means that the first farmers to adopt climate-smart techniques, or any new technique, tend to be better-off, be better educated and have larger, better landholdings than their neighbours. These producers often act as examples for their neighbours to follow.

It is possible to build farmers' resilience, for example through training that improves their skills or crop-insurance schemes that can compensate for losing a crop. Community solidarity can serve as insurance for small scale risk-taking when new technologies and techniques offer solutions to threats they all face.

INSECURE TENURE

Barriers

Landownership issues:

- Agricultural producers may lack secure tenure to the land they farm, for example they may lack a legal title to land that is formally owned by the state.
- Tenants or sharecroppers may rely on the landowner for access to the land and for supplying farm inputs.
- Pastoralists may graze their animals on common land or may rely on agreements with landowners.

Fencing, land-grabbing and the conversion of pasture to cropland reduce farming options. Agricultural producers in these situations therefore have little incentive to invest in land they work. For example, a smallholder tenant who installs an irrigation system may see the investment wasted if the landowner decides to terminate the tenancy. The landowner may terminate the tenancy because the land has become more valuable with the new installation. Women are often facing insecure tenure, as they are seldom owners of the land they farm.

Opportunities

While progress is slow, many countries are strengthening tenure rights for agricultural producers. If the tenure is established by a lease for a specific amount of years, the tenant can plan their investment in climate-smart practice options.

CULTURAL FACTORS

Barriers

Every community has its own cultural context, but some barriers are often encountered.

Table D4. Cultural barriers

Cultural factor	Common barrier
Traditional responsibilities	In some societies, women and men are expected to fill different roles. Some crops are regarded as men's, others are seen as women's. This restricts the possibilities of both men and women to grow other types of crops.
Local traditional leaders	In most societies, local leaders have a great deal of influence – by definition. If they do not support the introduction of climate-smart practices, success may be difficult.

Opportunities

One way to persuade reluctant participants to consider alternatives is to use examples or parables in a conversation or situation where the listener has no idea they are the targeted audience. In this case, the story would be about someone trying something different and finding great success and public approval. These are the opportunities that come from public outreach programmes and events.

If it is possible to convince local leaders of the value of climate-smart approaches, progress can be rapid. However, local leaders also may need to be convinced by appealing to their vanity or the potential for approval from the community or from higher levels of leadership. On the other hand, there may be some alternative, less obvious, local leaders who would be interested in trying new solutions. They may just need to be located.

LACK OF INFORMATION, KNOWLEDGE AND SKILLS

Barriers

- Like other people around the world, agricultural producers in developing countries have limited sources of reliable and impartial information. Most farmers get their information from other producers and since there is not yet a critical mass of farmers who use climate-smart techniques, the challenge for extension staff is to build that critical mass.
- Extension services in many countries are poor, and many extension workers themselves have weak knowledge about climate change and may not have heard about climate-smart approaches.
- Input-supply companies and local outlet stores, another potential source of information, are more interested in selling products than in promoting climate-smart solutions.
- Some governments rank building resilience in the face of climate change as a low priority in policy making.
- Agricultural producers may receive confused or contradictory messages from different sources, or even from the same source.

Opportunities

Relevant knowledge on climate-smart agriculture is increasingly available with a growing body of evidence moving from research to operational action. Sources of information are becoming more common that promote novel technologies able to enhance smallholder resilience and reduce climate change-related threats, as well as those revisiting and combining with traditional practices that conserve resources. Now these approaches include mitigation-enhancing practices that build carbon stocks in vegetation and in soils. All these activities help to reduce climate change-related threats. Our accumulating wisdom includes a wealth of high value traditional agriculture skills and tools, easily recognized and accepted by farmers. Climate-related knowledge, technologies and practices – gained through experiences around the world – can be adapted to local conditions in every community, by promoting joint learning among farmers, extension agents and researchers. Openness to learning lessons from the experiences of farmers faced with similar challenges and barriers is critical to disseminate climate-smart agriculture.

In this context, information and communication technologies are necessary to enable agricultural producers to adopt climate-smart techniques through new knowledge and skills based on:

- Traditional approaches such as training and demonstrations;
- Participatory techniques that include farmer-based extension and accessing channels such as radio, television, mobile phones and the internet.

The existing information services tailored to agricultural producers' needs include weather forecasts, market prices, links to suppliers and buyers, and production tips, available through these various channels. An important facet is the ability to call for and receive assistance in the face of an immediate challenge. Another success story is that of farmers using mobile phones to keep in touch with suppliers and potential buyers and to follow market prices that inform their real-time management decisions. Mobile phones and internet access offer great potential to keep smallholders and pastoralists informed and to give them a voice in the decisions that affect them.

LACK OF MARKET ACCESS

Barriers

Lack of market access can limit the shift to new crops and livestock types. Farmers who cannot market their produce have no reason to produce more than they can consume themselves. If markets exist but the price is low, they will also have few incentives to boost production.

Opportunities

Many governments and development programmes now recognize that markets and value chains are key components of agricultural development. Climate-smart agriculture offers an opportunity for agricultural producers to analyse their potential markets and adjust their production, so they can grow what the market requires. At the same time, in many countries infrastructure in the form of roads, electricity supply and communication networks are improving, making it easier for farmers to communicate with and supply appropriate markets.

LACK OF ACCESS TO INPUTS

Barriers

Even if farmers know about climate-smart techniques and want to use them, they may be hampered by a lack of suitable inputs. Conservation agriculture, for example, uses certain types of equipment that may not be easily available.

Advantageous crop and livestock breeds may also be hard to obtain. Examples include seed and planting materials of cover crops and legumes; seedlings of suitable tree species; traditional or adapted breeds of livestock; and seed of crop varieties bred to tolerate salinity, flooding and drought.

Opportunities

Access to inputs is improving gradually. Farmers can produce some of the inputs locally such as seed, tree seedlings, compost and manure. Often, those are the species that will work best anyway. For seed growers and nursery owners, or those who distribute their goods, providing these inputs can be a valuable source of income.

LACK OF SUITABLE FINANCE

Barriers

Rural finance is an important tool for farmers, who can benefit from several financial service sources including savings, remittances, leasing and insurance. However, financial services are poorly developed especially in many rural areas. What is more, financial products are not tailored to the needs of farmers, and banks tend to see farmers as high-risk clients due to their high dependence on unpredictable factors, such as the changing climate, and limited assets. Conventional insurance products do not suit smallholders' needs because the cost of servicing them in remote areas could be very high, including to assess damages. Such services add to premium loading, making insurance packages unaffordable. Moreover, reinsurance is difficult, as international reinsurance companies demand long-term risk data that is not often available in most developing countries – nor in some parts of developed countries.

Opportunities

To overcome the problem of extra initial costs that farmers would need to cover to invest in climate-smart practices, they would benefit from subsidies and loans that could be used to buy assets – such as high-quality seeds and necessary machinery, among other goods and services – and to purchase insurance products against climate-associated risks. In this sense, index-based weather insurance, where a farmer pays a small premium and receives a payout if the index falls beyond a given threshold, could be used to promote the climate-smart approach by making the payment conditional on adoption of climate-smart good practices, such as future cultivation of drought-tolerant crops.

CASE STUDY MALAWI

Index-based crop insurance for small-scale farmers

The World Bank, in close collaboration with Malawi's National Association of Small Farmers, has developed an index-based crop insurance contract that is more efficient and cost-effective than traditional crop insurance and can easily be distributed to individual smallholder producers to increase their access to finance and to protect them and loan providers from weather risk.

In 2005, 892 groundnut farmers purchased weather index-based crop insurance policies for a total premium of USD 36 600. As the crop insurance contracts alleviated the weather risk associated with lending, local banks came forward to offer loans to insured farmers. The farmers used these loans to purchase certified groundnut seed.

This arrangement – lending coupled with crop insurance – allowed farmers in the pilot areas to access finance that would not have been available to them otherwise. Credit, in turn, allowed them to invest in higher yield and higher return activities.

In 2007, the pilot was expanded to cash crops. By 2008, the number of participants had increased significantly, with 2 600 farmers buying policies worth USD 2.5 million.

Index-based insurance is not a panacea. Years of practical experience indicate that it is more effective when part of a larger package of risk management strategies and services.

Source: World Bank, 2012.

LACK OF EFFECTIVE ORGANIZATIONS AND INSTITUTIONS

Barriers

Organizations in many areas are weak and may promote current production techniques, not those that are climate-smart. As well, they may link to input-supply companies as sponsors for particular campaigns or events. Extension services that are key providers of assistance to farmers worldwide are still mostly public driven, although hampered by limited resources: under-funded, under staffed and having low capacity both in terms of technical and social skills, so that they struggle to promote climate-smart alternatives.

Opportunities

Government and donor commitments for climate change may lead to increased focus on agriculture, enabling the strengthening of key organizations and training staff so they can promote climate-smart techniques. Extension service capacities should be emphasized for enhancement and support given their unique opportunities to work directly with farmers over the long term. Extension officers network with a wide range of stakeholders to plan and coordinate climate-smart interventions. They can also enable establishment of platforms offering effective multi-stakeholder interactions where the private sector can play a role.

LACK OF CONDUCIVE POLICIES AND POLITICAL WILL

Barriers

Many governments rank climate change issues as a low priority in their policy making process. Many politicians are not well informed on climate issues or are sceptical of climate change realities.

Opportunities

The UNFCCC's 2015 Paris Agreement registered a global commitment to hold the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C. International and local pressure will keep this topic high on the international agenda. Funding, which is available to help developing country governments adapt to the future, will keep it on national agendas. This is an opportunity to promote climate-smart approaches in agriculture. To achieve this goal and to promote measures for both adaptation imperatives and mitigation objectives, stronger coordination mechanisms must be installed. These mechanisms should encompass the constellation of sectors – forestry, energy, water, finance and insurance and their related enabling institutions – to ensure climate-smart practices dominate human activities across Earth's landscape.

EXERCISE D.1 "WORLD CAFÉ" ON CLIMATE-SMART AGRICULTURAL PRACTICES

120 minutes

See Session D1.

1. Choose one of the climate-smart practices described in Session D1. Describe what it is to the participants and then explain why it is climate-smart. Invite a discussion on the practice. Can this practice be used in their area? How should it be adapted to make it applicable while still keeping it climate-smart? If it is not used, why not?
2. Divide the participants into several groups and give each group one of the other descriptions of climate-smart practices in this session. Get each group to nominate a chairperson.
3. Explain that they will repeat the process used in Step 1. Each chairperson describes the particular practice to the group, and then invites comments and ideas: Is the practice used, how it might be adapted to become more climate-smart, what could be added as a complementary climate-smart practice, and what might be best for their context?
4. The chairperson of each group notes their comments on a flipchart.
5. The groups then rotate: The chairperson stays seated, but everyone else rotates to a new group. The chairpersons then explain their practice to their new group and present the discussion from their previous group. The new group then adds any additional ideas they have. The chairperson notes these on the flipchart.
6. Repeat Step 5 one or more times.
7. Back in plenary, invite the chairpersons to present the major and cumulative findings from their encounters as well as the most significant divergent positions.

EXERCISE D.2 OTHER LOCAL CLIMATE-SMART PRACTICES

30 minutes

See Session D1.

1. Ask the participants to identify any other climate-smart practices they know of in their areas.
2. Ask them to describe the practice and explain why it is climate-smart.
3. How and to what extent do they contribute to the three pillars of climate-smart agriculture?

EXERCISE D.3 BARRIERS AND OPPORTUNITIES TO ADOPTING CLIMATE-SMART AGRICULTURE

60 minutes

1. Organize participants in groups of five. Ask each group to identify and discuss the factors that might hinder the adoption of a specific climate-smart practice, identified in previous exercises, in their particular community and experience. Ask each group to focus on one of the following groups of factors: socio-cultural, economic, technical, political, and biophysical.
2. Invite the groups to present the results of their discussion to the plenary.
3. After each presentation, invite the other participants to comment. Mention other factors that the presenting group has forgotten. Keep a record and make the discussions available to participants.

EXERCISE D.4 RISK MANAGEMENT

30 minutes

1. With farmers, identify the risks they may face.
2. Invite the participants to suggest ways to reduce these risks.
3. Ask them to identify ways that the government or development organizations could help them reduce their risk.

EXERCISE D.5 ACTION PLANNING

120 minutes

1. An action plan consists of a set of practical steps that the participants put into practice. It should reflect what the participants themselves can do, within the constraints they face. This final exercise enables the participants to develop an action plan to promote climate-smart agriculture in their own focus areas. If the participants are extension service providers, the action plans should describe what they can do to work with farmers to promote climate-smart agriculture. If the participants are farmers, the plans should show what they can do to put climate-smart techniques into practice on their own farms.
2. An action plan can include the following:
   - α. Timing: When the activities will be started and completed.
   - β. Activities: A brief description of what to do.
   - χ. Person(s) responsible and participants: The names of the individuals who will lead the work, and everyone who will participate, along with their roles.
   - δ. Location: Where the activities will take place.
   - ε. Inputs required: The cash, materials, labour and other inputs needed.
   - ϕ. Budget: A good estimate of the costs or resources required to achieve the activities, and where the resources will come from to implement them.
   - γ. Details: Any further information needed.
3. Ask the participants to brainstorm actions and activities that they themselves can do to promote climate-smart practices in their area. Go around the room once or twice, with each participant contributing an idea, with responses or further elaborations welcome.
4. Present what an action plan should look like:

Table D5. What an action plan looks like, first entry

Timing	Activity	Responsible	Location	Inputs	Budget	Details
Jan-Apr	Demo on drought-resistant crops	George	Village X	Seed, demo plot, transport	USD 100	4 training sessions (1 per month)
…						
…						

5. Divide the participants into groups by either subject area of interest – crops, livestock, fisheries – or geographical area.

6. Ask each group to develop a practical action plan to promote climate-smart agriculture in their area.
7. Invite the groups to present their plans to the plenary. Invite comments and discussion from the floor.

Note: Consider inviting guests to attend the final presentations.

EXERCISE D.6 CLOSE

30 minutes

1. Remind the participants that climate change is inevitable, and that it is happening, and that the changes will continue for generations. Reiterate the importance of climate-smart agriculture as an ongoing response to those changes, and its three objectives: food security, adaptation and mitigation.
2. Congratulate the participants on their contribution, and thank them for their attention. Wish them luck as they put their action plans into practice. Offer your assistance to answer questions and help solve problems in the future as they undertake their action plans, if you are able.
3. Hand out evaluation forms, ask the participants to fill them in anonymously, and have them collected.
4. Formally close the workshop.

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CLIMATE-SMART AGRICULTURE

TRAINING MANUAL

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Agricultural Development Economics Division (ESA)
Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla, 00153 Rome, Italy.
www.fao.org/in-action/epic

ISBN 978-92-5-131065-6
9 789251 310656
CA2189EN/1/10.18